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COMSATS INSTITUTE OF INFORMATION TECHNOLOGY, LAHORE

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COMSATS Institute of Information Technology (CIIT)

Address: Defence Road, Off Raiwind Road, Lahore.

Tel: +92(042)-111-001-007, Ext. 123

Email: ESSD@ciitlahore.edu.pk

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REGISTRATION HOURS

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IMPORTANT CONTACTS

Registration: Engr. Tariq Mehmood Raza (+92-300-6952062)

Accommodation: Engr. Muhammad Akmal Rana (+92-345-7353392)

Transportation: Dr. Abdul Razzaq (+92-300-4123743)

FOREWORD

Dear Distinguished Delegates and Guests,

The Organizing Committee warmly welcomes our distinguished delegates and guests to the 2nd International Conference on Energy Systems for Sustainable Development (ESSD-2018) held in Lahore, Pakistan. The objective of "ESSD-2018" is to bring together representatives from academia, industry, and authorities to exchange latest advances in knowledge and technological progress and to share experience pertaining technological, economic and environmental aspects of energy resources development and utilization, optimize the utilization of basic energy resources in the major energy consuming sectors in the developing countries and provide forum for East-west cooperation in the field of energy and environment. The Conference will bring together International experts and representatives from academia, industry, and authorities to exchange latest advances in knowledge and technological progress, and to share experience in economic and environmental aspects of energy developments. Idea of this International Conference is how best Pakistan can use the energy resources to meet growing energy demand, overcome energy crisis and achieve sustainable development.

We would like to thank the plenary and keynote speaker(s), program chairs, and organization staff for their contribution to the success of ESSD 2018. We hope that all participants and other interested readers benefit scientifically from the proceedings and find it stimulating in the process. Finally, we would like to wish you success in your scientific and technical presentations and social networking.

We hope you had a unique, rewarding and enjoyable week at ESSD 2018 in Lahore,
Pakistan.

With our warmest regards,

The Organizing Committee
ESSD-2018
February 21-22, 2018
Lahore, Pakistan.

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RESEARCH ARTICLES

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Public Banking Do Contract

Sohail Zafar Qureshi[1*], Kaneiz Fatima[1*], Bilal Mehmood[2*]

[1]Department of Economics, University of Balochistan, Quetta, [2]Department of Economics, GC University Lahore

Sohail Zafar Qureshi
Email: soahil.zafar@iiu.edu.pk

Abstract

It is understood that for ownership status, it does affect performance and growth in an economy in terms of efficiency. Squeeze excitement and changes in management in ownership effect performance and productivity. For state owned banks there is inconclusive arguments need researchers to bring more evidences in contract theory. Putting simply, it turns out an individual banking, operational learning, forwarding and asset management albeit allocation of resources, of course state bank of Pakistan need to bring more data from banks and its availability to researchers and policy makers. Public banking is globally accepted for strong governance such that any unit not performing well could be undertaken to rule out on part of government. However, it is not globally recognised. In some countries government ownership is crucial part of working for having a balance in social and economic objective.

Key words: public banking, efficiency, regulations, contract

Introduction

In Pakistan public servants are staffed by banking professionals depleting high salaried individuals to cope with international banking. This management is different than city management invoke political front with non-banking staff. In governing structure there are several models of governance might process to establish governance structure. There is also super governmental agencies and contracts and cooperation in priority for the local bodies protected from political influences. Provided, implement government policies public banking pave the way to work though. The need is tremendously full filled when it is matter of redistribution of wealth and income. That is a balanced economy a need to employ effective resources. In developing countries substitute ability of labor which further support in favour of do more people employed. Reforms in banking, increase government in banking enable greater control over the employment policies and creation of finance for stability purposes, all go through contract. It turns out one sided theory of foreign or private working is never acceptable contracts for having open arms to reform in grey area and take part though several operations in core government undertakings. In literature need for strong public banking play significant role in establishing contracts for growth and development of the country Levine (1997) Gertler (1998) Well functioning markets play vital role with in good governance for growth and development of the country more a causality run from finance to growth King and Levine (1997) Levine and Sara (1998) Beck et al (1999) Levine et al (1999). This means that in public banking finding new functional markets is a core determinant identifying local project based development. In essence of public banking it more a contract a number of research articles measure efficiency in banking Burki et al (2004) Alchian and Demsetz (1972) Andries and Cocris (2010)

Ataullah, Cockrell and Le (2004) Barth, Caprio and Levine (2004) Berger and DeYoung (1997) Bonin, Hasan and Wachtel (2005) Boubakri et al (2005) Baradaran (2014) Brealey (2001) Buch (1997) Caprio and Klingebiel (1996) Casu and Molyneux (2003) Claessens and Laeven (2005) Das (1997) Fama and Jensen (1983) Fiordelisi, Marqués-Ibanez and Molyneux (2011) Fries and Taci (2005) Hardy and Patti (2005) Hart (1988) Iimi 2004) Irfan (2008) Janjua and Malik (2011) Jensen and Meckling (1979) Joshi and Little (1996) Karim (2003) Karim and Jhantasana (2005) Karim, Chan and Hassan (2010) Kiani (2005) Lindgren et al (1996) Matousek and Taci (2005) Megginson (2005) Mohan and Subhash (2004) Munir et al (2012) Muller and Warneryd (2001) Qayyum, Khan and Ghani (2006) Reddy (1992) Shabbir and Burki (2014) Shepherd (1989) Shepherd (1989) Shleifer and Vishny (1986) State Bank of Pakistan (2012) Thomsen and Pedersen(1998) Tirole (1992) Vernon (1979) Weill (2003).

Public Ownership

In the meaning of ownership, researchers go through main objectives, own for a high share in market value, contract and managers in terms of power and utilities. Jesnen and Meckling (1979) took ownership as a part of production function, productive resources, technology in survival of fittest. To distinguish in between ownership structure is central in performance in banking industry. This could be due to industrial complexity, asymmetric information and high regulation. As pointed out by Barth et al (2004) and Weill (2003). It is utmost important to walk through governing for a suitable type of ownership such as to Fama and Jensen (1983) deplete agency costs. The role of privatization is also an important factor to consider in this stanza. A common division is foreign, private and public banks. In thin area out of these categories pubic ownership could be decomposed in concentrated and dispersed ownership group on the slandered of withholding shares of course up to date.

Literature high light in terms of the effect of ownership structure, its penetration in performance of the bank doing in mainly grey part of governance. Shareholders domestic and foreign are pretty smooth source stipulate category of ownership in Pakistan mostly remain in deficiencies of studies to date. For example studies done are documented by Buch (1997) Baubakri et al. (2005) Barth et al. (2004) Megginson (2005) Bonin et al (2005) furthermore particularly studies finding direct relationship between own and efficiency.

In ownership structure and bank performance it remains in grey area to answer efficiency and there it still remains. However public banks prove to be a source of efficiency in developing countries mostly providing services to small and medium size enterprises. It also encounters foreign banks in developing country not to take way all parts of financial sector including bliss. This serves as a major source of existence for government own do contract. In terms of allocation of credit Vernon (1979) in developing nations, ownership further be classified as public, foreign, personal family or majority own, dispersed own, subsidy of multinational, co-operatives Thomsen and Perdersen (1998). Here personal or family majority own, refer to rights especially voting rights in holding share to date. Hart (1988) view is worth mention not in favour of majority own right govern, but to managers for it does they might

foreigner, live in other countries operate bank. Managers do have better understanding and availability, access to resources and understanding. This let him draw conclusion its crucial curb information asymmetries between company and outside owners. See table follows own in Pakistan.

Table: 1

List of Public Banks in Pakistan

No.	Name.	Year Established
1.	National Bank of Pakistan[a]	1949
2.	Sindh Bank[b]	2010
3.	First Woman Bank	1989
4.	The Bank of Punjab	1989
5.	The Bank of Khyber	1991

a: Largest state owned bank.

b: Listed Public Sector Bank in the year 2010.

c: Source Munir et al. (2012)

Voting majority exceed for foreigners it names as foreign owned the clause of own found in Weill (2003) having large economies of scale due to intensive research and development. Every government in developing countries extend co-operation for having foreign investment there emerge new cultural financial systems. Of course new technology and new strategies from new culture to show some new to the people have surprise how it do where it get efficiency standards. Incredible uplift turns focus of others to look at foreign banks. A clause of public ownership is commonly referred as national or government own majority company see table 1 for Pakistan.

Evidence In the study of Qayyum et al. (2006) suggest that average spread of interest rate fluctuate not mentioning a source of distortion, however share of big banks decline over time. Giving more towards spread of foreign banks larger then public banks Kiani (2005) an average spread of big foreign banks higher than domestic own banks. However this comprises some part of whole spread representing some part not put on efficiency standards. Mergers of domestic and foreign banks boost efficiency for it not only get return on scale but to show unique standards. In terms of Shepherd (1989) it mostly to overcome market characteristics not in favour of merged ones suppose externalities, monopoly power penetration, leading to wake to give up for some new adopted standards governed by foreigners a source of development. Another characteristic is well recognized in developing countries for Zari Taraqiati Bank (ZTB) that care low income earning. This type of financing government do to get output to up lift Tirole (1992) poor and uneducated farmers take part in county production, a strategy could be one window operation reduce competition, reach out, reduce input price.

Inside and outside shareholders and Standards of managers begin with power, status and security such as act of harm Shleifer and Vishny (1986) for utility maximisation based on self-interests. This clearly shows to take interests of managers in account and their future goals, more facilities and strong incentive oriented environment. According to Alchian and Demsetz (1972) partnership some time cause free ride problem even a share of firm or company consuming additional marketable sources. Therefore it is vital for outsiders Muller and Warneryd (2001) to take part to increase performance and cash flows well-adjusted and ruled out residuals which need to distribute surplus to provide evidence for existence of right disbursement of surplus. In equilibrium outland investors to be able to extract least part of surplus having rights in residual claims. This improves efficiency standards through allocative efficiency. Never the less with full information system and

reduced shared holdings, it is a crucial analysis needs restructuring foreign, private and public own banks. Non the less foreign banking an out source and enabling financial services toward domestic markets having high absorb ability to grow. It is believed that managers having inland shareholders keep up hoops either for targeted achievements and pass through strategies governed by government to find out sectors adding inefficiency be replaced or got in order to pack up for new technologies in favour of standardised output input utilization of resources, a way forward for growth and development in managerial strategies. Public versus private ownership and bank efficiency, this is more toward public ownership, examines the arguments usually extended to build a case for privatisation of the public ownership. In the process a few facts are placed in proper perspective to facilitate aninformed debate on privatisation that in one time or another has been taken place for several banks in Pakistan in past. It birth to related issues in the banking sector. It is not correct, for example, to say, as is being alleged in the current literature on the subject that reforms over a decade now have not made any significant improvement in the performance of the public and they are facing a crisis or near crisis situation. The often repeated criticism of frequent recapitalisation of the nationalised banks Mohan et al. (2004) is based more on perceptions and less on factual analysis. The fiscal burden aspect that would appear has been exaggerated.

The competition and deficiency issues are generalised not withstanding a few distinctive features of the banking sector often, conclusions are derived by comparing non comparable units. Competition, efficiency and ownership play part, competition enhances efficiency is a terminology globally tested and its significance have been proved for its essence. Firms adjust their operations, maintain profitability and raise efficiency this opens a way out to less efficient firms to leave the industry. Intensity of argument lies in hot core for availability of wrong used resources release efficiency World Bank (2002). Although to achieve standards from strategy of World Bank (2002) it remain in grey area how to cope efficiency for a competitive economy that could lose features to again standards. A thin air area need analysed. Do contract reforms impact and performance. Now it standing, the constraints Shabbir and Burki (2014) under which it have to operate. The argument that they cannot
improve their performance and there is no option but to privatise has been weakened by the significant improvement these banks have shown in almost all the erformance indicators during the last six years or so when major reform measures have been initiated or implemented. The recapitalisation and efficiency an overview of reforms in financial sector, its impact towards public may be of use before assessing the change in the performance of the nationalised banks, which are targeted by the proponents of privatisation.

Do contract, Debate on Privatisation

Public banking in Pakistan needs to serve the public interests rather than private bodies. To ensure transparency evolved new governing steps accountability how bank manages invest through. It is keeping in view the mission of the bank if need a revision collection of contracts from community. Methodology could be though a regular inspection review and process of administrative code compliance and friendly in bank policies and quarterly reporting with new offers to owe

contracts. Board of governors ensure investment practices for a sound financial management personal and professional integrity most toward need of community at best taking in full confidence foreign and private banking. The debate on privatisation of public gets through high onset government reforms. For an illustration government liberalize process in Indian economy in 1991. A hard core issue for privatization of public banks. Here it is not merited so much to encounter Committee of Financial System. Narasimham Committee.

In November 1991 perhaps because at that time the urgency and priority was to revive the system. The committee, Therefore, observed that integrity and autonomy of functioning of banks and direct foreign investments is in our view by far the more relevant issue than ownership. A deeper look at cross country comparison and individual banking is needed for there are stipulations suppose in India how many are the branches of State Bank of India? These Issues of competitive efficiency Shabbir and Burki (2014) and profitability are in this sense, ownership neutral. Being a part of the macroeconomic reform programme the financial sector reforms process in its initial stage could not have assigned priority to Baradaran (2014) the issue of ownership.

The privatisation trends in financial sector have to be viewed basically as a part of macroeconomic reform. It ensure appropriate regulatory framework to enhance competition, making ownership a secondary issue Reddy (1992). Almost mid-way through the decade of reforms process Joshi and Little (1996) had evidence that empirical support for privatization in banking is especially strongly recommended as it is evident for having public ownership has virtually triggered the management efficiency of banks due to political and administrative interference in the allocation of credit. It turns out to get efficiency ends not from futile technology but through autonomy within public own. It emerge new system for having privatization rather than go through reform and restructuring in ownership from governance or vice versa in case of Pakistan.

Primarily first effort of having financial system operated in the form of bank was rather to fragile. At present it faces lots of challenges despite a cruel regulation structure and supervision through governance and even then getting into crisis situation. Out from the core in 1980 more than 130 countries do experience problems of course standing release for governance to stipulate International Monetary Fund members to take this fragility Lindgren et al. (1996) Caprio and Klingebiel (1996). Conflict arise when service takers get superiority in borrowing and funding with availability of deposits entangled with asymmetries of information going on with inputs of the banks. It is herd or crowd behaviour or an aerialist activity less lights and smug. It specifies major cores of contagious information asymmetry to run even a healthy thin area activity. Now standing, contagious run can rune whole financial system of course position all turn to crisis which in turn offset macroeconomic stability.

There is serious repercussion, where does volatility stands, a whole, system emains. Where as in financial system Reddy (1992) a wide spread distress emerge as a big joint. Expose with in grey area jolt, is there correlate shocks failure of one bank Brealey (2001) cause failure to another. Further in public sector it fails achieve efficiency standards. In addition to all worries a potential contagion there arise issues for public policy and

governance strategies. Banking system do not fit in pure definition of public good Irfan (2008) mobilisation for financial resources; provision Lindgren (1996) of payment service in a quasi-public good proportions.

To flesh out, literature on private and public ownership in past effect on bank performance result in inconclusive outcomes in Pakistan. Iimi (2002) took post reform period find inference through stochastic frontier approach rank state owned banks on the basis of efficiency. The study conceal for evidence on reforms in Pakistani banking sector in 1980 the total number of banks stood five. See the count stands in year 2015 in table 3.1 in issues of State Bank of Pakistan. It also provide directions and supervision for banks Ataullah et al. (2004) provided by the banking sector. In consequence government's discretionary intervention in the financial sector, development financial institutions and national commercial banks resulted in addition of NPL within strong governance and regulation. Hardy and Patti (2005) it remained little incentive for banks to operate efficiently. In evidence it not produce deteriorate financial system but reduce convergence through lack of self-esteem and wellbeing a whole. For this kind of government it not only needs accountability but governance in banking sector reforms. In this kind of activity it include, important areas on count "domestic debt, financial liberalization, monetary management, institutional strengthening, foreign exchange, State Bank of Pakistan (2000) capital market and banking laws." Internationally in literature Karim (2003) found public banks less efficient than private banks. Similarly World Bank (2002) there are evidences on public sector inefficiencies and as the proportion of public sector increases it further at length increase inefficiencies, result in poor growth, distortions in financial structure. Once reason for this could be political ties govern in governance.

Location on Evidence

A decentralised public bank is like towards more public funds and to community of course not investing elsewhere in the world in its working. A public bank can let down debt burden and city expenses bay making local loans at lower mark-up than offered by foreign or global banking such as public works projects. The profit of public banks could the paid to the location of bank to reduce channels of tax collection in favour of people to levy high burden of tax collection but relief invoking a bank of community. A good generation of profitability by cutting down expenditures in establishment and working cause revenue to the public bank it serve to the families by locating project of community welfare such as children scholarships better transport and decentralized community based works. In Public banking in Pakistan bank could participate in working of globally growing banks through guaranteeing and providing services of financial custodian in their community based loanable, credit and support it is an effort to benefit economy such as job creation business development and support for reachable technologies for housing.

In Czeh Republic public private sector efficiency illustration Several empirical analyses of the public and private sector efficiency refer. In 1990 evidences on banking sector performance gathered in favour of private banks than foreign banks conversely see in this regard study by Bonin et al. (2005) providing evidence for foreign own banks

more efficient then governed by public in Pakistan a supportive evidence Janjua and Malik (2011) either.

Matousek and Taci (2005) found evidences in favour of small banks as more efficient in primary establishments. Weill (2003) found evidence of getting targeted ends on efficiency by following foreign banks in Czech Republic and Poland mostly it emerge in their views from foreign capital. That is a prominent source of finance in banking. Fries and Taci (2005) showed larger share of assets work though reduction of cost raise efficiency. In this regard as private with majority of foreign banks Karim (2005) are most efficient then domestic banks.

Andries and Cocris (2010) emphasised need to look at quality of assets, this make through standard by improving lending and non performing loans. Casu and Molyneux (2003) Shepherd (1989) Fiordelisi et al (2011) found central European countries less efficient then counterpart European Union member states. Czech and Hungarian banking were more efficient than transition countries. On evidence foreign banks more efficiency then other structured. In support of arguments it was further investigated that size of banks matter. In Argentina, in many ways foreign banking has uprooted inefficiency, they work through many channels for an illustration Argentina banking has been reported in World Bank (2001, 2002). On evidence it shed light past experience of having downsizing accompanied by heavy strong hold on foreign banks in collapse of (2001) strategies have been see as contributing factor in share of foreign banks in 1994 and 1999 in turn contributed to economic growth. Majority of foreign owned banks increase, domestic credit provided by the banking sector could be one reason reduced during the similar period. Economic growth was lower during 1990s compared to 1980s. To what extent the benefits in terms of boost to economic growth and reduced financial fragility can be attributed to the increased market share, majority of foreign own banks can hardly measure if this is what the international experience shows. In sum reforms help improve performance.

In India decline in efficiency standards for an argument in public banking emanates from the core of perception such as general public sector enterprises. On evidence public banks are less efficient then foreign or private banks. The issue could be clause in two clauses one corresponds to measure and the other about whom own. Is it government that cause inefficiency? Theoretical aspects of measurement of Indian banking depict progress however, econometric otherwise. In evidence of Das (1997) during the period of 1990-6 overall efficiency exhibit a decline both pure technical efficiency and scale efficiency. In this study financial sector reforms and strategic steps to cope challenges through governance were important factor at disaggregate analysis. The major source of deteriation and inefficiency on evidence emerge from four public sector banks. On evidence provisioning which considerably caused operations as well Das (1997) as profits reflected by surface stocks. An accumulation of non-performing assets prior to 1991-2, moreover, this comes from passing the tests of achieving competitive efficiency a source of establishment, although new standards have been followed in best practices of Claessens and Laeven (2005) foreign banking. Competition compels use resources in efficient way the optimality bring in standards a way out to scale economies. A main indicator of financial efficiency used in international

comparisons is profit after text to total average ratio i.e., going by return to assets.

In accounting, operating performance and bank asset quality, it relates in each other one way or another it affect the standards. Suppose insufficient assets because loanable that in turn add fuel to fire for non-performing loans. One reason for adjusting administrative expenditure in this reason is increase in communication expenditure needed to get collection for non-performing loans. Rise in NPL Berger and DeYoung (1997) Karim et al. (2010) might form adverse economic activities refers to it as bad luck hypothesis in public banking. Furthermore, higher future costs generated due to lack of information about market. It further need to resolve from top management, itself get involved for enhancing non performing loans adding costs deteriorate bank efficiency in India.

Proposition I: Contracts out of degree of grasp in public banking foster growth and development, out of boundaries of domestic private or foreign banking, a new business with local clauses of business only in higher profitability margins tax payments governance which is otherwise for developed nations.

Proposition II: Public servants are staffed by banking professionals depleting high salaried individuals to cope with international banking and security a management
different than city management invoke political front with non-banking staff do takaful.

Proposition III: Sharia establishment in new governance technologies, for geographical segment activities, out sourcing of trust, including national investment trust, long term credit fund, qarz-i-hasna fund do contract structure curb marketing risk ‘garar’ and misrepresentations.

In sum, government demand more from bank once it proves failure. There could be a departure in contract. It is taken in supremacy of contract for access to credit, consumer protection safety and soundness. There are several enhancements to get government in confidence. The most important is government ideology for under taking of banks this requires a change in regulatory board. It needs banks to retain profitability for shareholders this cannot be secured by government regulation only of course it could not be attained only with imposition of regulations. Banks might differ in work out if not corporate establishments. This means least state control for modern policy makers is a shift toward more productivity coping with private trends approaching banking industry. This will cause a change in working and attorney with favourable ends in productivity in terms of large banks getting closer to small banks in operations squeezing and putting for favourable ends. In meeting public needs decentralization is known phenomenon in banking reaching to the need of customers. Contract is like black whole kind of thing everything is getting into it without escaping from it. Several measures are undertaken at governing for such as self regulations.

Strong regulatory nets stipulate performance openness and working bodies cause bank failure, the trends of sale business and curb on non performing loans, credit creation and opportunities of loanable with a safety net on input utilization demonstrate banks movement on trends of productivity. Secure working with customer satisfaction more to microfinancing and keeping in view regulatory is all putting in greater length out of grey area.

Conclusion

Liberalization and globalization is also entering through many channels when foreign technologies are adopted in domestic banking different cultures effuse to bring in some new to the economy as a whole which is part of innovation and invention not only in allocation of resource on oral but on scale and strategically help in expansion. Privatization on the other had work through inland governance of private sector to rule out deficiencies in factor market because it operates on competitive forces. It turns out it encourages the restructuring of unprofitable firms. Now standing, this means policy makers should raise hands in favour of privatization compete globally and improve performance in contract. In hard core area to work on excite is allocative efficiency and cost structure favourable for the bank. This is to point out privatization will change lower quality banking to high quality banking. Squeeze and excitement of achievement is again a policy matter suppose oral contracts of nonperforming loans merger, security, credit availability for having the best outcomes for the upward movement of entire system in a one unit for being all together is pleasure, for this there are many examples. The article strongly present public banking do contract there is implicit contract between state and banks it is out of historic rules need of regulations and code on legislative front. The contracts should be on the basis of security nets, access to credit and supremacy of customers. Revising contract is nothing if not innovated with latest developments and need of customers it should be taken in regulatory measures. In regulation on the development of public benefit making a new regulatory to assess the offers from private entities, it protects customers following developed countries in the years to come. The proposals like promotional activities in regulations and public banking to owe contract.

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MICROBIAL ENHANCED OIL RECOVERY AND FIELD TRIALS

Asim Saeed [1*]; Tariq Ali[1*]; Saeed Nawaz[1*]; Babar Shahzad[1*]; Sher Khalil[1*]

[1]Department of Petroleum and Gas Engineering, Dawood University of Engineering and Technology, Karachi, Pakistan

Asim Saeed
E-mail: asimsaeed180@gmail.com
Tel: +92303-3980567

Abstract
For production of oil from reservoir to the surface it requires a natural pressure mechanism of the reservoir, when it reaches its limit we precede towards artificial lift methods or injecting immiscible fluid that physically contact with oil. When even this method reaches its economic limit the EOR methods are applied to recover the remaining oil by various processes most commonly by chemical flooding.
But due to the technical complexity, operating cost of producing oil and environmental issues raised, the EOR process is no less than another limitation. To overcome this limitation and further continue to recover the oil trapped within the reservoir Microbial enhanced oil recovery (MEOR) is utilized. The MEOR process simply uses various microbes each to fulfill the job of synthetic materials. The microbes provide useful products such as biosolvents, biopolymer, biogas, bioacid, biosurfactants for EOR process. MEOR process proves to be an inexpensive method for recovering oil at an incremental cost as low as 3USD/barrel, it has lower technical difficulties and few surface facility modifications. The MEOR can be very useful in era of petroleum crisis where cause of high operating cost deserts the projects. It is estimated that after the limitation of conventional recovery methods 2 trillion barrels of oil will be left that are uneconomical to be produced with current EOR methods. This paper focuses on providing a brief introduction to the MEOR techniques, the candidates used for MEOR process and the process of applying this technique. This paper also provides information about the field trials for MEOR process and their success rates. The field trials are given for Bigwell field Texas and Southern Saskatchewan Canada.

1. Introduction

When a well is brought upon production of oil and gas, it has 3 methods for lifting the fluids from the wellbore to the surface. The methods employed are Primary recovery, Secondary recovery and Tertiary recovery.
At most the initial well production is due to the pressure contained within the reservoir that drives the fluids to the surface i.e. primary recovery. The primary recovery is ensued by gas cap drives, water drive, and solution gas drive or due to rock and fluid expansions. When the reservoir pressure declines that the fluid cannot be lifted to the surface, a static fluid column is found in the wellbore. The static fluid is lifted by use of secondary recovery mechanisms, which involves the injecting of external fluids or using artificial lifting methods. The fluids injected are immiscible and physically contact with these fluids.
When the secondary recovery method reaches its economical limit the system advances toward the tertiary recovery in which the fluids properties are altered to produce them to the surface. The commonly used methods are CO2 flooding, steam injection, thermal treating, situ combustion, polymer injection and many others.

EOR processes have been in the spotlight due to its technical advancement and there implementation since their introduction. Still with EOR processes and the other recovery mechanisms have helped to recover 1trillon barrel of conventional oil from upto 4 trillion barrels [1]. The world is remaining with 5 trillion barrels of heavy oil that requires incentive technologies regarding EOR or for impending streams [2]. The EOR has proven to be feasible but during oil and gas crisis period they become highly uneconomical, emanating temporary or permanent project desertions. The demerits of EOR methods are its technical complexity, high operating costs and expensive chemicals such as polymers and environmental issues that occur due to the mishandling of these chemicals.
While considering the EOR, an intuitive approach has been introduced know as Microbial Enhanced oil Recovery (MEOR). MEOR simply utilizes micro-organisms that help in to exhibit the requisite job. After primary recovery procedure we have approximately recovered 15-25% of oil and with secondary recovery mechanisms the recovery ranges from 25-40%. That concludes that 40-60% of oil is remaining that could be recovered by the MEOR process.

2. Microbial Enhanced Oil Recovery

The sense of utilizing the micro-organisms for recovery of oil was first proposed by Bckman in 1926. The idea did not receive the required attention till 1946 when Zobell and his coworkers conducted extensive research to confirm Beckman's proposal. Since then various studies have been conducted on application of micro-organisms. After the petroleum crisis in 1973 the MEOR process was being used as an alternative to the secondary and tertiary recovery methods. The reason that MEOR became an alternative was the high operating cost and lower profit from the EOR processes [3].

MEOR process has several advantages as compared to the EOR process, that it does not consume large amount of energy as the thermal process or steam injection process and have few surface facility modifications. They have very low operating cost and technical handling is simpler and easier than EOR process. It can also be applied in times during petroleum crisis. The result from various field trials show the incremental cost of a barrel of oil produced can be as low as 3 USD/barrel [4,5]. These indicate that Microbial process is inexpensive as compared to EOR process.

For conducting the MEOR process the following procedure is deployed:

1. Initial field screening to determine of field is a good candidate for MEOR.
2. Well sampling and laboratory analysis.
3. Growing and harvesting bacteria.
4. Pilot testing of prepared organisms to study field effects.
5. Full field applications.

The bacteria average size ranges from 0.5-5. Micrometer, that is provident for them to penetrate deep into the pores or in very small pore spaces of porous media [6,7]. Their application of being small size is helpful in carbonate rocks that have very small pore spaces on average greater than 30 micrometers with a pore throat opening less than 10 Micrometers [8].

Microbes can be classified into 3 types on basis of their consumption of oxygen:

a. Aerobic organisms:

Aerobic organism can grow and survive in an environment having sufficient supply of oxygen and also known as aerobe.

b. Anaerobic organisms:

Anaerobic organism can grow and survive in an environment without the presence of oxygen and also known as anaerobe.

c. Facultative organisms:

Facultative organisms can grow and survive in absence of oxygen or in presence very small quantity of oxygen.

Most successful applications of MEOR used anaerobic bacteria due to the reservoir environment present.

Microbes are grown by use of nutrients that spans 30% cost of the entire process. The microbes are grown by use of fermentation process using raw materials such as molasses, cheese, whey and others. The microbes basically require 3 components to grow that are carbon, nitrogen and phosphorous. The bacteria types produced are dependent on the nutrients, raw material and components provided for growth.

3. Application of Microbes

The applications of microbes (given proper nutrients feed) in enhanced oil recovery methods are:

a) Biogases:

The microbes produce hydrogen, carbon dioxide and methane gas by fermentation of carbohydrates that can be used to re-pressurize the depleted reservoir and reduce viscosity of heavy oils.

b) Bioacids:

The bacteria can produce lactic acid, acetic acid and butyric acid that are used to increase the porosity and permeability of sandstone and carbonate reservoir by dissolution of these formations.

c) Biosolvents:

The biosolvents commonly used are alcohols, ethanol, acetone and ketone. They are used to reduce the viscosity of oil near wellbore by dissolving long chains of heavy oils. They can also be used as co-surfactants.

d) Biosurfactants:

Biosurfactants are applied to reduce the interfacial tension between oil and water to increase the mobilization of oil through porous media. They can also be used to alter the wettability of the phases and emulsifications. Biosurfactants have come into lime light due to their bio-degradability, low toxicity and being inexpensive as compared to synthetic surfactants.

e) Biopolymers:

The biopolymers are mainly used for selective plugging of pore space to. These bacteria can be helpful in plugging thief zones and other undesirable zones. The biopolymers can also be helpful in increasing the sweep efficiency by partially plugging pore spaces to increase the capillary pressure to sweep through small portions. They also increase the viscosity of displacing water to to improve mobility ratios and sweep efficiencies.

Some examples of type of organisms used for MEOR are given in table 1 given below:

Table 1 Types of Organisms

Product	Micro-organism	Application In Oil Recovery
Biomass	*Bacillus lechniformis, Leuconostoc mesenteroids, Xanthomonas campestris.*	MPPM, selective plugging, viscosity reduction, oil degradation, wettability alteration.
Bio surfactants	*Acinetobacter, calcoaceticus, Arthrobacter paraffineus, Bacillus sp., Clostridium sp., Pseudomonas sp.*	Emulsification, interfacial tension reduction, viscosity reduction.
Biopolymer	*Bacillus polymyxa, Brevibacterium viscogenes, Leuconostoc mesenteroids, Xanthomonas campestris, Enterobacter sp.*	MPPM- Injective profile modification, mobility control, viscosity modification.
Bio-solvents	*Clostridium acetobutylicum, Clostridium pasteurianum, Zymomonas mobilis.*	Emulsification, viscosity reduction.
Bioacids	*Clostridium sp., Enterobacter aerogenes.*	Permeability increase, emulsification.
Biogases	*Clostridium sp., Enterobacter aerogenes, Methanobacterium sp.*	Increased pressure, oil swelling, interfacial tension reduction, viscosity reduction, permeability increase.

4. FIELD TRIALS

MEOR may not be widely applied as EOR is, but there are field trials on which the MEOR was applied to produce better than expected results. Some examples are:

a) TEXAS, USA:

One of the successful applications of MEOR has been confirmed from the Bigwell field located in Dimmet country, Texas.

The MEOR was applied on 41 producing wells with 44 treatments and 41 injection wells with 123 treatments. Due to this application an increase of 88% in oil production was found.

Some data is given in table 2 below:

Table 2 Job Analysis

Well	Pretreatment	Post-treatment
A-8	7 BOPD, 8 BWPD with 53% water cut.	9 BOPD, 4BWPD with 31% water cut.
B-17	11 BOPD, 11 BWPD with 50% water cut.	13 BOPD, 2 BWPD with 13% water cut.

The change in oil production and water production is given in Figure 1.

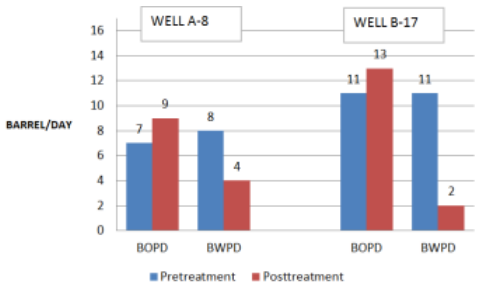

Figure 2

b) South Saskatchewan, Canada:

The wells in south Saskatchewan were treated with MEOR and shutin for 7days prior to production. The results for some wells are given in table 3 below:

Table 3 Job Analysis

Well	Pretreatment	Post-Treatment
Well A	8 BOPD, 131 BWPD with 94% water cut	26 BOPD, 120 BWPD with 80% water cut
Well C	9 BOPD, 316 BWPD with 97% water cut.	29 BOPD, 326 BWPD with 92% water cut.
Well D	3 BOPD , 9 BWPD	NO CHANGE

The change in oil production and water production is given in Figure 2 below:

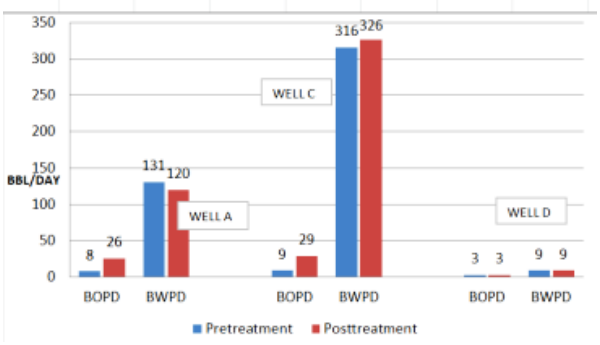

Figure 1

Conclusion

The MEOR process seems to be promising when compared to EOR in case of cost, technical complexity and surface facilities. They have wide range of microbes that can mitigate a variety of problems near wellbore or within the reservoir. But due to some reasons it is not widely implemented as the EOR process due to lack of quantitative measures of microbial performances such as

rate of reaction, stoichiometry and sophisticated handling required for the microbes.

But after all these reasons there are fields that provided prominent results for recovering oil by MEOR process. Since the current petroleum crisis and varying market of petroleum industry makes the EOR process difficult to operate at lower costs, where the MEOR process can outshine the EOR by very low incremental costs as low as 3USD/barrel of oil. But on some wells there was no change on deploying the MEOR process that limits the MEOR to be applied in various reservoir environments. For further application of MEOR process various studies are being conducted to make it a widely implemented process that is less dependent of petroleum market fluctuations.

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PAKISTAN'S SHALE GAS PLAY

Saeed Nawaz[1*]; Tariq Ali [1*]; Asim Saeed [1*]; Babar Shahzad[1*]; Sher Khalil[1*]

[1]Department of Petroleum and Gas Engineering, Dawood University of Engineering and Technology, Karachi, Pakistan

[*] Saeed Nawaz
E-mail: saeednawaz52@gmail.com
Tel: +92331-2259752
Fax: +213-5874359

Abstract

The current industrial growth has become rapid that it provokes the current supply of petroleum via conventional resources. The supply from the conventional sources are insufficient as compare to the demand. To mitigate demand and supply issue for petroleum, some nations have discovered the key solution to this problem is by adding unconventional resources into account. One of the provident unconventional resources is the Shale Oil and Gas reservoir that has become one of the major trends in the petroleum industry. USA is one of the largest Shale producers, whose shale oil 52% and gas 48% constitutes its total production hence leading to sustained supply and demand gap.

Pakistan is one of the nation's dealing with petroleum supply and demand gap. The current supply of gas in Pakistan is about 4BCFD followed with a demand of 6.2BCFD with a gap of 2.2 BCFD. It is estimated that the gap will reach 6.79 BCFD by 2030 under current available resources. Since Pakistan should consider its unconventional sources mainly Shale reservoirs. Pakistan compounds two shale formations i.e. Sembar and Ranikot formation in the Lower Indus basin.

This paper discusses the major shale reservoir characteristics to define a baseline for a shale reservoir to prove if it could be a potential shale producer. The characteristics of Sembar formation are defined and compared to the baseline inform of polar charts for a better understanding to determine if it could be an economical source when subjected for exploration. Sembar is compared to Barnet shale of Texas USA with an average production of 10-12 BCFD. When Sembar formation compared to the Barnett shale, they exhibit similarity and may provide similar productions as found in Barnett shale.

Introduction

The known ordinary wellsprings of oil and gas are exhausting speedier and the request of oil ascends with each passing day. To satisfy this request the oil business has moved towards whimsical sources that were once considered as uneconomical. However, with cutting edge innovation these whimsical sources have turned out to be plausible for generation.

As indicated by a definition created by US National Petroleum Council (NPC), Unconventional repositories are those that can be delivered neither at practical stream rates nor in prudent volumes unless the well is fortified by following innovations:

- Hydraulic Fracturing.
- Horizontal wells.
- Multilateral wells.

Unconventional reservoirs are determined as very-very low permeability reservoirs that have a permeability value less than 0.1MD. Shale Oil and Gas reservoirs are classified as unconventional resources.

The shale gas is a petroleum gas dominatingly found in shale rock. The name is gotten from its source shale, Shale is fundamentally a fine grain sedimentary rock made out of different minerals, for example, the parts of quartz, calcite, carbonates and different minerals. The shale rock likewise goes about as source rock to supply for hydrocarbons. Shale rocks are forced to high compaction because of which it is described of lower porousness for liquid streams yet have a higher porosity.

USA has connected the previously mentioned advances to create extensive amounts of shale oil and gas from these stores. The U.S. Energy Information Administration (EIA) appraises around 12.3 TCF of dry gas from shale stores, that involves around 48% of aggregate US gas generation and is relied upon to achieve 69% by 2040. While 4.9 million barrels for each day shale oil including around 52% of aggregate oil generation.

Pakistan is one of the countries with a developing economy bringing about higher request of oil and gas. According to overview (2014-2015) the supply of gas is 4BCFD and request is 8BCFD with a hole of 4BCFD and it is required to increment to 6.79 BCFD in the up and coming years. As per survey the gas statistics are show in figure 1 given below:

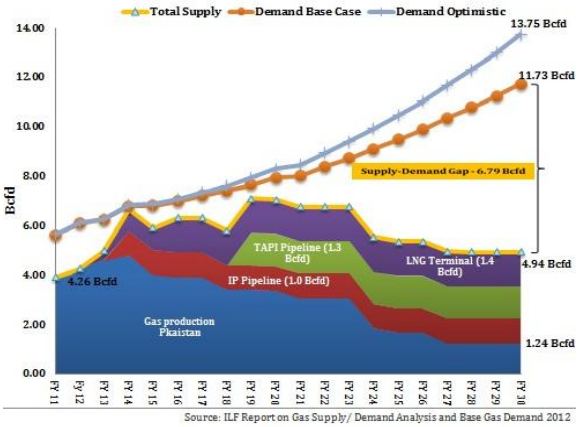

Figure 1 Gas Producion and Consumption

Characteristics of Shale Gas

There are different attributes of shale gas, yet the significant qualities for a shale gas to demonstrate on the off chance that it is a potential maker and worth of exploring are:

a) Total Organic carbon (TOC):

The aggregate natural carbon decides the amount of natural issue in shake that is communicated in weight %. The estimation of TOC is corresponding to the amount of oil and gas generated.

The scale for TOC is:

Table 1 TOC Ranges

RANGE (weight %)	DESCRIPTION
0.0-2.0	Poor risk for oil and Gas
2.0 <	Good risk for oil and Gas

b) Thermal Maturity (Ro):

Thermal maturity can be characterized as the temperature required changing over the kerogen into fluid or gas hydrocarbons with due time. Thermal maturity can be communicated in % and illuminates of temperature. The typical ranges for thermal maturity are as following:

Table 2 Thermal Maturity ranges

Range (%)	Hydrocarbon	Description
0.6	Onset Oil	Poor risk for gas
0.9	Peak Oil	Poor risk for gas
1.0	Wet Gas	Good risk for gas
1.4-2.1	Dry Gas	Good risk for gas

For Ro value greater than 2.1% it may danger the reservoir and CO2 productions are possible.

c) Transformation Ratio (TR)

The transformation ratio decides the transformation of kerogen under the warm development into oil or gas or mixed oil and gas storages. Transformation Ratio is expressed in % and the typical ranges are:

Table 3 Transformation Ratio ranges

Ranges (%)	Hydrocarbon	Description
0-50	Primary oil	Poor risk for gas
50-80	Mixed oil and gas	Poor risk for gas
80-90	Primarily gas	Good risk for gas
90-100	Primarily Dry gas	Good risk for gas

d) Gas Dryness:

This factor decides the nearness of dry gas in the formation. It is determined in % and the typical ranges are as following:

Table 4 Gas Dryness Ranges

Ranges (%)	Hydrocarbon	Description
0-50	Primary oil	Poor risk for gas
50-80	Mixed oil and gas	Poor risk for gas
80-90	Primarily wet gas	Good risk for gas
90-100	Primarily Dry gas	Good risk for gas

From the mentioned information regarding shale gas, the base esteems for a shale gas to be demonstrated as a potential maker by and large scale are as following in type of polar charts.

Table 5 Requisite Characteristics

TOC(wt%)	Ro (%)	GAS (%)	Tmax (ºC)	TR (%)
0.5	1	80	455	80

The base necessities for a formation to be a shale oil and gas maker are appeared in ***CHART1.***

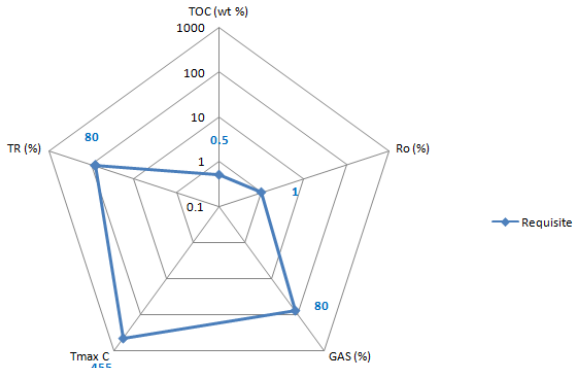

CHART 1 Requisite Characteristics

Shale Gas Reservoirs in Pakistan:

The shale gas repository in Pakistan is disseminated in the Baluchistan, Lower Indus and upper Indus in form of thick successions. The two noteworthy arrangements that have been distinguished as potential makers for shale gas are:

- Sembar formation
- Ranikot formation

As per report from the EIA appraisal Pakistan involves 586 TCF gas, from which 105TCF is actually recoverable. This information affirms Pakistan has the ninth biggest shale gas source on the planet.
Contrast the attributes of Sembar formation with the base essential properties that demonstrate if arrangement is financial. That is controlled by utilizing polar charts that thinks about the essential information to the Sembar arrangement information (the information gave is based on average esteems).

Table 6 Sembar Characterisitcs

Characteristics	TOC(wt%)	Ro (%)	GAS (%)	Tmax ^{O}C	TR (%)
Requisite	0.5	1	80	455	80
Sembar	1	1.3	90	470	90

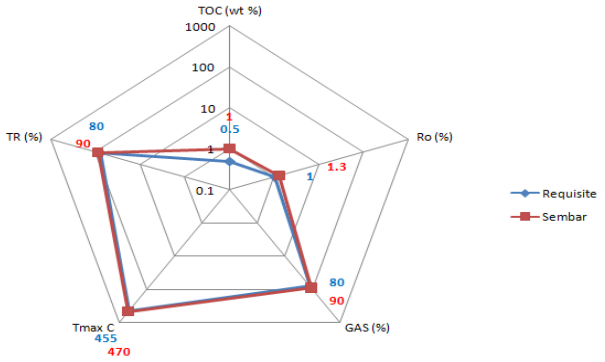

CHART 2 Sembar Characteristics

From the polar chart2 we can expect that the Sembar development can be a potential shale gas maker as it meets the base prerequisites.

Comparison of Sembar And Barnet Shale:

The Barnett shale is situated in Bend Arch-Fort Worth Basin, Texas, USA. The Barnett shale was found in the 1980's and begun on production from 1999. The reserves in the formation are around 44 TCF with depths of 6500-9500 ft. The Barnett shale is one of the pioneers in the creation of shale gas in the historical backdrop of USA with a normal generation of 12 BCFD.
The real reason for this paper is to contrast the Sembar development with the Barnett arrangement and decide whether it is a potential maker that could contribute in the gas generation of Pakistan. The trademark information got from the Sembar arrangement when contrasted with the Barnett shale are as following:

Table 7 Comparison of Sembar and Barnett Shale

CHARACTERISTICS	SEMBAR	BARNETT
Total Organic Carbon (wt %)	Ranges from 0.56-4.33	Ranges from 2-6
Thermal Maturity (Ro %)	1.3%	Ranges from 1.2-1.9%
Thermal Maturity (Tmax ^{0}C)	470 ºC	465 ºC
Total Porosity (%)	Ranges from 5-8%	Ranges from 3-6%
Transformation Ratio (TR %)	90%	93%

The information to be utilized as a part of polar charts for examination depend by and large esteems as following:

Table 8 Characteristics to beCompared

Characteristic	TOC (wt %)	Ro (%)	GAS (%)	Tmax C	TR (%)
Requisite	0.5	1	80	455	80
Sembar	1	1.3	90	470	90
Barnett	2	1.6	90	465	93

From Polar Chart3 we can accept Smebar development to be like Barnett shale.

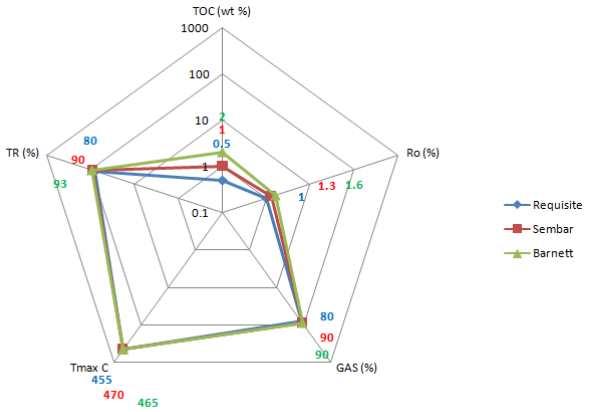

CHART 3

Conclusion

Since America has connected the innovation to create from unconventional sources, the whole world has been driven on a similar track to evacuate the absence of vitality required to run the modern world, and Pakistan is one of the countries with a developing economy that is struggling for supply-demand of energy. The officially created Barnett shale is as yet contributing in the day by day generation by 12BCFD by and large. Pakistan has additionally found two noteworthy shales that are Ranikot and Sembar development.

The average daily gas generation and utilization is 4BCFD and 8BCFD individually, as anticipated this hole will increment in the coming future and Pakistan is left with 23 TCF of petroleum gas holds that are relied upon to be completely drained by 2025. To overcome this distinction Pakistan needs to move towards the unpredictable asset and deliver from the mentioned arrangements. In the event that the shale gas stores of Pakistan are subjected to generation, they might be sufficient for the following 44 years.

The Sembar formation has ended up being a potential maker as it meets the base necessities for potential maker in CHART 1.When contrasted with Barnett arrangement (Chart 2 and chart 3), the Sembar formation imparts the majority of likenesses to the Barnett formation that is thought to be one of the pioneers in the USA gas generation.

In the event that Sembar arrangement is explored for shale gas and oil then it might turn out to be a potential maker and help to decrease supply-request hole and help in the monetary development of Pakistan.

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Electricity Theft- a well known problem of Hyderabad

Ammara Kaynat[a,*]

[a]Graduate Student of Architecture Department MUET, Jamshoro,

[*] Corresponding Author
E-mail: ammarakaynat92@hotmal.com
Tel: +923313690063

1. Abstract

Being under developing country, Pakistan with several other issues faces Electricity theft at a miserable state, it is a great threat for the economy of Pakistan and it produce several other mafia and unfair means in a society. The public through various sources are engage in electricity theft regularly. In the era of globalization, one of the rising issues of developing and under developed country is handling such huge unfair means. Pakistan is a facing a great burden on country's economy in the shape of electricity theft. The core aim of this paper is to overview current situation of electricity theft practices in Hyderabad and to highlight its negative impact on economy. This research include line loses of electricity which government have to pay itself due to theft for Hyderabad city which results in detection in several areas & inflation in rates of electricity units. The research proposes a balanced & practical approach that achieves sustainable reduction practice in Power thieving. Hyderabad is 2nd largest city of Sindh and 6th in Pakistan. Unfortunately it does not pose proper metering & billing system. The research aims to uncover the reasons of electricity theft in Hyderabad city especially residential areas. For data collection, various areas in the city have been visited. Interviews were conducted from public and from HESCO department officers. A questionnaire survey has been conducted to list out top most significant causes of electricity theft in city. With the help of these surveys the critical causes have been identified and discussed with the field expert for their possible solutions for Hyderabad. This will help in achieving control over thieving methods and will help in reducing the factors affecting the illegal customers.

Keywords: Electricity theft; Hyderabad City; Metering & Billing; HESCO.

2. Introduction

Electricity thieving can described as, using electricity without a valid obligation & contract from utility in order to alter its measurement [1

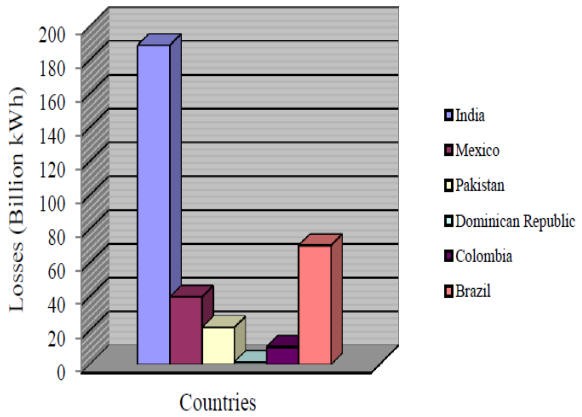


FIG # 1 [2]

3. Problem Statement:

Electricity theft is at the hot favorite issue throughout the globe, but in Pakistan it has a miserable effect on economy, which are passed routinely on the customers in the shape of high electricity bills & energy charges , in a country where the fix wages of labor is only 15000/- re per month, how one can pay high electricity bills. Electricity theft takes place in a variety of forms and continues with the support of people from utility staff, labor union leader, consumers, bureaucrats, political leaders and high level utility officials. Electricity theft is the problem challenging power utilities, in other words it can be describe as using electricity from company without consent of company. Significantly, it can be considered as enough to destroy the entire power sector of country.

4. Research Aim& Objective:

Aim of study is to provide solution for Electricity theft especially for residential areas. This aim include following objective:

- To highlight the issues of Electricity theft. i.e.: social & economical.
- To work out the possible solutions to reduce the issues.

5. Research Methodology:

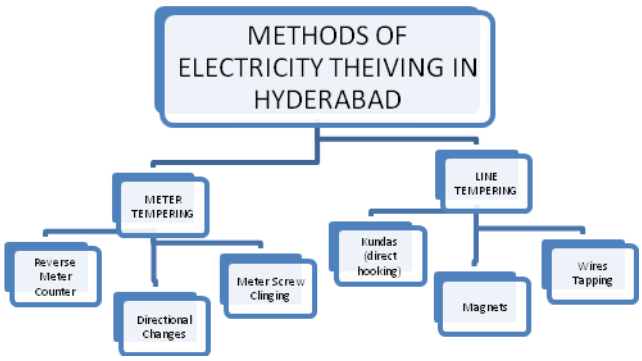
The study for this paper includes a survey for residential area of Hyderabad city in order to get knowledge about the types of electricity theft. The cross sectional study involved multi-stages of random time survey of areas in order to know about the theft measures taken by dwellers. This study focuses residential area of Hyderabad.

6. Case Studies:

Author conducted case studies in Latifabad unit # 7,8,9,11, & 12. The core of all these case studies were getting knowledge about methods of electricity thieving & factors influencing the public for thieving. Majority of public's response remains same, the data collected during the case studies is discusses below, the data is divided into 2 main categories i.e. Methods & techniques of electricity theft in Hyderabad & Factors influencing the illegal customers. An unstructured interview with the officials of Electricity was conducted which results in getting knowledge about methods to control power theft, and the steps taken by Government to overcome the situation. which is also discussed below.

7. Methods& Techniques of Electricity Theft In Hyderabad:

This paper enlist the thieving techniques used by public in Hyderabad. these methods are discussed as below:



➢ **METRE TEMPERING:**

- **REVERSE COUNTERING:**
  Impostors after opening the meter they invert the meter counter as per desire. From that point onward, they wrap meter again and no one can comprehend about the acts of neglect in meter until the point when it is send to research facility for test.

- **DIRECTIONAL CHANGES:**
  In this training buyer alter the course of meter. In this , pivoting plate totally stop its circle move until the point that meter is moved to its straight position. At the point when the heading of meter changes the turningcircle will be stop consequently Usually meters are introduced inside the home in straight position on divider or other appropriate place.

- **METER SCREW CLINGING:**
  At residential level it is basic practice , done by sticking the meter upper and lower screws, It hold the pivoting plate free developments at ordinary level and when there will be another dispute on turning circle on account of screws the turning circle backs off naturally.

➢ **LINE TEMPERING:**

- **HOOKING:**
  It is the most widely recognized utilized strategy, 80% of worldwide power robbery is by this technique. The customer takes advantage of an electrical cable from a point in front of the vitality meter. In this technique vitality utilization is unmeasured and obtained with or without switches.

- **MAGNETS:**
  Buyers utilize the magnet material for moderate the pivoted plate of electro-mechanical meter. It is additionally a typical strategy for power burglary. In this normal system the purchasers open the electro-mechanical meter and just put the attractive material on the upper surface of pivoting circle. It discourages the free development of plate and a slower spinning.

- **WIRES TAPPING:**
  This is simple technique for customers to submit the negligence on board as it gives simple approach to expelling and reconnect the unbiased wire. In this method the power is disseminated through electro-mechanical meter board yet there is no any free development of turning meter plate since it needs the availability of both (load and nonpartisan) wires.

8. Factors Influencing The Illegal Customers

Factors influencing the customer to involved in electricity, author get these factors while surveying, public questionnaire provide several factors influencing electricity thieving which are as follows:

TABLE # 1: Factors influencing the electricity theft

SERIAL #	FACTORS INFLEUNCING ILLEGALCUSTOMERS
1	Illiteracy
2	Un employment
3	High Energy rates
4	Corruption
5	Poor Law enforcement
6	Weak management

- **ILLITERACY:**

  Illiteracy is the root cause of any malpractice in country, in case of electricity theft, the people acknowledge it as their right to stole some units from main line, it is the height of illiteracy that the public never feel responsible for the inflation of unit rates if electricity and never feel it as a crime or sin .

- **UN EMPLOYMENT:**

  Pakistan's youngsters face another issue of unemployment as after completing 16-18 years of education they still face failure for getting proper job and hence suffer several other issues. most of the middle class families depend upon their young child and hence on not getting job at an efficient time, they starts several mal practices which include electricity theft too.

- **HIGH ENERGY RATES:**

  Energy rates are increasing with the passage of time, that's why it is hard for a family to bear the expenses of utility bills and where ever they can get benefit, either from illegal means, they avail the benefit. government should consider the energy rates and should have a second eye on those increasing energy rates.

- **CORRUPTION:**

  Corruption does not means thieving on a high level, it is also consider when public is busy in low level of thieving and other malpractices, electricity theft is also a corruption and those who are engaged in it must be punished.

- **POOR LAW ENFORCEMENT:**

  Poor enforcement of punishment for electricity thieving on each level increases the graph of illegal usage of electricity, presence of law and order is not enough to get rid of this crime, as the implementation is necessary which is not present.

- **WEAK MANAGEMENT:**

  Management teams who survey the areas to note down regarding thieving practice are weak in sense of management, there are several officials who inform their friends, relatives about the survey team and made them conscious regarding the teams.

9. OVERCOMING THE PROBLEM:

The author proposed several measures to overcome the electricity theft problem which are discussed as follows:

- **PUBLIC AWARENESS:**

  Public awareness is the key for success or failure of any of the problem , in electricity theft it is the major measures to overcome it as the public is aware of this crime but they are not ready to leave it, in this regard advertisement, campaign, social media & banners with the punishment, law & order about electricity theft can make a difference.

- **RISING THE WAGES:**

  The low wages of 15000 re. for labor increase the thieving as a middle class man is not able to pay all the utility bills legally, on survey, most of the people give the same reason of low monthly wages for electricity theft, in this regard increasing the labor wages can heal their major problems of utility bills and other necessities.

- **EMPLOYMENT OPPORTUNITIES:**

  As unemployment in young generation leads towards the criminal activities, the need of hour is to provide employment opportunities to youngsters with healthy pay in which they could be able to bear the expenses of their family.

- **LOWERING THE UNIT RATES OF ELECTRICITY:**

  Government should take serious notice on rising of electricity rates, as Pakistan is an under developing country where a middle class family is unable to pay

their utilities, so the government should lower down the price of electricity units in order to reduce the rate of electricity theft.

- **STRONG IMPLEMENTATION OF LAW & ORDER:**

Strong enforcement of punishment for electricity thieving on each level can reduce the graph of illegal usage of electricity, presence of law and order & implementation of law and order, both are different on practical approaches, there is law and order, punishment, deduction on electricity theft but the implementation is absent. Not only on public level, the law enforcement is also needed at official level of WAPDA.

- **DOOR TO DOOR AWARENESS:**

Likewise Polio awareness programs is being done at door to door, the electricity issues must be discussed with public specially middle and lower class residential, and should encourage them to use legal electricity and paying of legal bills on time, for this purpose officials who are good in communicating with public must take initiative in order to encourage the users to use electricity legally.

- **AWARENESS CAMPAING AT EDUCATIONAL LEVEL:**

Students are Pakistan's future, today's initiative and encouragement towards legal usage of electricity at educational level i.e. school, college & university can make a difference in future, young students must be encouraged for saving the electricity & using it legally too.

- **REAWRDS FOR LEGAL CUSTOMERS:**

Government should award those customers using electricity legally in shape of electricity units per month, this will encourage the users to save and use electricity legally at its maximum level and it will be promoted by one house to another.

- **INTODUCING OTHER MEANS OF ELECTRICITY GENERATION:**

There are several students who proposes the means of electricity generation other than water, Pakistan should take a serious note on those proposals and should work out practically and those with successful results should be implemented on national level permanently.

- **INTODUCING SOLAR PANELS :**

In the era of globalization, one is not able to bear the expenses of utility bills, the government should allow a particular KWH amount of solar panels to be installed at residential, commercial & industrial area, according to the demand of that building. this will not only help in minimizing the theft but also will reduce the amount of energy loss that Pakistan faces every year.

10. LITERATURE REVIEW:

A few strategies as of late were proposed for discovery of area of altered vitality meter or tapping on a feeder for distinguishing unlawful clients. To control power burglary some there non specialized measures were likewise executed which incorporate battle against illicit consumption& assessment of clients with suspicious load profiles. For conquering defilement in utilities a functional system is should be present, considering the business forms, specialized administration, legislative issues and advancements in conveyance in mechanization, observing and control which hand-off on area . Farming association's normality is should have been done also with non-specialized measures. Proposition in regards to voting public is to be made through successful enactment of correspondence furthermore with critical systematization of new procedures &stakeholders, extemporized administration data frameworks by embracing current innovation [7]. Periodical assessment of unlawful associations require a great deal of work and careful authorities for recolor The recognizing hardware [8] is effective and helps in identifying power burglary in appropriation links laid underground. Mano R. et al. recommends execution of guidelines for examination of the unlawful purchasers. RAAP is use to distinguish incomes which are engaged with robbery it is focused at change of incomes by diminishing misfortunes at business level around 20% every year [9]. The Electricity Act of 2003 India, has announced power burglary a culpable offense and gave full flexibility to authorities to assess and identify illicit purchasers. Karachi Electric Supply Company , Pakistan got a fatwa on power burglary, from Islamic researchers, they pronounce power robbery as a wrongdoing [10]. The reward for investigating relies upon the quantity of cases examined as there is a group's orchestrated the procedure of review. Such impetuses are corresponding to the aggregate number of unlawful utilization cases they recognize [11].Several specialized measures were additionally executed for helping utilities in their fight against NTL. GE has licensed a vitality meter that take readings of power utilization effectively, regardless

of whether the in& out-going meter terminals are switched. This prevented unlawful buyers from turning around the bearing of meter to decrease their bill. Introducing a prepaid vitality meter can be an answer for control illicit power use &monitoring of dissemination framework [12]. Finding power burglary on a dissemination feeder can be identified in view of the estimations of the stagepoint and impedance of the transmission lines at two distinctive working frequencies individually [13].Bandim C.J. et al. proposed using focal eyewitness meter for optional terminals of circulation transformer. The vitality utilization esteem which is perused by the focal onlooker meter is contrasted and the entirety of vitality utilization esteems read by all vitality meters in go. At that point these two estimations of the current are analyzed for assessing the aggregate power that is being devoured illicitly [14]. VEMS are proposed to utilized , the sort of framework that could battle power robbery. It can gather, process &transfer information between different meters, It additionally controls robbery by recognizing the conceivable areas. A remote charging framework can likewise be created by adjusting the proposed display [15]. A remote check meter can distinguish the illicit power utilization relies on the measure of misfortunes and time stamp of the check meter. It can be actualized before assessment of illicit buyers by and by the authorities, in view of the customer estimations [16].Jamil M. et al., proposed smaller scale controller based vitality meter being able to screen and control the power supply of customers, that aides in identifying the meter altering [17].In expansion, a creator recommended to utilize e-metering frameworks, it can gather the information and can influence it under process, and in addition distinguish load to profile's anomalies &indicating power burglary [18]. A creator proposed utilization of Genetic Algorithm-Support Vector Machines (GA-SVM) for discovery of unlawful power. Each house's heap expending information was gathered and procedures for information mining are utilized to channel and afterward bunch these clients previously distinguishing illicit utilization. Clients are assembled by the degree of load variation from the norm in stack profile with high likelihood of burglary are investigated personally[19-20]. A machine ELM is proposed to assess the anomalous load that demonstrate power robbery, Nizar A.H. also, Dong Z.Y. utilized online successive ELM (OS-ELM) calculations for gathering &detecting the profiles of load to diminish NTL [21-23]

11. CONCLUSION:

Power robbery in numerous nations is a typical issue and overall electric utilities need to forego important measures of incomes consistently because of power burglary. It brings about tremendous budgetary misfortunes of utilities and damages future speculation. It is the need of hour to rather focusing on the law implementation &technical measures; However, power stealing proportion is expanding with the progression of time and it is more than earlier years in view of absence of discipline or the individuals who are associated with altering the meter or have utilized the unlawful power association ,law and request, absence of administration, poor foundation, poor preparing of staff, poor checking framework and debasement are the fundamental driver of power robbery .Electricity burglary is offense and the individuals who are occupied with illicit association ought to be rebuffed. The advance and improvement of economy are reliant on accessibility of power as now daily's the vast majority of our modern part relies on mechanical methods for process.

12. ACKNOWLEDGEMENT:

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Photovoltaic Based PWM Inverter Using Experimental Approaches

Abid Ali Dogar,[a,c] Zunaira Huma Malik,[b] Irfan Ullah[c*]

[a] Department of Electrical Engineering, School of Engineering, Minhaj University Lahore, Lahore, Pakistan
[b] National Transmission and Dispatch Company, WAPDA, Lahore, Pakistan
[c] Electrical Engineering Department, School of Engineering, University of Management and Technology, Lahore, Pakistan

[*] Corresponding author. Tel.: +92 300 9572152
E-mail: irfanullah@umt.edu.pk

Abstract

Due to limited available conventional resources for power generation, the world is inclined towards finding new renewable energy generation. The utilization of solar energy has rapidly increased due to its benefits such as, sustainable energy source and helps to reduce CO2 emission. While the photovoltaic (PV) system provides direct current (DC) whereas the installed system and appliances are based on AC, Thus, an inverter is required to convert DC to AC. To this end, we present a method to calculate optimum operating parameters for photovoltaic-based pulse width modulation (PWM) inverter by applying different switching techniques using micro-controller. Variations on the input voltage level and switching frequency are utilized to see their impact on the operation of inverter and harmonics produced. Three different switching techniques (Square wave, 3-level modified sine wave and PWM) are applied on ordinary inverter using Micro-Controller. Spectrum Analyzer is used to see the output impact, wave forms and total number of harmonics and maximum efficiency. Finally, the harmonics produced by the inverter are analyzed and minimized with the variation in the voltage and switching frequency parameters. Using PWM technique, 3rd, 5th and all odd harmonics are eliminated, as a result, the maximum amount of power loss will be overcome. Experimental results show that careful selection of inverter parameters yields inverter's operation with highest efficiency and lowest harmonics distortion.

Keywords: *photovoltaic; inverter; harmonics distortions*

1. Introduction

Electricity plays a vital role for urbanization, industrial and financial growth of any country. [1] Today's world is still mostly dependent on conventional energy source for power generation as well as transportation industry. Due to limited available resources, the world is inclined towards finding new, renewable environmental friendly energy sources. [1]Both conventional and non-conventional energy resource are being used for generation of electricity Solar and wind energy are among those energy resources, which can be replenished over time. The utilization of these renewable resources has rapidly increased due to their environment friendly and modular nature. [2].

Over the last decade, solar PV(photovoltaic) energy has grown at an average rate of 60% annually, thus surpassing 1/3rd of cumulative installed capacity of wind energy. [3]. Solar energy has become an important part of power systems in some regions because of its cheap and environment friendly nature. PV/solar cells that are used in the system are semiconductor devices and convert irradiance of sun-light into nearly DC electricity. Groups of these cells are used as arrays to generate electricity to charge batteries or operate motors or to operate other electricity loads. PV system can be configured as off-grid/stand-alone (without the electricity network system) or as on-grid interconnected to the electricity network [4].

This generated DC electricity from the PV panels cannot be directly fed to the utility grid nor can electrical appliance can operate directly on it. Thus, some intermediate device must be implemented that will change the DC supply to AC supply Inverter convert the DC form of electrical energy into AC.

Relationship of Inverters and PV arrays have been studied previously. Maximum Power point voltage of a PV module may lie anywhere between 23V to 38 V [5]. The PV module may be arranged in series or parallel arrangement to the load demand. Different array arrangement has been analyzed in [6] to determine the maximum possible output power. Studies have been performed with different inverter topologies are used such as center inverter, string [7],

multistring and team configuration with series and parallel arrangement of PV cells. [8]. However, focus of these studies is on the configuration of arrays and on the voltage, that yields the maximum possible output power of the array. To achieve the maximum efficiency in the inversion process, the desired input voltage to the inverter needs to be addressed

Open circuit voltage and short circuit current of a PV cell change with the change in irradiance and temperature, hence the maximum power point. Although much work has been performed for maximum power point tracking for solar cell, but in this paper, we will focus on the optimum operating parameters of a PWM inverter using experimental approach. The output terminals of the solar panels are directly connected to the DC input bus of the inverter.

In addition, in third world countries like Pakistan energy crises has taken root. Battery operated UPS are installed in most of the places to compensate for some loads during the load shedding hours. These UPS are equipped with inverter for smooth operation of electrical and electronic appliances. Lighting loads can be operated with UPS but with other electronic equipment there is a risk of damage to them. The quality of inverter output waveform is usually determined by the harmonic content in it. An ideal inverter should only have a fundamental harmonic component at the designed frequency.

This paper focuses on investigating the effect of different input and output parameters (specifically the efficiency and harmonic content) on a unipolar PWM inverter topology. The controlling parameter include DC input voltage, switching frequency and output load. Input voltage and switching frequency of the inverter can be adjusted to produce the desired/same output voltage at the fundamental frequency. Optimum input voltage and the switching frequency of the inverter will be determined. Three different switching techniques have been applied and the results for their effect on the output voltage, total harmonic distortion and harmonic elimination are compared.
Section II deals with a brief introduction of the used inverter topology and the design of the proposed circuit. Section III explains the operation of the proposed design and analyses the efficiency and total harmonic distortion. Section IV presents results and discussion.

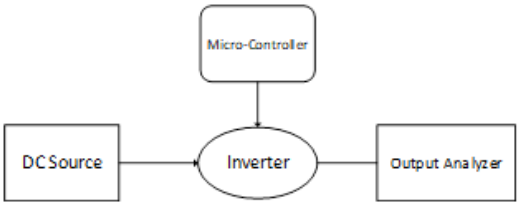

Fig. 1. General Block Diagram of DC Source Inveter using Microcontroller.

Figure 1 is the general block diagram of inverter design using micro-controller with a DC source of 12V, output of inverter is analyzing to find out the output voltage level, output power, harmonics and efficiency by applying all three switching techniques. After see the variation in input voltage level and switching we see impact on output analyzer block.
This is Simulated form of Microcontroller Based PWM inverter. In this Design by using single microcontroller, three different switching techniques be performed. When we press switch one Square wave switching technique code running and we see the output waveform and then also see the harmonics present in it.

2. Inverter

Inverter converts dc power into ac power with desired frequency and output voltage. Inverter can be categorized as single-phase and three phase inverters [9], unipolar and bipolar inverter based on the switching signals [10]. Moreover, they can be further classified as Voltage fed inverter [VSI.] (constant input/source voltage), current fed converter [CSI] (Constant input/source current) variable DC [direct current] linked inverter (controllable input voltage).

Different switching techniques have been applied:

1. Single pulse width modulation
2. Multiple Pulse width modulation
3. Sinusoidal pulse width modulation (SPWM)

Figure –2 shows single phase bridge inverter which uses of PV based DC backup source and MOSFET switches [4]. Even though MOSFET switches have high ON state resistance and conduction losses [5], in this paper MOSFET's are used because of the following reasons. MOSFET being a voltage-controlled device, it can be driven directly from CMOS or TTL logic. The gate drive current required is very low.

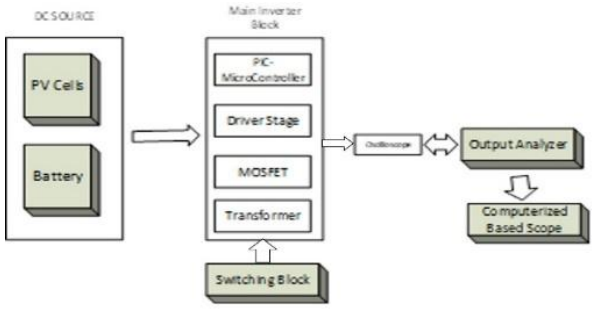

Fig. 2. Block diagram of PV Based PWM inverter.

Circuit in Figure 3 is the simulation-based model design which is to be tested and verify the all major and minor aspects of inverter before implantation. After successfully designing and testing in Figure 4 shows the hardware implementation of Micro-controller based PWM Interver using PV system as a main DC Source.

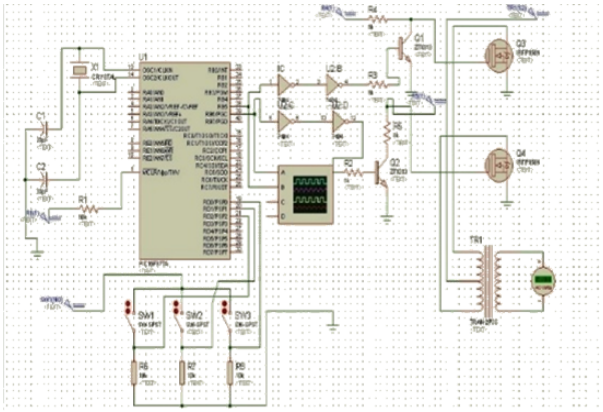

Fig. 3. Simulated design of DC source PWM inverter.

Fig. 4. hardware implementation of Micro-Controller Based PWM inverter

3. Wave Form

3.1. Square Wave Switching Technique

Using conventional system, we generate all three types of techniques, but the main issues are their accurate shape. We also see their actual output while generated using different combination of conventional semi-conductor devices. Figure 5 given below shows Square wave by using 555 timers with the combination of a 7473 IC.

Fig. 5. square wave signal

Harmonies is one of the most important factor in efficiency of any inverter. In Square wave the number of harmonics is relatively high in number which reduce the operational efficiency of all the attached appliances. After generating the AC signal of 220v by using square wave switching technique. The figure 6 shows harmonics present in output voltages generated using square wave switching technique.

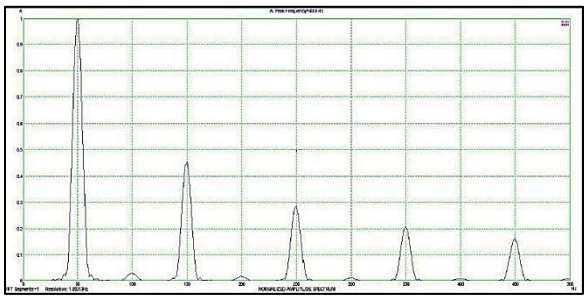

Fig. 6. Output harmonics using Square wave switching technique

We See that using square wave there will be 1st, 3rd and all other Odd harmonics will appear. Which will overcome the overall efficiency of and destroy the actual shape of pure sine wave. We may also find out these harmonics mathematically. We see that the output efficiency is decrease and around 26% which is not suitable for semi-conductors-based appliances. Also, this low efficiency loses the power in form of heat which further creates chance for short circuits and fire.

3.2. 3-Level Modified Sine Wave

Using 3-level Modified sine wave as a fundamental switching frequency. By carefully calculated their duty cycle and to generates from Micro-controller. We see that there will be less numbers of harmonics will produce on output side. If we see the output wave form as shown in figure 7. On x-axis we have frequency and its multiples and on y-axis we have peak voltages.

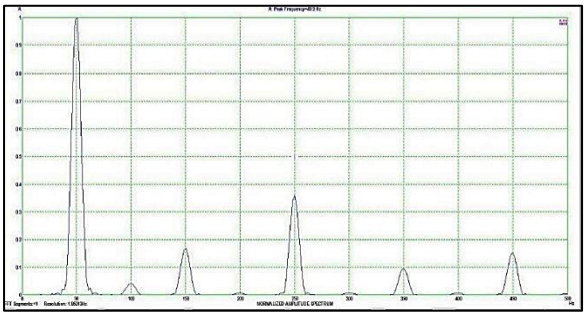

Fig. 7. Output harmonics using 3-level modified wave switching technique

The 3rd, 5th and other harmonics will be eliminated and which yield to increase the overall output efficiency. By using 3-level modified sine wave as switching frequency the output efficiency increases up to 87% along with that the overall power consumption and losses will also be overcome.

3.3. Pulse Width Modulation

Using Pulse Width Modulation technique as the fundamental switching frequency will goes high and low so rapidly and the time interval by which the pulse goes high and low be carefully calculated. When we generate

the PWM by using Micro-controller keeping in view the duty cycle instead of other way. We will see that there will be remarkable changes occurs on output side. If we see the output is constant and the output voltage form is pure sine wave which is impossible in square wave-based inverter.

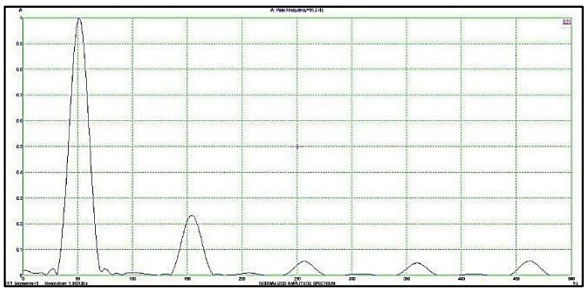

Fig. 8. Output harmonics using PWM switching technique

In figure 8 we seen that the by using PWM based switching techniques the harmonics in output voltages will be overcome as shown in figure the 3rd, 5th and all other odd harmonics will be eliminated. As a result, the over all efficiency of an ordinary inverter will be increase and by adding Micro-controller as a source of PWM generation the overall output efficiency will reach up to 95%. Results shows that PWM based inverter and now harmful for appliances. The value of THD in practically is less than 22%

4. Mathematical Modeling / Analysis

4.1. Total Harmonics Distortion (THD)

THD is the measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. To understand a system with an input and an output, such as an audio amplifier, we start with an ideal system where the transfer function is linear and time-invariant. When a signal passes through a non-ideal, non-linear device, additional content is added at the harmonics of the original frequencies. THD is a measurement of the extent of that distortion. When the input is a pure sine wave, the measurement is most commonly the ratio of the sum of the powers of all higher harmonic frequencies to the power at the first harmonic, or fundamental, frequency.

$$\text{THD} = \frac{P_2+P_3+P_4+\cdots+P_\infty}{P_1} = \frac{\sum_{n=2}^{\infty} P_n}{P_1} \quad (1)$$

$$\text{THD} = \frac{P_{total}-P_1}{P_1} \quad (2)$$

Measurements based on amplitudes (e.g. voltage or current) must be converted to powers to make addition of harmonics distortion meaningful. For a voltage signal, for example, the ratio of the squares of the RMS voltages is equivalent to the power ratio

$$\text{THD} = \frac{V_2^2+V_3^2+V_4^2+\cdots+V_\infty^2}{V_1^2} \quad (3)$$

4.2. Duty Cycle

The time that an entity spends in an active state as a fraction of the total time under consideration. The term is often used pertaining to electrical devices, e.g., switching power supplies. It is also sometimes used pertaining to living systems such as the firing of action potentials by neurons. In an electrical device, a 60% duty cycle means the power is on 60% of the time and off 40% of the time. Here one period is the length of time it takes for the device to go through a complete on/off cycle. Duty cycle is the ratio of the duration of the event to the total period.

$$\text{Duty Cycle} = \frac{\tau}{T} \quad (4)$$

τ is the duration that the function is active.
T is the period of the function.

4.3. Root Mean Square (RMS)

During the experiment calculating the RMS values of every technique which we use. By deeply studying the entire thing we can be able to say that the RMS value of PWM technique is very much better as compared to other two techniques which we use before. The theoretical concepts are given below in which we can be able wh1o to find out the RMS of any signal.

$$x_{rms} = \sqrt{\frac{1}{n}\left(x_1^2 + x_2^2 + x_3^2 + \cdots + x_\infty^2\right)} \quad (5)$$

$$RMS_{Total} = \sqrt{\left(RMS_1^2 + RMS_2^2 + RMS_3^2 + \cdots + RMS_\infty^2\right)} \quad (6)$$

Practically we see the VRSM of PWM is 0.1365V.but in 2-level square wave the VRMS is 0.29656V. we see both of the RMS we can easily say that PWM is very much better technique as compare to 2-level square wave.

4.4. Fourier Analysis

The coefficients of the Fourier series are computed with a pair of integrals that produce the coefficients of the sine and cosine terms in the series. For a signal f(x) with a zero-dc component, the integrals are.

$$\text{f(x)} = a_1 cosx + a_2 cos2x + a_3 cos3x + \cdots + b_1 sinx + b_2 sin2x + b_3 sin3x + \cdots \quad (7)$$

$$a_n = \left(\frac{1}{\pi}\right)\int_0^{2\pi} F(x)\cos(nx)\,dx \quad n > 0 \quad (8)$$

$$b_n = \left(\frac{1}{\pi}\right)\int_0^{2\pi} F(x)\sin(nx)\,dx \quad n > 0 \quad (9)$$

Numerical evaluation of the coefficients for the square wave indicates that if the square wave is to be considered a sine wave with distortion, the THD is in the range of 45% (-7 dB). The third harmonic, the hardest to filter out, is one-third the magnitude of the fundamental (-10 dB). Turning now to the modified sine wave, let us define the width of the positive and negative portions as 2α as depicted. Evaluation of this expression for various values of α indicates that the minimum harmonic distortion occurs at α = 0.352л, where the THD is 23.8% (-12 dB), about half that of the square wave. The third harmonic is about 6.5% (-24 dB) of the fundamental, also a significant improvement over the square wave. However, these figures indicate that the modified sine wave is far from being a true sine wave, and suggest that improvement is in order

5. Coding

To generates the switching voltages, Micro-controller (16F877A) based system used along with generic code is written in Protron IDE by carefully calculate the duty cycle in all three techniques. The code given below contains all three types of switching techniques (Square wave, 3-level modified sine wave, PWM).

```
Device 16F877A
XTAL 12
TRISD = %11111111
TRISB = %00000000
Main:
If PORTD.0 == 1 Then
GoTo label
ElseIf PORTD.1 == 1 Then
GoTo LABEL2
ElseIf PORTD.2 == 1 Then
GoTo Label3
ElseIf PORTD.0 == 0 Then GoTo Label1
ElseIf PORTD.1 == 0 Then GoTo Label1
ElseIf PORTD.2 ==0 Then GoTo Label1
EndIf GoTo Main
label:
High PORTB.6
Low PORTB.5
DelayMS 6.5
Low PORTB.6
High PORTB.5
DelayMS 6.5
GoTo Main
Label1:
Low PORTB.6
Low PORTB.5
GoTo Main
LABEL2:
Low PORTB.6
Low PORTB.5
DelayMS 4
  High PORTB.6
  Low PORTB.5
DelayMS 6
  Low PORTB.6
  Low PORTB.5
DelayMS 4
  Low PORTB.6
  High PORTB.5
DelayMS 6
GoTo Main
Label3:
Low PORTB.6
Low PORTB.5
DelayMS 2
High PORTB.6
Low PORTB.5
DelayMS 2
Low PORTB.6
Low PORTB.5
DelayMS 1
High PORTB.6
Low PORTB.5
DelayMS 4
Low PORTB.6
Low PORTB.5
DelayMS 1
High PORTB.6
Low PORTB.5
DelayMS 2
Low PORTB.6
Low PORTB.5
DelayMS 4
High PORTB.5
Low PORTB.6
DelayMS 2
Low PORTB.5
Low PORTB.6
DelayMS 1
High PORTB.5
Low PORTB.6
DelayMS 4
Low PORTB.5
Low PORTB.6
DelayMS 1
High PORTB.5
Low PORTB.6
DelayMS 2
Low PORTB.6
```

```
Low PORTB.5
DelayMS 4
GoTo Main
```

```
fund_pwr = ff_sq_2(f0*l/fs+1)^2;
total_pwr = sum(ff_sq_2(1:l/2).^2);
harmonic_pwr = total_pwr - fund_pwr;
THD = (harmonic_pwr^0.5/total_pwr^0.5)*100
```

6. Results

After successfully computing the results from the hardware implementation of inverter and by replacing the ordinary semiconductor-based inverter to Micro-Controller based inverter using 3-level modified sine wave and PWM. Comparison the efficiency of all three switching techniques is shown in Fig. 9.

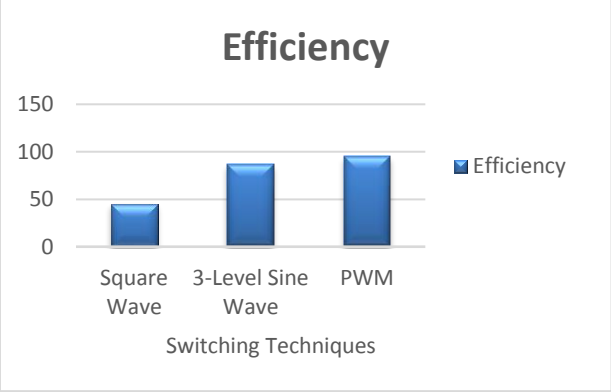

Fig. 9. Efficiency comparison of different switching techniques

The other major parameter which is to be considered is the Total Harmonics Distortions (THD). Along with the efficiency there will be an inverse relationship between THD and efficiency. Figures 10 shows the THD in all three switching techniques.

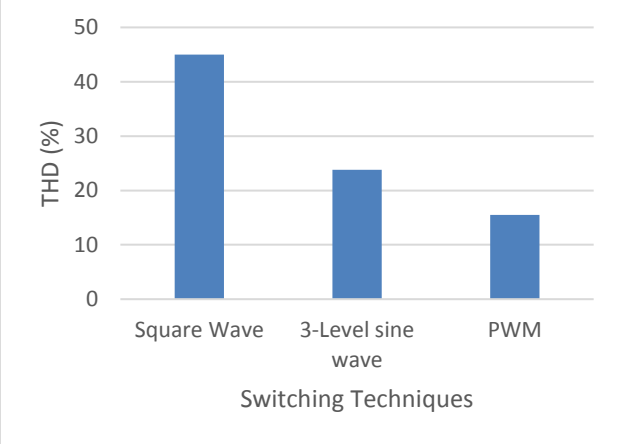

Fig. 10. THD (%) comparison of different switching techniques

7. Conclusion

At the end it is concluded that by using PWM technique the output efficiency increases because of the THD in PWM minimum as compared to other two switching techniques, by using 2-level Square wave the value of THD maximum. But when we use 3-level modified sine wave we see that the 3rd harmonics decreases as a result the power losses in 3-level modified sine wave Minimum as compared to 2-level square wave. PWM technique in which by calculating duty cycle we gets nearly sine wave and we also seen that 3rd, 5th and all others Odd harmonics will eliminate. So, using PWM Technique generated by PIC-Microcontroller we improve the output efficiency of inverter with cheapest price.

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On Proportional Resonant Controller for voltage dip mitigation using a Dynamic Voltage Restorer

Hatif Bin Abdul Majeed[a,*]; Hassan Abdullah Khalid[a]

[a]U.S - Pakistan Center for Advanced Studies in Energy (USPCAS-E), National University of Sciences & Technology (NUST), Islamabad, Pakistan

[*] Hatif Bin Abdul Majeed
E-mail: hatifmajeed_pk@hotmail.com
Tel: +923217303094

Abstract
A Dynamic Voltage Restorer (DVR) is a series connected voltage source converter, mainly used for voltage dip mitigation. This paper presents a comparison between the stationary and rotating reference frame based cascade control structures for DVR. Stationary frame controller consists of an inner Proportional Resonant (PR) current and outer proportional voltage control. Similar cascade structure is used in the rotating frame controller but with a conventional Proportional Integral (PI) current control. For both the controllers the performance analysis is presented while considering the computational time delays. The simulation study presents the results under balanced voltage dip with linear and nonlinear loads.

Keywords: *dynamic voltage restorer; proportional resonant; proportional integral; power quality enhancement*

1 Introduction

Due to increasing automation in the industry and penetration of renewable and electronics loads in the grid. The power quality has become a very serious concern for future electric grids. The power quality are variations in voltage and current from their fundamental waveform. Major issues include: voltage sags, voltage unbalance and, current and voltage harmonics [1]. Among them, the voltage sags are most severe due to their high probability of occurrence, mainly caused due to sudden tripping of heavy loads or a network fault. Several off the shelf solutions exists for voltage sag mitigation among them the series connected Voltage Source Converter (VSC) or Dynamic Voltage Restorer (DVR) is more common [2].
A DVR consists of several components as shown in Figure 1, including an LC filter, a VSC, injection transformer and an energy storage device like a super capacitors or Superconducting Magnetic Energy Storage (SMES) [2]. It injects the missing voltage between the load and the grid to maintain the nominal load voltage [3]. Due to short mitigation interval, a very high bandwidth controller is required. Traditionally, Proportional Integral (PI) controllers is the industrial benchmark that has been effective in mitigating voltage sags using DVR. However, it relies on park transformation for DC conversion that depends on the angle calculation using a Phase Locked Loop (PLL) [5-6]. This leads to increased settling time and overshoot limiting the overall controller bandwidth [5]. This problem can be overcome by using the Proportional Resonant (PR) controller without using any dc-quantities and hence the park transformation. It basically, provides a high gain at the selected frequency i.e. resonant frequency and approximately zero gain all the other frequencies, while offering high stability and robustness. Their ability to track sinusoidal signals they can operate in both the single and three phase systems [6]. Due to its simplicity and added benefits, this controller has been utilized as current controllers for grid tie VSCs [7-8], harmonic compensation [9], active damping [10] and in other power quality enhancement using FACTS devices [11-12]. However, the detailed comparison with the conventional PI controller is still missing in the literature.
This paper presents a comparison of cascade control scheme for series connected VSC with inner current (PI and PR) and outer proportional voltage controller. The computational time delay has also been considered in the simulation. Performance of both control schemes are compared for balanced voltage dip with linear and non-linear loads.

2 System Model

System model that is used in this study is shown in Figure 1 [13]. The system is comprised of a grid and a load

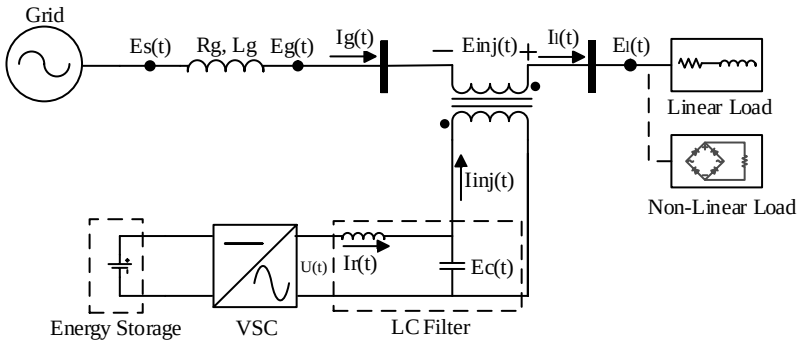

Figure 1 One Line Model of System and DVR

with an ideal series injection transformer connected to a VSC. Turn ratio of the injection transformer is 1:1. R_g, L_g shows the line impedance of the distribution lines, $E_g(t)$ and $E_l(t)$ depicts grid and load voltages. Two load types are considered in this study i.e. linear and non-linear loads.
An LC filter is connected at the output of VSC to remove the switching harmonics, $I_r(t)$ shows the current through the inductor and $I_{inj}(t)$ shows the current injected by the DVR, while on the other hand $E_c(t)$ is the capacitor voltage of filter which is being injected into the grid. The VSC is attached to an energy storage device which is considered ideal for this study. System model and controller parameters are consolidated in Table 1.

Table 1 System Model & Controller Parameters

Grid Parameters			
Grid Peak Voltage	E	325.26 V	1 pu
Grid Peak Current	I	10 A	1 pu
Grid Frequency	f	50 Hz	
Apparent Power	S	3.26 KVA	1 pu
Filter Parameters			
Filter Resistance	R_f	0.0248 Ω	
Filter Capacitor	C_f	0.00006 F	
Filter Inductance	L_f	0.002 H	
PI Controller Parameters			
Voltage Controller Gains	K_{pv}	0.06	
	K_{iv}	60	
Current Controller Gains	K_{pc}	6	
	K_{ic}	74.4	
PR Controller Parameters			
PR Based Current Controller Gains	K_{pr}	2	
	K_{ir}	400	

In Figure 1, Kirchhoff's Current Law (KCL) is applied to the output of DVR in a stationary reference frame using the alpha and beta components by Clarke's Transformation, equation derived for the current Ir(t) is

$$Ir^{\alpha\beta}(t) = Cr\frac{d}{dt}Ec^{\alpha\beta}(t) + Ig^{\alpha\beta}(t) \quad (1)$$

Similarly, if Kirchhoff's Voltage Law (KVL) is applied in the same stationary reference frame, equation derived for the output voltage of the DVR U(t) is

$$U^{\alpha\beta}(t) = Ec^{\alpha\beta}(t) + RrIr^{\alpha\beta}(t) + Lr\frac{d}{dt}Ir^{\alpha\beta}(t) \quad (2)$$

As the turn ratio of injection transformer is taken 1:1, capacitor voltage (E_c) will be equal to voltage injected by the DVR i.e. (E_{inj}) and the injected current (I_{inj}) will also be equal to the grid current (I_g). A PLL is used to determine the phase angle of the grid voltage that is used in Eq. 1 and 2, which are further transformed into their dq-components by using Park's Transformation. After transformation, equation for I_r is

$$Ir^{dq}(t) = Cr\frac{d}{dt}Ec^{dq}(t) + Ig^{dq}(t) + j\omega Cr * Ec^{dq}(t) \quad (3)$$

and the equation for U(t) is

$$U^{dq}(t) = Lr\frac{d}{dt}Ir^{dq}(t) + RrIr^{dq}(t) + Ec^{dq}(t) + j\omega Lr * Ir^{dq}(t) \quad (4)$$

3 Controller Design

Control technique exploited for both PI and PR controllers consists of two individual series connected closed loop cascaded controllers i.e. voltage controller in the outer loop and current controller in the inner closed loop as shown in Fig 2.

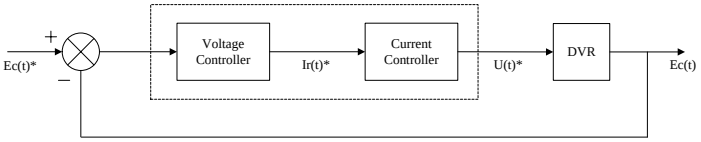

Figure 2 Control System Cascaded Structure

Voltage controller controls voltage across the filter capacitor (E_c) and current controller controls current passing through the filter inductor (I_r). Furthermore, all the signals being used in the control systems are sampled by

Zero Order Hold (ZOH) technique with the sampling time (Ts) of 0.2ms.

3.1 PI Controller

In case of PI controller, by taking the Laplace transform of Eq. 3 and eliminating the cross coupling and feedforward signals, plant's transfer function is derived which can be used for the designing of voltage controller [13].

$$G_{vplant}(s) = \frac{Ec^{dq}(s)}{Ir^{dq}(s)} = \frac{1}{sC} \quad (5)$$

Voltage controller system with feedback is shown in Figure 3.

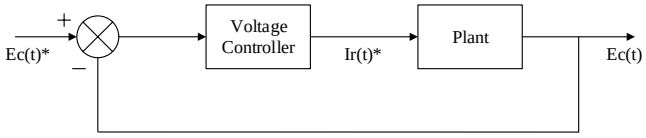

Figure 3 Voltage Controller System with Feedback

It is evident from the Fig 3 and Eq. 5, the transfer function for voltage controller with input $E_c(t)^*$ and output $E_c(t)$ is

$$G_{closedloop}(s) = \frac{Ec^{dq}(s)}{Ec^{dq*}(s)} = \frac{G_v(s)G_{vplant}(s)}{1+G_v(s)G_{vplant}(s)} \quad (6)$$

The filter capacitor that is being used here is a lossless capacitor, a proportional controller is derived which should be sufficient in controller design, which is directly dependent on the bandwidth of the voltage controller as well as the capacitance. However, to remove the steady state error an integral part of the controller is also included with a gain of K_{iv}. Hence, the final equation of the voltage controller transformed back in continuous time domain is

$$Ir^{dq}(t) = K_{pv}\left(Ec^{dq*}(t) - Ec^{dq}(t)\right) + K_{ic}\int\left(Ec^{dq*}(t) - Ec^{dq}(t)\right)dt + Ig^{dq}(t) + j\omega C * Ec^{dq}(t) \quad (7)$$

For current controller design, Laplace transform of Eq. 4 is taken and as a result the plant's transfer function is derived which is

$$G_{cplant}(s) = \frac{1}{(sLr+Rr)} \quad (8)$$

Fig 4 shows system for current controller with feedback

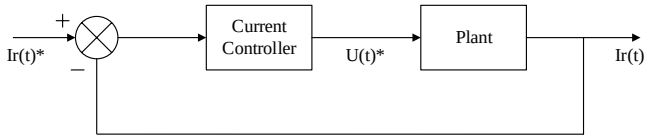

Figure 4 Current Controller System with Feedback

Fig 4 shows that $I_r(t)$ is output and $I_r(t)^*$ is the input of the current controller, as a result the closed loop transfer function for the current controller can be written as

$$G_{closedloop}(s) = \frac{Ir^{dq}(s)}{Ir^{dq*}(s)} = \frac{G_c(s)G_{cplant}(s)}{1+G_c(s)G_{cplant}(s)} \quad (9)$$

So, the transfer function for the PI current controller is

$$G_c(s) = Kpc + \frac{Kic}{s} \quad (10)$$

In Eq. 10, K_{pc} shows the proportional gain and K_{ic} represents the integral gain of the controller [13]. In this case the proportional gain is directly dependent on the bandwidth of the current controller and the filter inductance while integral gain is dependent on the resistance of the filter inductance.

Final equation for the current controller after transformation into continuous time domain is

$$U^{dq}(t) = Kpc\left(Ir^{dq*}(t) - Ir^{dq}(t)\right) + Kic\int\left(Ir^{dq*}(t) - Ir^{dq}(t)\right)dt + Ec^{dq}(t) - j\omega Lr * Ir^{dq}(t) \quad (11)$$

3.2 PR Controller

Control structure is kept same as that of PI controller for comparison purposes as already shown in Fig 3 and 4. As evident from Eq. 5, plant equation for voltage controller includes the same lossless capacitor. Hence the same voltage controller with a proportional gain K_{pp}. Now, the proportional resonant control is applied to the inner current controller.

Transfer function for a typical PR controller in continuous frequency domain is given by [6]

$$H^{PR}(s) = Kp + Ki\frac{s}{s^2+\omega^2} = Kp + KiR^1(s) \quad (12)$$

Where ω is the resonant angular frequency and $R^1(s)$ is the resonant term having infinite gain at the resonance frequency ensuring accurate tracking of the reference signal rotating at resonance frequency. Thus eliminating the need for transforming all the signals into respective dq-components [14].

The PR controller form in Eq. 12, does not take into account the computational delay of the controller. By adding computational delay the transfer function for the resonant terms becomes

$$R^{1d}(s) = \frac{scos(\omega NTs) - \omega\sin(\omega NTs)}{s^2+\omega^2} \quad (13)$$

Where N is the number of sampling periods that needs to be compensated with most optimum value of 2 [6]. As a result, the transfer function for inner current controller becomes

$$H^{PR}(s) = Kp + Ki\frac{scos(\omega NTs) - \omega\sin(\omega NTs)}{s^2+\omega^2} \quad (14)$$

PR control structure is shown in Fig 5.

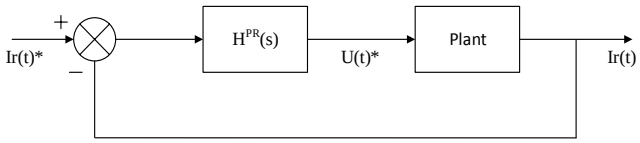

Figure 5 PR Inner Current Control Structure

Bode plot of the controller is shown in Figure 5, taking ω=314 rad/s, N=2, K_{pr}=2 and K_{ir}=400. It shows the gain of 300 dB at fundamental frequency of 50 Hz. Furthermore, phase margin before and after 50 Hz is almost zero degrees, which gives the assurance of high steady state accuracy.

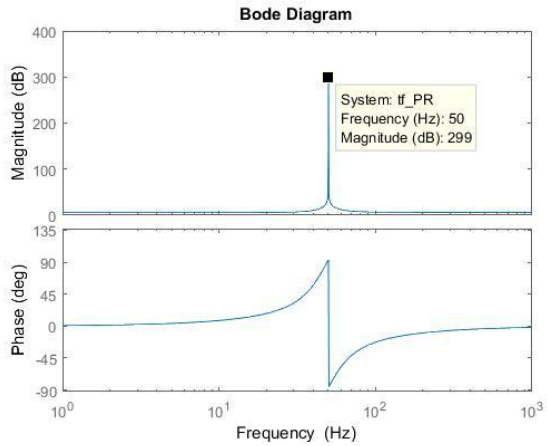

Figure 6 Bode Plot of an Ideal PR Controller

After transformation in continuous time domain, final expression for voltage controller in this case is

$$Ir^{\alpha\beta*}(t) = Kpv\left(Ec^{\alpha\beta*}(t) - Ec^{\alpha\beta}(t)\right) + Ig^{\alpha\beta}(t) \quad (14)$$

and the expression for inner PR current controller in continuous time domain is

$$U^{\alpha\beta}(t) = Kpc\left(Ir^{\alpha\beta*}(t) - Ir^{\alpha\beta}(t)\right) + R^1(t) * Kic\left(Ir^{\alpha\beta*}(t) - Ir^{\alpha\beta}(t)\right) + Ec^{\alpha\beta}(t) \quad (15)$$

Where

$$R^1(t) = \cos(\omega t + \omega NTs) \quad (16)$$

For discrete implementation Tustin method is used to for PR controller as suggested in [6].

4 Simulation Results & Analysis

Simulation study is performed in MATLAB/Simulink using the system parameters as mentioned in Table 1 using linear and non-linear load. In linear load, the rated apparent power is 1925 W while in case of non-linear load its value is 1600 W.

A 50% voltage sag is simulated for a duration of 0.1 sec from 0.2 to 0.3 sec. The three phase, αβ and dq-components of the load voltage are shown in Fig 7.

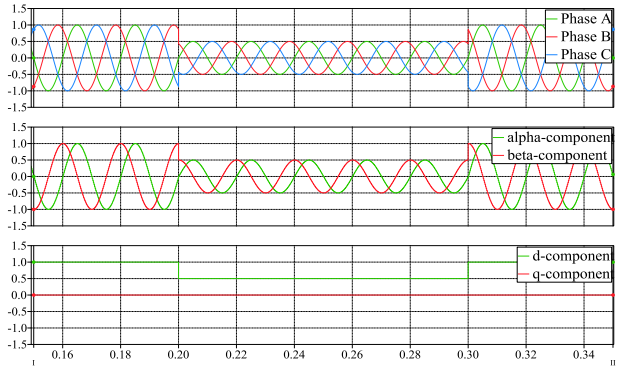

Figure 7 Voltage at PCC with Balanced Voltage Sag

Response of PI controller with linear load is given in Fig 8 that shows the three phase, αβ and dq-components load voltage. While Fig 9 presents the response of PR controller three-phase, αβ load voltage and three-phase load current.

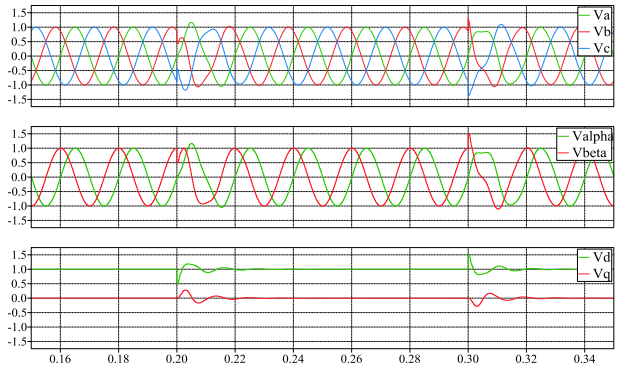

Figure 8 Voltage at Linear Load side with PI Controller

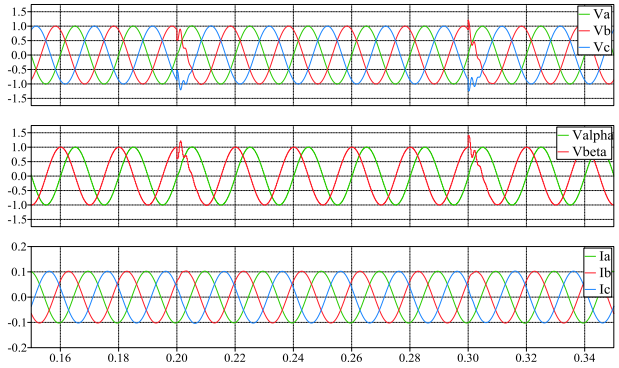

Figure 9 Voltage at Linear Load Side with PR Controller

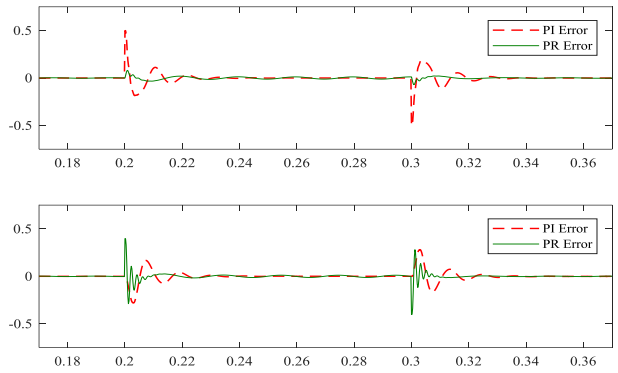

Figure 10 PI & PR Error Signal Comparison for Linear Load

Fig 10 shows the error signal of PI load voltage controller that is overlapped with the error signal of PR controllers for comparison purposes, which in turn shows the response of the controllers. It is evident that the voltage sag is mitigated completely within 25 ms in case of PI controller while for PR controller the response time based on settling time of the error signal is around 8 ms.

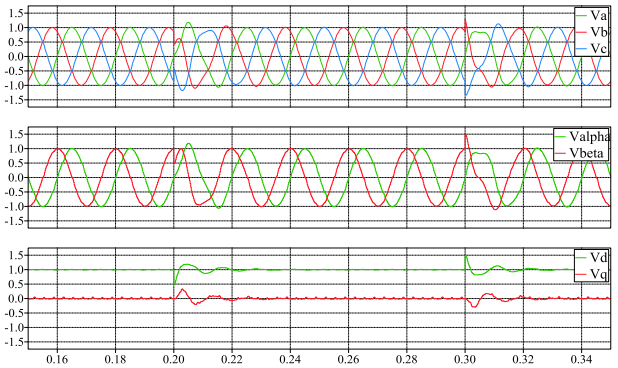

Figure 11 Voltage at Non-Linear Load side with PI Controller

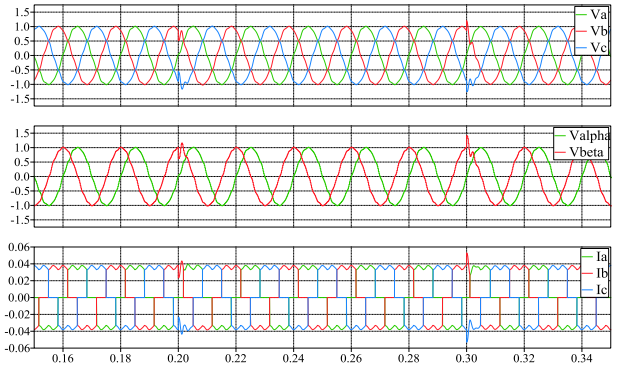

Figure 12 Voltage at Non-Linear Load side with PR Controller

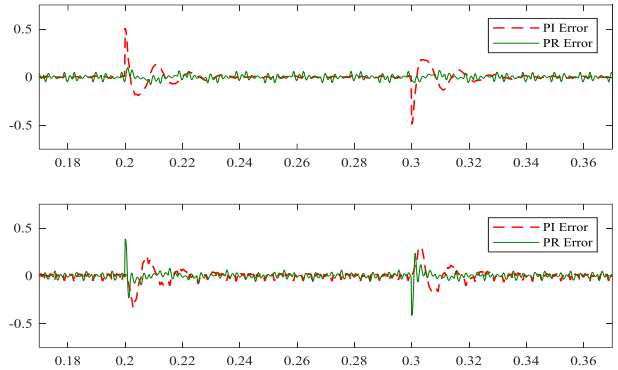

Figure 13 PI & PR Error Signal Comparison for Non-Linear Load

Similarly response for both controllers is observed with a three phase balanced voltage sag for non-linear load. Fig 11 and 12 shows the three phase, αβ and dq-components of load voltage with three-phase load current for non-linear load. Due to non-linear load, some voltage harmonics can be observed in Fig 13 that shows the error signal comparison of PI and PR.

CONCLUSION

A performance comparison of cascade schemes using a PI and PR current controllers are given in this paper. Simulation results are presented for balanced voltage sag under linear and non-linear load. It has been observed that the PI controller gives long settling time while mitigating the 50% balanced voltage sag with a high overshoot. While PR controller showed almost half the settling time with negligible steady state error and a low overshoot. Thus providing superior performance than the conventional PI controller for voltage dip for both linear and non-linear loads.

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Integrating Micro Hydro Electric Power Schemes into Grid Systems: Review of Barriers, Procedures, Requirements and Problems

Waqas Ali[a,*]; Haroon Farooq[a]; Muhammad Usama[a]; Adnan Bashir[a]; and Ata Ur Rehman[a]

[a]Department of Electrical Engineering (RCET), University of Engineering and Technology, Lahore, Pakistan

[*] Corresponding Author
E-mail: waqas.ali@uet.edu.pk
Tel: +92556770168
Fax: +92556773214

Abstract
The grid integration of renewable energy has become more common in recent years. The reasons behind are the increase in world's electricity demand, power capacity improvement of local grids to meet up the escalating demand, increasing cost of fossil fuels, economic benefits of no fuel consumption by renewable energy sources, business opportunities, energy security, energy independence and more importantly the environmental concerns and global warming due to the excessive use of conventional energy sources. Like the grid integration of different forms of renewable energies, the integration of Micro Hydro Electric Power (MHEP) into grid systems is also imminent owing to its tremendous performance and potential benefits in terms of high efficiency, high capacity factors, low output power variations and greatly feasible with low investment costs when compared to other renewable technologies specifically wind, wave and solar power of the same size. This paper presents a review of the factors associated with the grid integration of MHEP schemes and discusses the key barriers, relevant procedures, major requirements and significant problems pertaining to their grid integration. Various strategies to overcome barriers and practicable solutions to mitigate and to compensate the problems encountered during grid integration are also described for consideration.

Keywords: *Renewable Energy (RE); Micro Hydro Electric Power (MHEP); Grid Integration, Distributed Generation (DG).*

1 Introduction

Micro hydroelectric power (MHEP) is a kind of hydro power scheme that can generate electricity up to 100 kW using water flow [1]. It is an excellent way of harnessing renewable energy (RE) from small streams and rivers. It appears as a clean, attractive and the highly expanded source of RE over the world that has certain benefits over its large scale hydro counterparts. These potential benefits are as follows [2-7]:

- Efficient energy resource.
- Reliable source of electricity.
- No reservoir required because of run-of-river structure: the water runs straight directly through hydro turbine and drop back into the river to utilize it for other purposes.
- Low ecological impacts on surroundings.
- Cost effectual energy solution: as no fuel cost, operation and maintenance expenditures are also reasonably low in comparison to the same size of other technologies of RE.
- Energy for developing and under developing countries: micro hydro has economical adaptability and versatility, and lengthy span of life.
- MHEP can be used to supply electricity to small rural and isolated communities.
- Minimum environmental impacts in comparison to the conventional power plants that utilize fossil fuels.
- Have low failure and malfunction rate.
- Have quick start-up and make fast adjustments in the output power.
- Can be integrated with the electric grid system: if the produced power is surplus, utility companies can purchase the generated electricity and integrate it into the local grids.
- There can also be a chance of enhancement of micro hydro power level with intake from the integrated connected grid.

The MHEP schemes are generally used to feed power to remote isolated residences or communities where electricity grid is not available, and/or the grid system extension is not economically practicable due to large investment required for transmission/distribution network [8]. However, in recent years, their integration back into the local grid system when the produced electric power is

in excess is also evident [3]. It is mainly due to their confirmed advantages in terms of good performance such as high efficiency (70-90%), high capacity factors (> 50%), approximately constant output power and being highly feasible with low investment costs when compared to the same size of other renewable technologies specifically wind, wave and solar [2, 9, 10, 11, 12]. Moreover, the payback period for grid integrated systems is reasonable, often 5-8 years or less [11-13]. Therefore, where the potential sites are available near to the local grids, MHEP systems can be functioned in integration with the main grid systems. The major motives behind are to attain financial advantage of no fuel consumption by water turbines, power capacity enhancement of local grids to catch up the rising load demand and to keep the electric supply uninterrupted in the system [14].

Usually, all the renewable energy technologies including MHEP are considered as intermittent sources of power, therefore their integration with the grid system infrastructure is a difficult task [15]; which leads to various complexities and risks that range from power production to load management and from reliability to cost efficiency of power supply. Though, their grid integration facilitates to increase the plant load factor by generating additional revenue which ensures sustainability of the projects. In addition, it decreases the dependability of the distribution network on a single point of supply; thus helping the grid integration of distributed generation (DG) to reduce transmission/distribution losses [16]. But, there are several factors exist pertaining to the grid integration of MHEP based renewable energy systems [10, 17, 18, 19, 20] that need to be considered and addressed appropriately in order to gain the full advantages of integrating MHEP schemes into grid systems. So, this paper reviews and presents all these factors include key barriers, relevant procedures, major requirements and significant problems for the grid integration of MHEP schemes followed by various solutions.

The paper is organized as: section 1.1 presents the general layout of MHEP scheme. Section 1.2 and 1.3 give the key barrier including overcome strategies and relevant procedures for grid integration of MHEP schemes respectively. While, the major grid integration requirements and significant problems along with the solutions regarding to the grid integration of MHEP systems are discussed in section 1.4 and 1.5 respectively. Conclusions followed by the acknowledgment and references are presented in section 1.6.

1.1 General Layout of MHEP Scheme

Micro hydro power is based on the principle that falling and flowing water has a certain amount of potential and kinetic energy [21]. By means of a turbine or water wheel, this energy in falling and flowing water is converted into useful mechanical energy. Then, through an electric generator, the produced mechanical energy is converted into electrical energy.

Fig. 1 illustrates the general layout of a typical MHEP scheme. The water is diverted through an intake weir from the river. The diverted water then goes towards settling basin where it is sufficiently slowed down to settle out the suspended particles. Then water from settling basin is brought to a forebay tank through an open channel or canal, which makes sure and maintains a constant head of water before entering to a penstock. In the tank, debris is filtered and water is conveyed to turbine through penstock (a pressure pipe that leads water directly towards the turbine). The power conversion process takes place inside the power house, the hydro energy stored in water is converted into mechanical energy by a water turbine and this converted energy from turbine is transferred to generator that converts it into electricity. Lastly, after energy extracting from water flow, the water from turbine again releases back into river through a tailrace.

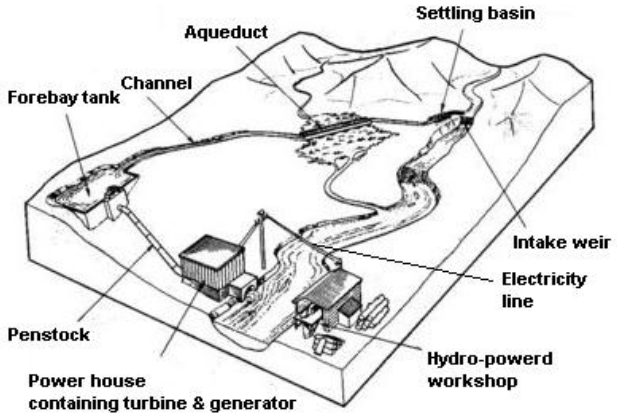

Figure 1 General site layout and components of a typical MHEP scheme (source [22])

1.2 Key Barriers and Overcome Strategies

Due to the growing energy demand and environmental concerns, the grid integration of MHEP based DG has gained a great popularity in the electricity market throughout the world. However, in spite of this, certain key barriers still exist that need to be overcome. These key barriers are listed as follows [23]:

- Lack of marketing.
- Utilities framework and culture.
- Strength of integrated grid.
- Transmission/distribution access.
- Capital expenses vs variable energy costs.
- Limited role of private sector.
- Lack of expertise and capability.

Many studies are found in literature on grid integration of RE technologies, in which few have presented some policies to promote RE integration with local grid systems and strategies to overcome the obstacles arrive in the way of grid integration of DG. These strategies are given as under [23]:

- Train RE engineers, designers and operators.
- Promote market development.
- Support utilities RE procurement.

- Encourage private investors.
- Provide long term contracts.
- Facilitate and assist access to electricity grid.
- Value RE attributes.

1.3 Relevant Procedures

Codes, standards, and utility policies and procedures regarding grid integration of RE systems differ amongst regions and countries. However, in various countries, particularly in the developing world, these norms are not yet to be well defined and clear. And in countries where these things do not exist, grid integration is determined and resolve on a case-by-case basis. The majority of the public sector and/or private utility companies in such countries are unaware and unfamiliar with administrative procedures and technical standards for making grid integration. On the other hand, many countries exist in the industrialized world that offer simplified relevant procedures for RE based small and mid size DGs integration with grid systems; these are discussed as below [24].

1.3.1 Grid Integration Application

The first step of the process is to apply for grid integration interconnection. It should be transparent, clear and straightforward. Moreover, to ensure a reliable, safe, secure and perfectly metered utility interconnection, the provided information should be sufficient.

1.3.2 Approval of Utility

A utility should set appropriate criteria to approve, deny, or condition interconnection of a DG. The process of approval should be critically based on a series of questions and screens who decide which procedural pathway is followed by small power producer (SSP) to integrate their system.

1.3.3 Commissioning, Testing, and Follow-up

Once the permission is granted to integrate the DG with grid system. Regulatory authority and/or utility normally perform commissioning and testing of the project construction. In addition, SPPs are mandatory to submit periodic reports on their interconnected system, and the utility company reserving the right to execute any inspection of the system.

1.3.4 Implementation Responsibility: SPP or Utility?

The more common and conventional approach to utility grid interconnection of DG for integration is that SPP to work for installation of equipment on its side of the PCC (point of common coupling) and the utility to work on its side of the PCC with having the right to examine equipment and their installation on the SPP side of the system also.

1.3.5 Metering

The metering as a rule is installed at or near the PCC. The modern digital meters are better than conventional analog meters as they measure in much wider range such as current, voltage, real and reactive power, maximum demand, and time of use while analog meters measure only net collective energy. Now, digital meters are incorporated with modern communication technologies to send data wirelessly to SPP and/or utility, these meters come into the category of smart meters.

1.3.6 Integration Interconnection Cost

The costs linked with making a grid integration of DG consist of equipment costs, labor costs associated with intertie equipment installation, commissioning and inspection costs, utility administrative costs, and liability insurance particular to the grid integration. Normally, cost of interconnection depends upon type of DG and system size and it varies country to country.

1.4 Major Requirements

The grid integration of MHEP schemes technically demands and prefers synchronous AC interconnection of all interconnected systems [25]. At a common level, the first main requirement for both grid and interconnected DG is that they should share the common frequency either at 60 Hz or at 50 Hz [25]. Then, they must remain in synchronism by regulating frequency. The second major requirement is that they should be interconnected at a same voltage level [25]. However, along with the aforesaid requirements, some other major and common requirements for the grid integration of MHEP schemes should also be fulfilled for the safe and healthy operation of MHEP schemes in grid connected mode. These requirements are as follows [25-28];

- Overall design and structure of system.
- Safety of system and consumers.
- Safety of plant operating in parallel with grid.
- Protection of plant and system.
- Control and monitoring of system.
- Metering.
- High quality of power.
- Communication and data exchange.

Normally, MHEP schemes are installed either with induction generator or with synchronous generator. Each of these generators has certain features and characteristics that necessitate serious consideration when integrating them to the local grid system [24].

1.4.1 Synchronous Generator Requirements

Usually, synchronous generators require complex protection. They must be synchronized before being connected to grid in frequency and phase [28].

1.4.2 Induction Generator Requirements

While, induction generators are not synchronized before integration, as they need supply of reactive power from capacitor banks or grid to generate electricity. To limit the inrush currents, they are usually connected through a soft starter [28].

1.4.3 Human Safety Considerations and Requirements

This is also very important requirement that should be considered critically for human safety. For this purpose, install lockable switches at easily accessible positions [23]. On need, manually isolate renewable energy based DGs from grid. And also update circuit diagram regularly and display at appropriate locations [23]. Set up a direct communication between SSP and utility at any critical disturbance event.

1.5 Significant Problems and their Solutions

The renewable DGs are relatively small as compared to other generations and/or power sources of conventional nature on the grid. Their integration with the existing power system grid infrastructure can cause the instability of interconnected grid due to their erratic and intermittent power production nature. So therefore, to integrate them into the power grid system is a challenging task. Likewise, MHEP based DG systems are also intermittent nature, therefore their integration with grid creates many problems that must need to be addressed to gain the full RE resource potential. Hence, the list of problems encountered during the grid integration of MHEP schemes is as follows [23, 24, 25, 28, 29, 30]:

- Frequency fluctuations and regulation.
- Voltage rise and reverse power flow.
- Voltage imbalance.
- Voltage fluctuations and regulation.
- Output power fluctuations and regulation.
- Power factor (PF) correction.
- Harmonics distortion.
- Unintentional and safe intentional islanding.
- Control of faults in grid connected mode.
- Battery storage problems.
- Protection coordination.
- Loss of Synchronization.

Technically, the all aforementioned problems are very important for a power system. This is because the system's stability and security is strongly dependent on them. So, they must be address vigilantly and carefully. However, alongside these, some other problems are also need to be tackled. Such as, institutional cooperation, lack of trained man power, RE resource dispatchability and harmonization of technical standards among stakeholders.

1.5.1 Solutions

The growing strength of renewable energy resources and DGs necessitates innovative tactics and schemes for grid integration, operation, control and grid management so as to maintain and enhance the reliability and quality of power supply. Thus, keeping in view of the abovementioned problems for grid integration of MHEP systems, some potential solutions proposed in different studies are as follow [15, 23, 28, 31, 32, 33].

- Power electronics technology should be used for complex control of grid and integrated RE systems.
- Harmonic compensators should be used to reduce harmonic contents in power supply.
- Electromagnetic interference (EMI) should be minimized so that it cannot affect the operation of protection.
- Power conditioning system should be provided to control THD (Total Harmonic Distortion) and PF.
- Fast responding frequency and voltage regulator should be used.
- Batteries and auxiliaries should be sufficient capacity to ensure the operation of all protection during loss of supply.
- Proper monitoring and information exchange is extremely essential for better coordination.
- Automatic synchronization should be preferred for grid interconnection over manual methods.
- Protection should also be provided to avoid unsynchronized connection.
- System protection should also be provided against transient abnormalities at grid.
- Protection equipment must meet the standard requirements and there should be no compromise on at least minimum protection.
- Renewable energy technologies including MHEP should be excluded from the competition by giving them priority to dispatch.

1.6 Conclusions

This paper presents the review of different grid integration factors of micro hydro electric power schemes. The work describes the key barriers and strategies to overcome these hurdles in the path of grid integration. Alongside, the paper gives simplified procedures regarding the grid integration of MHEP based small and mid size DGs, and also presents the major grid integration interconnection requirements for AC synchronous interconnection. The significant problems encountered during the grid integration of MHEP systems are also presented in this review paper. Finally, the review also suggests and recommends a number of viable and achievable solutions to avoid and compensate the problems of voltage, frequency, and power variations and quality through appropriate control, synchronization and protection when integrating MHEP sources into the main or local grid systems.

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Effect of Reduced Graphene Oxide as Counter Electrode Material and Low-Cost Natural Dye as Photosensitizer on Dye-Sensitized Solar Cells

Urooba Azhar[a, *]; Maleeha Anwer[a]; and Samia Arshad[a]

[a]Department of Materials Engineering, NED University of Engineering & Technology, Karachi, Pakistan

[*] Corresponding Author
E-mail: uroobaazhar11@hotmail.com
Tel: +92 336 2001619

Abstract
The importance of green power resources is being significantly increased as the energy crises is taking a vital position in every country. Sunlight being an abundant source offers a cost effective and clean solution to problems of energy generation. Dye-Sensitized Solar cells (DSSC) are an economical class of solar cells that address the corresponding issue. In this research, DSSCs were manufactured using ITO coated glass substrate, by employing Micro Crystalline Titanium (IV) Anatase, on the photo-anode, dipped in natural cherry dye. For counter electrode; Graphite, Graphene Oxide (GO), and Reduced Graphene Oxide (rGO) were coated to fabricate three different cells and the results were compared. The internal electrical continuity was established by I^-/I^-3 electrolyte. The synthesized materials were characterized by XRD, X-ray diffractograms obtained for rGO show sharp diffraction peaks at $2\Theta=26.5$Å confirming the existence of rGO. In FTIR spectra, major absorption peaks of GO and rGO were obtained at $1050cm^{-1}$ and $1500cm^{-1}$ respectively. The UV-Vis Spectrum further confirmed the presence of rGO, showing the major peak of 260 nm. The fabricated DSSCs were characterized by Probe Station Keithley SCS 4200 which gave the I vs V graphs assuring the successful formation of diode. Among the three cells, rGO based DSSC gave the highest value of Voc = 0.65 volts and thus the power conversion efficiency was calculated to be $\eta=5.23\%$.

Keywords: Dye-Sensitized Solar Cell (DSSC); Counter electrode; Reduced graphene oxide; Natural dye

1 Introduction

Harvesting the solar energy and converting it into electricity is considered as a huge challenge. Photovoltaic devices are used for this energy conversion [4]. In this research, Dye-sensitized Solar Cells are fabricated to do so. It utilizes natural ingredients for dye i.e. cherry juice, which acts as a photosensitizer to absorb photons coming from sunlight and adapting them into useful electrons. Different carbonaceous materials used for the fabrication of cells gave the most promising efficiencies and enhanced cell durability. Successful fabrication of DSSCs can be called upon to replace the conventional solar cells [5] due to the possibilities to design solar cells with a large flexibility in shape, color, and transparency [6]. Furthermore, impart non-toxicity, cost- 2 effectiveness, and energy efficient production methods [7] Conventional solar cells consume renewable energy to give a solution to this problem but inherit several demerits such as high production and maintenance cost, difficult fabrication processes, fragile form and poor transparency. DSSCs have emerged from a class of solar cells to give better solutions and variety of applications. This type of cells is low-priced and easy to fabricate. They benefit in low-density applications such as roof tops and windows [8]. This article covers the methods and materials for fabricating DSSC by modifying the counter electrode which helps to evaluate the importance and necessity of research on this title. DSSC is an organic solar cell consisting of nanoscale components [9]. Dye-sensitized solar cells (DSSC) convert any visible source into electricity and offer reliable different concepts for photovoltaic devices [10] lower in cost and efficient. Dye performs the basic function to absorb visible light and transfer electrons to the conduction band of the semiconductor [11], [12]. These cells are fabricated by a semiconductor which is called photo electrode and a catalytic electrode named counter electrode with an iodide/triiodide electrolyte sandwiched between them. The electrodes of DSSC consist of a glass plate which is coated with a transparent conductive oxide (TCO) film. Indium tin oxide (ITO) or fluorine doped tin oxide (FTO) are most widely used [13]. The anode is transparent so that sunlight can be absorbed by the dye-sensitized solar cell. In between the anode and counter electrode, is a path of titanium dioxide nanoparticles, that acts like way for electrons flowing through the cell. The TiO_2 nanoparticles are coated with photosensitive dye. An electrolyte fills the

gap between the TiO_2 nanoparticles and helps transfer electrons from CE to dye molecules [14]. After the dye releases an electron it needs another electron to replace it. On the other hand, a CE consists of film of graphite or platinum. Anode sends electron to CE. The electrons travel through the electrolyte and the TiO_2 nanoparticles to create an electric current. The electrons are originated from the dye when it is hit by light and travel towards anode [15]. Electrolyte transfers an electron to the dye to fill the space of electron which the dye had lost. When this occurs, iodide molecules are oxidized into triiodide. The triiodide recovers its electron from the counter electrode which reduces it back to iodide molecules. When all this process works together electricity is generated [16].

2 Experimental Work

Graphite powder and Micro Crystalline Titanium (IV) Anatase were purchased from DAEJUNG Co. Ltd. All the other reagents mentioned in the following processes were purchased from Merck (Pvt.) Ltd. All the reagents used in this research were of industrial grade and possessed highest available commercial purity.

2.1 Synthesis of Graphene Oxide by Modified Hummer's Method

Modified Hummer's Method illustrates an efficient way to produce separate graphitic ultrathin films/powder on a larger scale in a less hazardous manner. This method is selected for the oxidation of graphite flakes by robust oxidizing agents; $KMnO_4$, $NaNO_3$ and H_2SO_4 heating and stirring leading to the formation of Graphene Oxide. Washing and drying of the solution to obtain a neutralized GO powder. 1g of graphite was mixed with 0.5 g of $NaNO_3$ and 23ml of 98.08% conc. H_2SO_4. This mixture was then stirred using a magnetic stirrer for 30 minutes in an ice water bath. After that, 3g of $KMnO_4$ was added and the mixture is again stirred for 1hr. at 35˚C. Then 50 ml Distilled water was added and solution was stirred for 1 hr. at 98˚C. The solution was then treated with 140mL DW +10 mL H_2O_2 for 45 mins. Washing with 5% HCl and DW was done and then the sample was dried in sunlight [1].

2.2 Reduction of Graphene Oxide by Hydrazine Hydrate

Chemical reduction of graphene oxide by hydrazine hydrate provides an effective way of producing rGO with high chemical conductivity. N, N-dimethylformamide (DMF) acts as solvent and hydrazine hydrate assists in the reduction process, removes oxygen containing groups and separates layers for better electron movement. 1g of previously prepared GO powder by modified hummer's method was ultrasonicated with DMF for 1 hour using an ultrasonic cleaner. 10 ml of hydrazine hydrate is added into the obtained solution which is then stirred for 6 hours at 80˚C. After that, the solution is washed with DW until the pH becomes 7 and then the solution is dried to get a powdered sample of rGO. Hydrazine hydrate and DMF were purchased from (Merck & Co.) [1,19]

2.3 Preparation of Graphite, GO, and rGO Based CEs

Three CEs were prepared by using ITO coated transparent glass substrates (purchased from Ossila limited, UK) of dimensions 20mm x 15mm (3 cm^2). These three glasses were then dip coated with graphite, synthesized GO, and synthesized rGO. 1. Graphite slurry was prepared by mixing 0.1g graphite powder with 10ml isopropanol and ultrasonicated until a homogenous solution was obtained. ITO coated glass substrate was then placed on Hotplate at 90°C and the solution was poured drop wise. It was then placed in vacuum oven at 230°C for 10 min 2. In case of GO and rGO, 0.1g of GO and rGO the slurries were prepared by mixing 0.1g of GO/rGO powder and 10ml of isopropanol. Two drops of Ethylene glycol were added in the slurry as a binder to provide better adhesion between the coating layer and ITO glass. It was then cured as mentioned in point 1.

2.4 Preparation of micro crystalline TiO_2 photoanode

Ethylene glycol was added drop by drop in micro crystalline TiO_2 powder until a homogenized slurry was obtained. It was then coated on conductive side of the ITO glass by manual doctor blade to prepare photoanode. Glass substrate was placed in furnace at 400°C for 20 min for curing and evaporation of binder. It was then dipped in cherry dye overnight, washed with distilled water followed by ethanol and dried.

2.5 Preparation of Electrolyte

1.6 g of Potassium Iodide and 0.2 g of Iodine crystals were added in 10 ml of Ethylene glycol. The mixture was stirred with glass rod until the dark brownish colored solution was obtained. This solution was used as iodide/triiodide electrolyte.

2.6 Assembling of DSSCs

Previously prepared photoanode and CEs were assembled using binder clips. 2 drops of the prepared electrolyte [2.5] was injected at the seams of the glass assembly. Binder clips were alternately clipped and unclipped so

that all the electrolyte is pulled in between the two glass slides through capillary action. The active area of fabricated DSSC was 2.3cm². [20]

3 Results and discussions

3.1 Characterization of GO and rGO

rGO was characterized using XRD PANalytical Model with Cu K_α = 1.54060Å. The data was collected between start Position 2θ= 10.0125˚ and End Position 2θ=79.9875˚. As shown in Fig 1, major peak of rGO obtained at 2θ=26.5˚. The broadening of diffraction peak is due to the formation of GO into rGO. XRD reports the interplanar spacings between the carbon layers which depends on the concentration of oxygen functional groups. The more the reduction of GO into rGO, the more the peaks of graphite and rGO are closer to each other due to approximately same interplanar spacings. It also shows that the rGO Nano layers are exfoliated into monolayer and resulted in a new structure which is distinct from GO and Graphite [2]. Broad peak also indicated the removal of intercalated oxygen functional groups and water molecules which results in high electrical conductivity. [17]

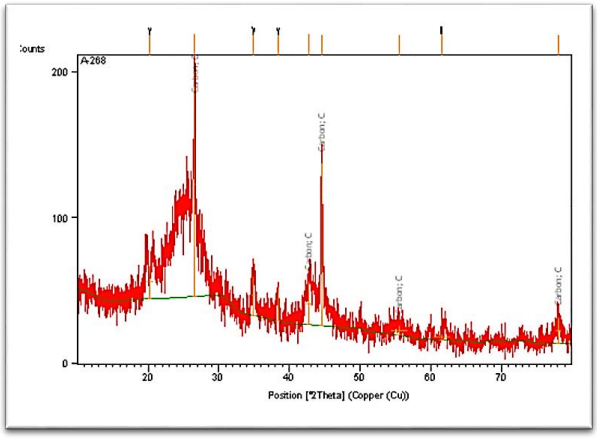

Fig 1. XRD of Reduced Graphene Oxide

In UV-Vis spectroscopy the main absorption peak at 260 nm is observed in the spectrum as shown in Fig 2. A UV-Vis spectrum of pure GO shows two absorption peaks: one at <230 nm, presumably due to the $\pi \rightarrow \pi^*$ transition of the C–C bonds, and another shoulder at <300 nm corresponds to the $n \rightarrow \pi^*$ transition of the C=O bonds [4]. When GO is chemically reduced, a red shift in plasma peak at 260 nm is observed, due to a decrease in oxygen functional groups and an increase in aromatic rings, causing electrons to be easily excited at a lower energy. The shift in the absorption of C=C bonds also suggests that GO is reduced consequently restoring the electronic conjugation within graphene sheets. This reflects increment in the concentration of π electrons and structural ordering, which proves that sp^2 carbon is restored and atoms are rearranged. [1]

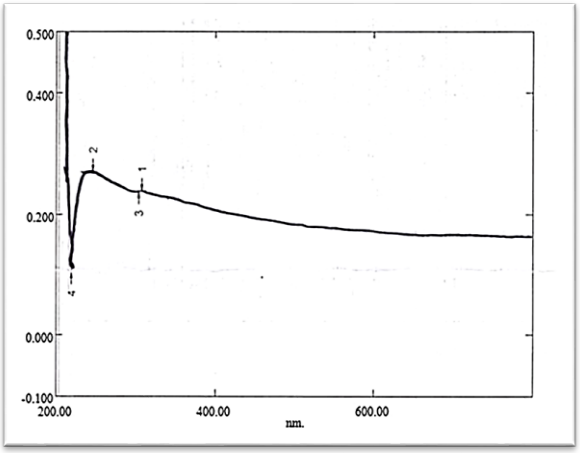

Fig 2. UV-Vis spectrum of Reduced Graphene Oxide

The FTIR spectrum of GO and rGO further verified the formation of corresponding materials. In the FTIR spectrum of GO in Fig 3a, A strong major peak near 1020 Vmax/cm^{-1} is observed which represents the C-O stretching vibration. This indicates the presence of ethers, esters, carboxylic acids or alcohols. Other characteristic peaks that can be viewed clearly lie between 1550-1700 Vmax/cm^{-1} which are responsible for C=O and aromatic C=C stretching vibration confirming the presence of carbonyl groups. These strong peaks do not appear in graphite's spectrum showing that oxidation step is responsible for the formation of many oxygen-containing functional groups. A comparatively weaker peak present between 3600-3800 Vmax/cm^{-1} shows OH stretching/ free hydroxyl units indicating alcohol or phenol functional groups [2,18].

The chemical reduction of GO into rGO (Fig 3b) causes almost all the peaks to weaken and even some are disappeared. This decrease in the intensity specifies the removal of oxygen containing functional groups. The major peak of rGO is observed between 1450-1600 Vmax/cm^{-1}. A strong peak observed at 650 Vmax/cm^{-1} shows the presence of aromatic C-H bonds. Also, C=C peak at 1600 Vmax/cm^{-1} in the spectrum of rGO samples confirms the sp^2 structure of carbon atoms.

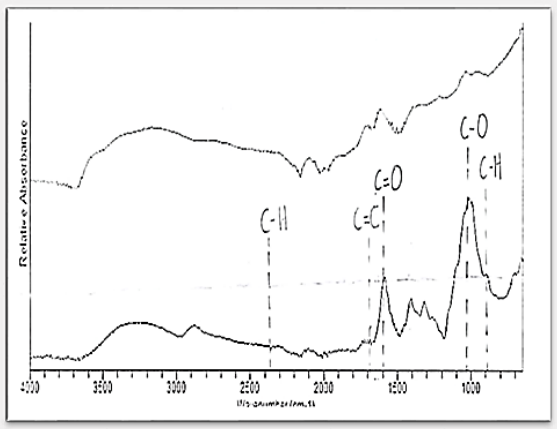

Fig 3a. FTIR of GO

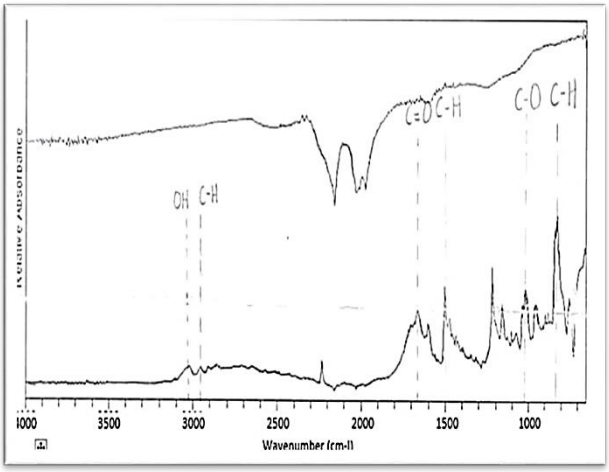

Fig 3b. FTIR of rGO

3.2 Characterization of DSSC

Keithley probe station SCS 4200 was utilized to measure sunlight to energy conversion efficiency. A photocurrent voltage versus current graph was plotted in dark and under UV light source (11watts) with an active cell area of 2.3 cm². The measurement parameters that were calculated include Open circuit voltage (V_{oc}), Short-circuit current (I_{sc}), Fill factor (ff), and energy conversion efficiency. In first test (Fig 4a.), no light source was directed towards the cell and the voltages ranging from 0-1 volts were applied. The generated currents on the applied voltages and shape of the curve confirmed the diode behavior of the DSSC. To examine the photovoltaic performance, the I-V curves in Fig 4b were obtained under the illumination of a UV source, while the voltage values remain same and power conversion parameters were generated. The calculated ff, Jsc, and Voc were applied in the formula to calculate the photo conversion efficiency of the fabricated DSSC.

$$\eta = (J_{sc} * V_{oc} * FF) / I_o$$

The Keithley probe station measured the following parameters of the DSSC:

Table 1 Probe Keithey Result 1

Incident light source	Open Circuit voltage (V_{oc})	Short circuit current (I_{sc})	Fill factor (FF)
UV lamp	0.7 volts	0.226 µA	77.106
No light	0.0 volts	0.024 µA	-

Table 2 Probe Keithley Result 2

Incident light source	Maximum Power (P_{max})	Maximum current (I_{max})	Maximum voltage (V_{max})
UV lamp	12.2 µW	6.119 µA	2.0 volts
No light	988.5 µW	988.5 µA	1.0 volts

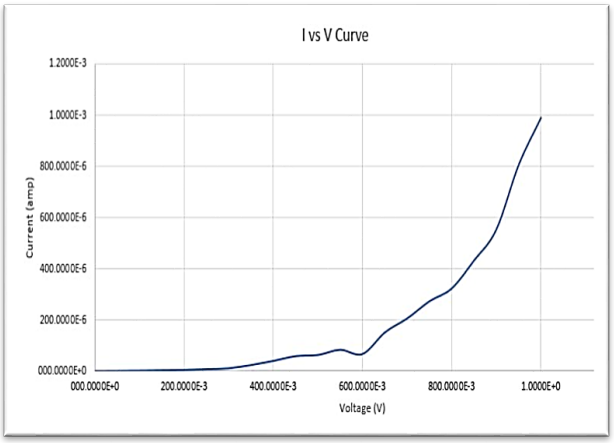

Fig 4a I-V Characteristic curve of DSSC in dark

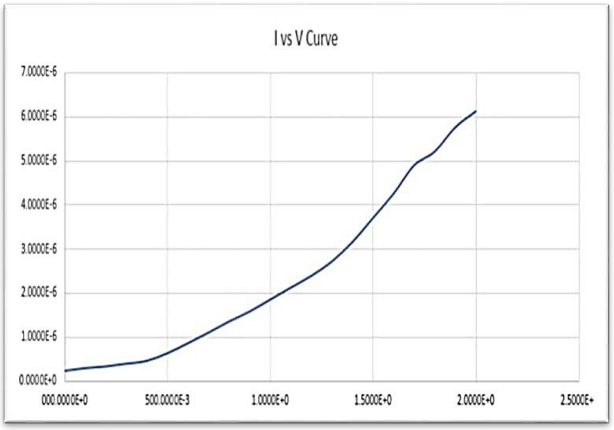

Fig 4b I-V Characteristic curve of DSSC under UV light

The DSSC with chemically reduced GO counter electrode (CE) exhibits V_{oc} of 0.65 V which is higher than the V_{oc} of 0.52 V and 0.36 V exhibited by graphite CE and graphene oxide CE DSSCs respectively. Thus, it yields efficiency (η) of 5.23% higher than the efficiency value of rGO based CE DSSC in [3]

4. Conclusion

In this work, the fabricated DSSCs substituted the expensive synthetic dyes as well as platinum catalyst which reduced the overall cost of the cell. GO, rGO were

synthesized using easy and less time-consuming method. The series of carbon family i.e. (graphite, GO and rGO) were employed in CE coating, in the fabrication of different DSSCs. Graphite, GO and rGO gave open circuit voltages of 0.52V, 0.36V and 0.65V respectively. It was found out that the rGO based CE gave the best open circuit voltage measurement in direct sunlight. This cell was considered for further testing and gave V_{max} = 2 V in illumination of 11 Watts UV light source. The conversion efficiency was enhanced by the reported work and was calculated to be 5.23%.

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Thermodynamic Optimization of Air Bottoming Cycle for Waste Heat Recovery

Abubakr Ayub[a,*]; Nadeem Ahmed Sheikh[b]; Rasikh Tariq[b]; and Muhammad Mahabat Khan[a]

[a] Department of Mechanical Engineering, Capital University of Science and Technology, C.U.S.T, Islamabad, Pakistan
[b] Department of Mechanical Engineering, HITEC University, Taxila, Pakistan

[*] Corresponding Author
E-mail: abubakr.ayub@cust.edu.pk
Tel: +923005346959

Abstract

Growing concerns of environmentalists have led the researchers to improve the performance of the gas turbines by reducing its carbon footprints. Besides increasing the turbine inlet temperature and pressure ratio of the gas turbine, one suitable way is to recover the exhaust heat from gas turbine using a waste heat recovery unit or units and employ it to produce useful power with the help of bottoming power cycles. Available steam Rankine bottoming and organic Rankine cycles are not suitable for small power plants (i.e. less than 50MWe); therefore, air bottoming cycle (ABC) is a viable option to be used as a waste-heat system of gas turbine cycle. In this work, we carried out a thermodynamic optimization of an ABC having a gas turbine in topping cycle. Energy analysis is used for this thermodynamic analysis. The component wise methodology is adopted, and sensitivity analysis is carried out to find the maximum thermal efficiency point of the ABC. The sensitivity study is conducted by varying mass flow rate ratio, pressure ratio, and effectiveness of integrated heat exchanger (IHX). It is observed that the increasing the mass flow rate of the bottoming cycle have adverse influence on performance parameters (efficiency and work output). After optimization, it is concluded that using ABC configuration, the overall plant efficiency is increased to ~43% as compared to simple topping cycle.

Keywords: *Air Bottoming cycle; energy analysis; combined cycle; thermodynamic optimization.*

1. Introduction

Gas turbines are the major source of power production in many countries. Gas turbines work on Brayton power generation cycle in which the compressed air enters in a combustion chamber. The combustion process increases the pressure and the temperature of the exhaust gases and the gas turbine produces work by expanding them. However, the shorter expansion of the gases in the turbine of the topping cycle wastes a lot of energy to the environment which significantly increases the environmental pollution; and as a result, the ozone layer depletion and global warming concerns are on rise. Therefore, there is a need of a waste-heat recovery system for the gas turbine topping cycle. Alklaibi et al.[1] estimated that the exhaust temperature of the gas turbine is between 370 to 540^{o}C; therefore, an air bottoming cycle (ABC) is a favorable option to be used as a waste heat recovery unit of gas turbine topping cycle. William Farrell patent the air bottoming cycle in 1998[2] and reported that this integration increases the thermal efficiency of the gas turbine while retaining its operational flexibilities. Afterwards, Poullikkas et al. [3] identified that the waste heat recovery from the gas turbine topping cycle increases the fuel to electricity conversion efficiency. Poullikkas et al. [3] also reported that the total power output of the ABC is increased to 18-30% as compared to a simple gas turbine. In a series of similar analysis; O. Bolland et al. [4] reported that the ABC increases the efficiency of LM2500PE gas turbine by 10%. They also proposed that ABC is an economically viable option too.

Mikhail et al. [5] evaluated the technical and the economic feasibility of the air bottoming cycle in a cogeneration scheme in which the hot air from the gas turbine is passed to food processing industry. They also proposed a case study of another powerplant in which the hot air from the gas turbine also provided pre-heated air to the industrial furnace. Najjar et al. [6] proposed the performance analysis of the air bottoming cycle for the gas turbine topping cycle. They reported that the proposed integration can reach a thermal efficiency of as high as 49%. They also performed a detailed parametric analysis by varying the turbine inlet temperature (TIT), mass flow rate ratio (MFRR), and the pressure ratio of the gas turbine. They concluded that the air bottoming cycle has

30% and 23% of higher work output and thermal efficiency respectively as compared to that of gas turbine alone.

In this work we carried out a thermodynamic analysis and optimization of gas turbine with air bottoming cycle as a waste heat recovery unit. The mathematical model is developed based on the energy and mass balance equations on each of the component of the powerplant. We also carried out a parametric study by varying the mass flow rate ratio, effectiveness of IHX and pressure ratio. The analysis is carried out to monitor the performance parameters of the powerplant which are overall work output and first law efficiency.

2. Description of Air Bottoming Cycle

The schematic representation is shown in Fig 1. The system comprises of two power cycles; topping gas turbine and bottoming air Brayton cycle. The air first enters topping compressor at state 1T. After compression, heat is added due to combustion process in combustion chamber (CC). In combustion chamber, combustion of fuel (CH_4) and air occurred which produced gaseous mixture at high temperature. The gaseous mixture at state 3T is expanded in turbine T1, thus produce power output. A part of turbine power output is consumed by air compressor C1 called back work ratio.

The exhaust gases carry large energy at state 4T. This energy is consumed by bottoming Air Brayton cycle via Integrated heat exchanger (IHX). The air which is the working fluid in bottoming cycle recovered energy due to heat exchange in IHX. As a result, the enthalpy of air at state 8 increases. The high energy potential of air at state 8 is utilized in turbine T2 for power production and operation of compressor C2.

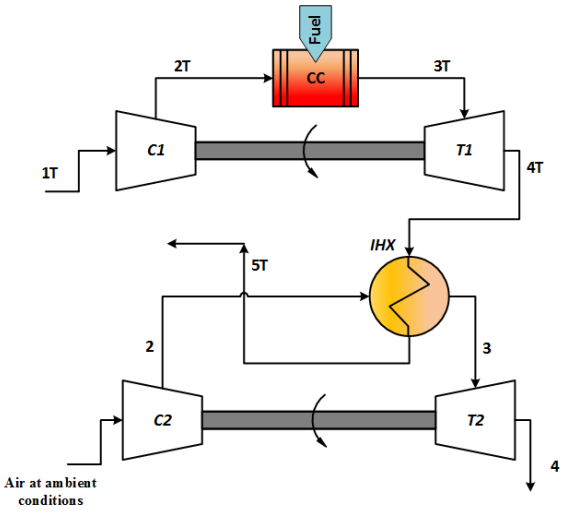

Figure 1 Schematic representation of air bottoming cycle

3. Thermodynamic Modeling and Analysis

3.1 Modeling

The power cycle explained in section 2 is modeled using energy balance relations. The first law of thermodynamics is applied to each component of the system. The first law relations for each component are delineated below:

Compressor C1

$$W_{c1} = \dot{m}_{air}\left[h_{2,T} - h_{1,T}\right] \quad (1)$$

$$\eta_{c1} = \frac{h_{2s,T} - h_{1,T}}{h_{2,T} - h_{1,T}} \quad (2)$$

Combustion chamber CC

$$Q_{in} = \dot{m}_f Q_{LHV} \quad (3)$$

$$\left[\left(1+\frac{\dot{m}_f}{\dot{m}_{air}}\right)h_{3,T}\right] - h_{2,T} = \eta_{combustion} \times \frac{\dot{m}_f}{\dot{m}_{air}} \times Q_{LHV} \quad (4)$$

Turbine T1

$$\eta_{t1} = \frac{h_{3,T} - h_{4,T}}{h_{3,T} - h_{4,Ts}} \quad (5)$$

$$W_{t1} = \dot{m}_g\left[h_{3,T} - h_{4,T}\right] \quad (6)$$

Compressor C2

$$\eta_{c2} = \frac{h_{2s} - h_1}{h_2 - h_1} \quad (7)$$

$$W_{c2} = \dot{m}_{b,air}(h_2 - h_1) \quad (8)$$

Turbine T2

$$\eta_{t2} = \frac{h_3 - h_4}{h_3 - h_{4s}} \quad (9)$$

$$W_{t2} = \dot{m}_{b,air}(h_3 - h_4) \quad (10)$$

The heat recovery from exhaust gases in IHX is calculated by,

$$Q_{IHX} = \dot{m}_{b,air}(h_3 - h_2) \quad (11)$$

Where h_3 and h_{5T} is calculated using effectiveness method [7] based on heat capacities of inlet streams at state 4T and state 2. Furthermore, the bottoming and combined cycle performance parameters are evaluated using following relations,

$$W_{total} = W_{net,T} + W_{net,b} \quad (12)$$

$$\eta_b = W_{net,b}/Q_{IHX} \quad (13)$$

$$\eta_{comb} = W_{comb}/Q_{in} \quad (14)$$

3.2 Analysis

The thermodynamic analysis involves the calculation of power output and thermal efficiency of individual (topping and bottoming) cycles and the combined cycle. The analysis is done using Engineering Equation solver (EES).

3.2.1 Operating Parameters and Assumptions

Following assumptions are made for analysis:

- All processes are at steady state,
- Compression and expansion processes are adiabatic but non-isentropic.
- Pressure drops in the components and heat transfer with surroundings are negligible.
- Exhaust gas mixture is assumed as an ideal gas air for retrieving thermo-physical properties.

The thermodynamic properties at all states are calculated using component wise relations presented in section 3.1. Moreover, the input and operating parameters are taken from literature are given in Table 1. The methodology for thermodynamic analysis is illustrated in fig 2.

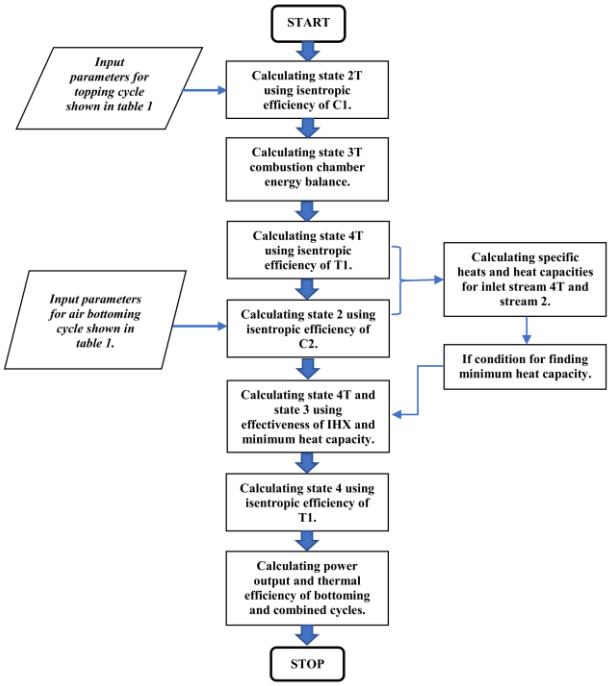

Figure 2 Methodology for analysis

Table 1 Input and operating parameters for analysis[8]

Parameter	Value
Topping Conventional Gas Turbine Cycle	
Compression ratio (R_c)	14
Turbine inlet temperature (TIT)	1500 K
Efficiency of combustion chamber (η_{comb})	0.97
Isentropic efficiency of compressor (C_1)	0.8
Isentropic efficiency of Turbine (T_1)	0.9
Mass flowrate of air (m_{air})	105 kg/s
Temperature at inlet of compressor (T_{1T})	303 K
Pressure at inlet of compressor (P_{1T})	0.1 MPa
Bottoming Air Brayton Cycle	
Temperature at inlet of compressor (T_1)	303 K
Pressure at inlet of compressor (P_1)	0.1 MPa
Isentropic efficiency of compressors (C_2)	0.8
Isentropic efficiency of Turbine (T_2)	0.9
Compression ratio (r_c)	4
Effectiveness of IHX (ε_{IHX})	0.85

4. Results and Discussion

The performance of the combined cycle is studied for variation in mass flow rates. A dimensionless number of mass flowrates is introduced which is the ratio of bottoming air mass flowrate to the topping air mass flowrate. The ratio is given as,

$$MFR = m_b / m_T \quad (15)$$

The large MFR number means large mass flow rate in bottoming cycle, thus, represents the larger size of the power cycle and vice versa.

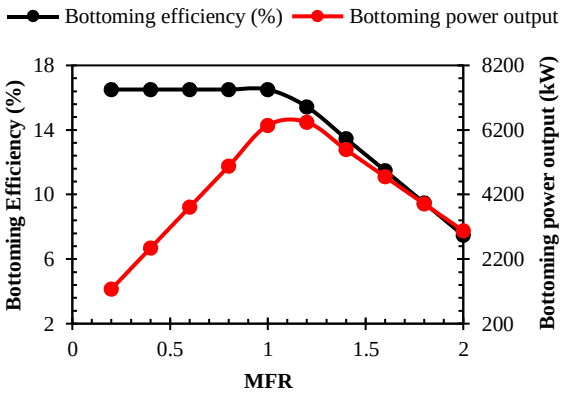

Figure 3 Performance of bottoming cycle with variation of mass flow rate at TIT =1500 K and $r_c = 4$

The variation of power output and thermal efficiency of bottoming air Brayton cycle is illustrated in Fig 3. The bottoming power output showed the increasing trend for MFR<1.2 and decreasing trend for MFR≥1.2. Since, the increment in the mass flow rate of bottoming cycle decreases its potential to elevate its temperature from integrated heat exchanger; therefore, the efficiency and the work output decreases after MFR greater than 1.2. This phenomenon can also be observed in Fig. 4 where the combined efficiency is decreasing after an MFR value of 1.2.

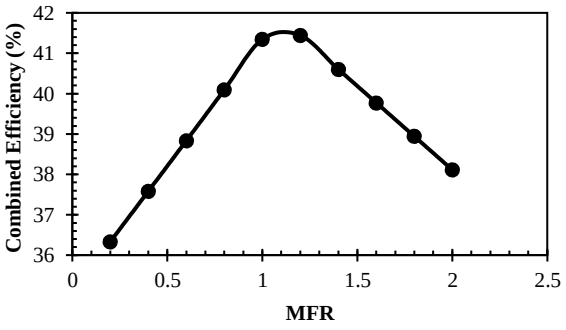

Figure 4 Performance of combined cycle with variation in mass flow rate at TIT = 1500K and $r_c = 4$

It is concluded from Fig 3 and 4 that the maximum performance is found around MFR= 1.2.

4.1.1 Optimization

The thermal efficiency of the combined cycle is also maximized using Conjugate directions optimization technique accessible in EES. The objective function and constraints are as follows,

Maximize:
Thermal efficiency (η_I)

Constraints:
$0.2 \leq MFR \leq 2$
$0.9 \geq \varepsilon_{IHX} \geq 0.7$
$8 \geq r_C \geq 1$

The optimum results are shown in Table 2. The optimum performance is found at $\boldsymbol{MFR}$=1.1, $\boldsymbol{\varepsilon_{IHX}}$ = 0.9 and $\boldsymbol{r_c}$ = 3.7. The gain in performance compared to simple gas turbine cycle is also calculated to assess the significance of waste heat recovery. Therefore, the percentage gain in thermal efficiency is 21.4%.

Table 2 Optimum results of ABC cycle

Power input in combustion chamber	101130
Combined cycle power output	43067 kW
Combined cycle thermal efficiency	42.6%
Heat recovery	45425 kW
Bottoming cycle power output	7598 kW
Bottoming cycle thermal efficiency	16.7%
MFR	1.1
ε_{IHX}	0.9
r_c	3.7

CONCLUSION

This paper presents a thermodynamic analysis and optimization of Air bottoming cycle for waste heat recovery of conventional gas turbine cycle. Waste heat recovery greatly increase the performance of gas turbine. Moreover, it helps in reducing harmful gases going into the environment, hence, plays dynamic role in minimizing global warming and carbon foot prints. Following can be concluded from this study:

1. The performance of combined system is better than simple gas turbine cycle (topping cycle)
2. The optimum thermal efficiency of Air bottoming combined cycle is 42.6% at MFR =1.1, r_c =3.7 and ε_{IHX} =0.9.
3. The gain in thermal efficiency compared to topping gas turbine cycle is 21.4 %.

RECOMMENDATIONS

As a future work, it is recommended that exergy and economic analysis should be done for ABC combined system for better evaluation of available energy utilization and overall economic and environmental foot print. This will lead to commercial utilization of this power system for various industrial and agricultural applications.

ACKNOWLEDGMENT

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Potentials and Prospects of Solar and Off-Grid Renewable for Sustainable Development in Libya

Dr Satya P.Bindra[1]; Amal Sh. Almsalati[2]; Nabil Salih[3]; Waled Astiata[4]

[1]OKYD Ambassador Tripoli City Libya, [2]UNFCC Women Gender Focal Point Libya & CEO Al Fawz Intl, [3]High Institute Garabouli Libya, [4]Tripoli University Libya

ABSTRACT

The paper is designed to present potentials and prospects of Solar and Off-Grid Renewables for sustainable development of Libya. As elsewhere, Libya in crisis too is affected not only by human-induced climate change, but also disruptions and the volatility of world oil markets. After describing the potential and prospects for replacing nonrenewable fossil fuels (i.e., hydrocarbon) as a backbone of the economy in Libya by a range of renewables including wind, solar-PV, hydropower, geothermal, and biomass to deliver energy it focuses on land opportunities and constraints and on production costs as a function of resource availability and depletion and of innovation dynamics. It outlines a range of renewable production technologies to help demonstrate how to try to spread and instill the culture within Libyan society of the idea of renewable energy (RE). It uses best practices and lessons learned to start this culture at an early stage via universities, Libyan academies, high institutes, technical colleges & schools in Libya. Lessons learned are described to highlight a way forward towards a low carbon economy in the country to combat the dangers of global warming through the use of abundantly available renewable potential The objective is to ensure that by 2030, there will be substantial increased share of renewable energy in the global energy mix. It aims to double the global rate of improvement in energy efficiency. It helps by 2030, enhanced international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology. The goal is to expand infrastructure and upgrade technology for supplying modern and sustainable energy services in Libya and its MENA, Africa & Euro Med regions, in particular land locked & least developed countries, Small Island developing States, in accordance with their respective programs of support.

The off-grid component demonstrates the role of micro grids in the region, smart villages, aggregated small scale PV installations and energy storage. Finally it demonstrates efforts under way through International Solar Alliance (ISA) to help achieve *the Sustainable Development Goals (SDGs) through entrepreneurship and innovation*, and the World Entrepreneurs Investment Forum (WEIF) to leverage entrepreneurship and creative thinking to strengthen sustainable development and to show everyone in business on how to scale up access to green energy including the clean electricity.

Key Words: Off-Grid Renewable, Sustainable Development, Libya, Energy & Sustainable Development (Track-2), Energy Management (Track-3)

1. INTRODUCTION

The solar energy is at threshold of its biggest days. The amount of solar energy that reaches earth's upper atmosphere is about 1,350 W/m2—the *solar constant.* The atmosphere reflects scatters and absorbs some of the energy. Peak solar intensity is at solar noon. Energy from the sun reaches earth as *direct, reflected* and *diffuse* radiation. *Direct radiation* is highest on a surface perpendicular to the sun's rays (angle of incidence equal to 0 degrees) and provides the most usable heat. *Diffuse radiation* is energy from the sun that is scattered within the atmosphere by clouds, dust or pollution and becomes non-directional. The amount of the sun's energy reaching the surface of the earth also depends on cloud cover, air pollution, location and the time of year. Libya accounts for over 6 million population spread over an area of 1.76 m sq km bordering the 2000 km of Mediterranean Sea coast line in the north. The country's renewable energy resources have the potential to produce the equivalent to almost seven million barrels of crude oil per day in energy. Because of its wide applications due to its convenience in use and being economically effective in many application , the renewable energy is used in Libya in the form of photovoltaic conversion of solar, solar thermal applications, wind energy, and Biomass. It could generate enough renewable power to meet its own demand and a "significant part of the world energy demand by exporting electricity. As per recent estimate Libya has an average daily solar radiation rate of about 7.1 kilowatt hours per square meter per day (kWh/m²/day) on a flat plane on the coast and 8.1kWh/m²/day in the south region with average sun duration of more than 3500 hours per year. [9] The country barely uses only 0.1% of its estimated 88% desert territory for solar power.

Paper is designed to demonstrate that how OKYD Ambassador team and UNCSD Rio+20 Focal point on future country wants for sustainable livelihood in Libya is devising a clear strategy to demonstrate that within a defined timetable renewable energy technology has the potential by taking it forward. This is intended to be achieved by using solar power on three principles: collection, storage and distribution of the sun's energy. This is being planned by assisting the country in developing its manpower as human resources capable of installing and maintain renewable energy systems. Strategy considers harnessing not only the country's 88% desert territory for solar power but also its dry, hot and prolonged gusts as of great potential for wind power. By harnessing the renewable energy resources available in the form of solar and wind power, country would, not only meet its own demands for energy, but also a significant part of the world's demands by exporting electricity as a gateway to EU & Africa

.2. AN APPRAISAL OF RENWABLE ENERGY SITUATION IN LIBYA

The use of renewable energies has been introduced in a wide application due to its convenience use and being economically attractive in many applications, the most potential renewable energy sources are solar energy, wind energy, and biomass. Photovoltaic conversion which is the direct conversion of solar energy to electricity may be the most reliable source for rural electrification. The use of wind energy to electrify remote areas will not be a reliable source as wind energy is not a continues supply, beside the use of wind source need maintenance personal, so this option will not be a reliable power supply in remote areas for developing countries. Biomass energy sources are limited to small applications of individuals as an energy source but not as electricity source.

As per recent estimates Libya is to invest $140 billion in projects over the next ten years. The areas earmarked for development includes a programme by the General Electric **Company of Libya (GECOL)** to increase capacity from about 13,000 MW in 2012 to 19,000-20,000 MW by 2020; Country is committed to a $2.5-billion upgrade of the state's busiest airports, which aims to expand capacity to about 28 million passengers a year from an estimated 5 million; In addition there is a provision of 200,000 new homes, with supporting infrastructure, in the next seven years. It is estimated that the country will face a housing shortfall of 500,000 units by 2020. In terms of housing for locals, there is seen to be a significant requirement for new units nationally to meet demand. Many new large-scale projects were under construction prior to the revolution but have yet to be completed. In 2013, 30,000 housing units with 131 contracts for infrastructure had been activated, some of which are completion projects and some newly activated. In the eastern Libyan city of Shahat there is planning to build 4,500 new residential housing units. The promotion of private sector industry and the diversification of the economy are priorities and will require the development of properly planned industrial zones like Free zones to encourage private industrial development. The retail market is underdeveloped, and the construction of several planned retail malls have yet to start. There is a limited supply of purpose-built office space in Tripoli and this is still predominantly provided in the Tripoli Tower (formerly Burj Al Fateh Tower), which provides moderate quality accommodation, and the Dhat El-Emad development which is an older building. A new office building next to Tripoli Tower, Burj Bulayla, has still not been opened and occupied.

94.5 percent of Libya land is desert and semi desert inhabited by Ethnic Arabs, Arabized Berbers, Tuareg and Tubu population which forms around 97% of population. The country has virtually no accessible water resources on the earth's surface. Libyan climate ranges from Mediterranean along the coast line to extremely dry in the interior south. The barren, flat and undulating plains have barely 1.03 percent land as arable. Out of petroleum, natural gas and gypsum as most prominent natural resources, the first two are the main driving factor for the Libyan economy. Hydrocarbons contribute about 95% of export earning, 65% of the GDP and about 80% of government revenue.[1] It is also due to the fossil resources, that Libya has always enjoyed a fairly high international interest and relevance. Although aftermath of 17, Feb 2011 revolution has impeded its economic activities, it is still widely considered to be a land of a unique opportunity for entrepreneurial activity and thus economic growth.

95% of Libyan export revenues is dominated by the oil sector. As per estimates in 2011, Libya has produced about 30,962 ktoe of energy, which is about 360,088.19 GWh. Crude oil makes up almost 79% of energy production. Renewable energies have been neglected and has only risen to about 0.06%.[5] [1]Due to rounding's, the percentages may not add up to a hundred.

2.1 An Overview of Electricity Demand and Supply & Consumption

The electricity generation has more than doubled from 2000 to 2010. The country as per 2010 estimates had a total electricity installed capacity of 6.8 GW, which is generated by power plants either fueled by oil or natural gas. World Bank estimates show that, 99.8% of the Libyan people have access to electricity, which is the highest rate among African countries.[7] Out of the total final consumption of 22,035 GWh in 2011, Commercial and Public Services accounted for 36% whilst the residential sector amounted to 24% and the Industry to 22%. Electricity consumption in Libya during 2011 was of the order of total 32.96 TWh meaning 3.73 MWh per capita.

The national electric grid consists of a high voltage network of about 12,000 km, a medium voltage network of about 12,500 km and 7,000 km of low voltage network. Some villages and remote areas which are located far away from these net-works cannot be connected to the grid due to economic reasons. Those locations with a small population and a small amount of energy demand, use diesel generators as a power supply, requiring regularly maintenance and supply of fuel.[10]

There is an operating grid interconnection to Egypt with a capacity of 240 MW which is 180 km long. Regarding to grid access of renewable energy projects, there is neither a priority access granted to RE by law nor has a grid code been developed yet. Additionally, a detailed map for potential RE site is missing.

3. PROBLEMS & PROSPECTS FOR SOLAR ENERGY IN LIBYA

The present energy supply in Libya like most other countries cannot be considered as a sustainable

sources of energy, as the energy costs exploding, the sources are limited, and the environment issues. For Libya the conventional sources of energy are limited to two sources.

1. Oil with a total discovered resource estimated by 40 billion bbl.

2. Natural Gas with a total discovered resource estimated by 1300 billion m^3.

The oil resources for Libya will not last more than 50 years as of today production and discovered resources, while the natural gas is expected to last more than that. Libya is an oil exporting country and most of the produced energy is exported. As per an estimate in 2050 the price of oil barrel may reach more than 200 $ / barrel, it is expected that Libya would need about 70 million barrels of oil per year for its electricity requirement, this will cost about 14 billion dollar per year. The option would be better to sell the oil or to burn it, the answer will depend on the availability of alternative sources which can replace the conventional sources of energy like solar energy. The solar radiation in Libya is equivalent to a layer of 25 cm of crude oil per year on the land surface.

Libya is developing local Libyan resources based on stocktaking exercise on problems and prospects by stakeholders to meet the anticipated future renewable energy needs in cooperation with global, regional & UN partners who are already engaged to review, amend, modify and add value to our renewable business plans. With the state of the art input from the world class partners OKYD Ambassador, UNCSD Rio+20 Libya National Focal Point, US GESMI, WEF Switzerland, MITA Malta, UNDP ICT Practice area, UNIDO/NEPAD APCI, EU 2014 ERASMUS Plus, etc) Libya aims to develop the Renewable industry by matching the available resources to the upcoming projects. This is in line with the national economic development strategy in New Libya using Assessment Centre Approach for tapping underutilized and Critical Link in the Organizational Value Chain. Using reliable (i.e. consistent in measurement) and valid (i.e. measure what they purport to measure) the value added by Assessment Centres in development and selection practices are based on validated design, compared to conventional standardized psychometric measures. Against this background, Libyan Assessment Centre uses these sophisticated tools, especially in light of a hibernating global economy for rebuilding Libya. Libyan Assessment Centre methodology is designed so as to demonstrate the following:

- strong return on investment;
- precision and accuracy in measurement;
- integration of technology;
- support better talent management, selection, and development decisions;
- reduced cultural bias;

- clear linkage to key organizational outcome (i.e. higher performance, lower turnover, less absenteeism);
- justification of further investments in HR initiatives to senior management; and
- increasing the perceived value of HR to the organization

Thus the main purpose of Assessment Centers (ACs) in Libyan energy organizational environment is to help successfully and accurately measure job-related traits of individuals to help predict their future performance and assess their suitability for roles. Effective human resource strategies being employed includes: selection and development decisions; workforce capability; employee engagement; talent management and succession planning that would be built on the foundation of accurate and reliable information. It uses proven expertise to help in providing rich layers of information for managerial decision-making. Human related diagnostic information is intended in all likelihood only result in valued organisational outcomes when assessment practices are clearly linked to long-term strategy.

Numerous methods employed by OKYD Ambassador team and UNCSD Rio+20 Libya Focal point to estimate the potential of renewable in Libya shows that since energy prices are heavily subsidized in all economic sectors in Libya, it is difficult to estimate the potential of renewable and energy efficiency on a cost-effective basis. The present status is that Renewable are not utilized in significant amounts. Barely 5 MW solar energy is separated into several small PV projects, have been installed yet. Country fails to meet its international obligations requirements envisaged under various UN conventions on climate change.

3.1 Solar Power Resources

A general solar map developed using satellite data shows that Libya has a great potential for solar energy. However, it requires developing a detailed solar atlas.[11]. Estimates in the coastal regions show that the daily average of solar radiation on a horizontal plane accounts to 7.1 kWh/m2/day. However, the radiation is 8.1 kWh/m2/day in the southern region. The average sun duration of more than 3,500 hours per year means it is equivalent to a layer of 25 cm of crude oil per year on the land surface.

The total installed capacity of solar energy which is barely 5 MW in 2012 is achieved from small **PV** projects since 1976. In the first instance solar system were used to supply a cathodic protection for the oil pipe line connecting the Dahra oil field with the Sedra Port. During 1980, first PV system was used in the communications sector to supply energy to the microwave repeater station near Zella. In all till 2006, 80 stations running by PV in the field of communications have been established.

As per estimates in 2005, the total installed photovoltaic peak power was around 420 KWp. In 2012, it exceeded to 950 kWp. At El-Agailat, a PV pumping system was installed at the beginning of the 1980s. Till 2006, 35 PV water pumping projects have been installted (~110 KWp). The total capacity of PV water pumping system was 120 kWp in 2012. The use of PV systems for rural electrification was only starting in 2003. By 2006, the total number of remote systems installed by General Electric Company of Libya (GECOL) was 340. It had a total capacity of 220 kWp. The Center of Solar Energy Studies (CSES) and the Saharan Center also installed 150 with a total power of 125 KWp. In 2012, the rural electrification PV systems have a capacity of 725 kWp. Currently, there are 3 PV projected in the pipeline: a 14 MW power station in Houn, a 40 MW project in Sabha, and a 15 MW power station in Ghat.

The estimates on technical potential in respect of concentrated solar power (CSP), shows that country can generate around 140,000 TWh/year which is equivalent to 27,000 GW of capacity at 60% load factor.[1] Overview further shows that in 1983, 10 systems of solar heaters were installed. Till 2006, an additional 2000 had been deployed. UNDP in line with the United Nations global development network advocating for sustainable development has recently installed solar panels for back-up power in 15 different hospitals across Libya as well as one municipality building between 2016 and 2017. It plans to install more in other hospitals and public facilities such as schools and municipal buildings in 2018. The intensification of the Libya conflict since 2014 has caused critical infrastructure damage, disrupting basic services such as water, sanitation and electricity supply. To meet people need for electricity UNDP is providing with a clean alternative i.e. solar energy as a long term and sustainable solution as an efficient alternative source of power which reduce the carbon footprint and can help a country to insulate from price fluctuations in global energy markets. The goal is to

support through ensuring constant and cost-effective access to electricity, while also mitigating the impact of climate change and advancing multiple Sustainable Development Goals.

This solar energy solution is found to decrease the public buildings reliance on the devastated national grid ensuring a continuous -and easy to maintain – source of electricity. This off-grid solution is working 24hrs a day connected to the Grid in Emergency cases (Cloudy periods) if needed. The system can be described in two main sub-systems, the production of electricity using solar panels & Energy storage using some high capacity batteries.

With the installation of solar systems in health facilities are providing more patients with access to medical care through a stable, clean and reliable energy supply. The aim is to help save lives and using solar panels for the health sector is proving to be a very smart choice.

Patients using these hospitals have now access to uninterrupted health services. The capacity for each hospital is between 15 and 20 KVA and the system is modular and can be upgraded to tens of times of its capacity, if the needed space for the upgrade is available, whether on the roof or on a ground fields. Meanwhile, other system components can be upgraded as well, like the batteries bank and Inverters. UNDP Libya hopes to install solar power panels in other hospitals and public facilities such as schools and municipal buildings.

UNDP has been informed by doctors that power used to go off during surgical procedures and they had to stop the operation until the generator was turned on and this was putting at risk the patient's life. However, since the solar panel were installed, they are continuing the medical procedures without interruption. In addition equipment such as ventilators and anesthetic machine that were at risk of damage due to the power cut, are now safe.The system is not only providing them with a sustainable long-term energy solution, but is also helping them financially because the electricity bill will be reduced thanks to the solar grid.

Thus solar system in health facilities is helping Libya to achieve some of the Sustainable Development Goals such as good health and well-being, affordable and clean energy, climate action and partnership. This is is indeed a significant contribution to the 2030 Agenda for Sustainable Development and its commitment to 'leave no one behind.

Ultimate aim is to achieving complete coverage of the electricity requirements for 20% of Primary Health Care Health Facilities in Libya and 83% of hospitals for emergency wards, operating theatres, delivery rooms, pharmacies and laboratory services as well as coverage of close to 200 other health facilities such as NCDC branches, dialysis centres, dental clinics, etc. This would greatly improve both the access to and the quality of health services while reducing the operational costs.

3.2 Potentials to build and foster partnerships and share best practices in RE entrepreneurship and innovation.

Bearing in mind the arid semi-arid climate of Libya the conservation of energy and RE improvement is economically feasible through International Solar Alliance (ISA) that focuses on growth, where the large part of that has to come from the technology changes and innovation which is a continuous process. And unless, the industry, government, or all the stakeholder, whether it is NGO or consumers, everybody needs to be aware and updated as to what is the new trend in the market. It is innovation that has brought the cost down, that has made solar affordable in last five years, and we definitely will continue with that. The whole idea of ISA is to facilitate an affordable finance for solar, which will help in supporting agriculture, mini and microgrid all of that for the member nations. So, in the process, all the experience will be shared, and all the risk will be brought to the front where there will be standard protocol formulated to mitigate them. The fund is also being created for this, approximately more than $1 billion has already been allocated for the ISA physical roadmap. So, it would help to create an integrated global solar market and adopt it and support across ISA member tropical countries. . It is hoped that this process will help outline a range of renewable production technologies to help demonstrate how to try to spread and instill the culture within Libyan society of the idea of renewable energy (RE). It uses best practices and lessons learned to start this culture at an early stage via universities, Libyan academies, high institutes, technical colleges & schools in Libya. Lessons learned highlight a way forward towards a low carbon economy in the country to combat the dangers of global warming through the use of abundantly available renewable potential. This would

help ensure that by 2030, there will be substantial increased share of renewable energy in the global energy mix. The goal is to expand infrastructure and upgrade technology for supplying modern and sustainable energy services in Libya

The off-grid component will focus on the role of micro grids in the region, smart villages, aggregated small scale PV installations and energy storage. After presenting the commercial and industrial opportunity it will dwell upon Solar Media's hotly anticipated Women in Power business led by UNFCC Women Focal Point by bringing together the most exciting and tenacious female owned businesses from across the region.

Thus, it demonstrates efforts under way to achieve *the Sustainable Development Goals (SDGs) through entrepreneurship and innovation*, and the World Entrepreneurs Investment Forum (WEIF) to leverage entrepreneurship and creative thinking to strengthen sustainable development around the world. Indeed, this is the way forward to bring major sources of funding from development finance to private equity grants, foundations and commercial debt to show everyone in business on how to scale up access to green energy including the clean electricity.

4. RESULTS OF STOCKTAKING EXERCISE FOR THE ENERGY SECTOR IN LIBYA

An in-depth stocktaking exercise by stakeholders of Libyan problems, prospects, situation assessment prepared and presented by OKYD Ambassador Team and UNCSD Rio+20 Focal point at numerous forums reveals that country had and is still is having a fairly one-sided economy that heavily relied (and still relies) on the occurrence of fossils. Due to inherent over dependence and ease of accessibility to huge quantity of fossil energy sources, renewable energy sources were considered to be of secondary relevance. Thus the efforts for pursuit of a diversified and sustainable energy sector has been and still are limited during the old regime mentality that had strongly subsidized energy coming from domestic fossil sources. It developed and maintained hydrocarbon sector with little or no economic incentive to shift to a more sustainable energy mix.

Respondents of solar applications in buildings design survey shows that passive solar is best for buildings that have low internal heat gains and in which direct solar gain is directed to absorbent thermal mass. This is a way forward to combat the dangers of global warming and encouraging the use of solar energy as renewable sources of energy.

Post-revolutionary establishment of a Ministry of Electricity and Renewable Energy is indeed a step towards right direction towards sustainable livelihood of Libya. It is an encouraging step towards the integration of the subjects of renewable energy and energy efficiency into the national agenda. The good news is that the Renewable Energy Authority of Libya or REAOL soon after 17 Feb 2011 revolution has established a target of 10% renewable by 2025, which would account for a total capacity of 2219 MW. Intermediate targets are 389 MW by 2015, and 1069 MW by 2020.

Overview of Laws and Regulations in the country shows that there is no legislation which covers the financial support for solar energy or which addresses the issue of financing additional costs of solar energy projects. In addition much in demand pressure for the need for a clear legislation for the participation of private capital in the power sector is missing.

There is an absence of policies for solar energy in Libya. There are no public competitive bidding for large-scale private solar energy projects. In addition, there is no obligation to conclude long-term power purchase agreements with solar energy producers. Sorry state is apparent from the fact that there are also not feed-in tariffs and no net-metering policy for small scale solar energy projects.

In respect of finance and investments, Libya does not have an RE fund for financing RE projects. Further review of present situation shows that the currently planned projects are planned to be financed through government budget. The power sector is still closed for private investors. There are no financial guarantees to private investors to ensure payment under power purchase agreements by the Libyan government. Internal tax privileges are not provided for solar energy projects. Libya needs a sea change. The *Keys to Success are:*

1. Accelerate technology transfer to Libya & neighboring Arab, MENA, Mediterranean, Euro-Med & African countries, through Libya (The Gateway to both EU & Africa).
2. Promote renewable culture within the region and establish related industries.

3. Strengthen strategic partnership with first tier renewable technology providers.

4. Create successful business projects through technology investments.

Libya Government needs to follow good practices that gives multiple benefits to solar energy projects such as no need for industrial clearance, availability of loan, excise duty exemption, custom duty concession, financial support to renewable energy's R&D projects, income tax holiday, accelerated depreciation, preferential tariffs, interest and capital subsidies, energy buy-back and third party sale and trading. At the same time, the Libya Government must reduce the capital cost of solar and related renewable energy projects so that more and more companies can invest in the sector. To fulfill this aim, Government must adopt latest and suitable technologies in the sector and promote healthy competition by conforming and complying with best practices. REAOL employees need to be leaders in their field capable of delivering valued organizational outcomes where assessment practices are clearly linked to long-term strategy.

5. CONCLUDING REMARKS

Libya is rightly considered as a high potential place for renewable energy sources, the use of a stand-alone PV power supply in communications, cathodic protection, rural electrification, and water pumping. After a brief overview paper indicates that solar energy is deemed as the future energy. OKYD Ambassador Team & UNCSD Rio+20 Focal point through its participation in 23rd Conference of Parties of the United Nations Framework Convention on Climate Change (COP23) on November 13, 2017. Bonn Germany gives direction with its various connect, comply and conform (3Cs) policies think tank and working groups. The meeting of Libyan private sector companies engaged in the RE sector indicates ways in which the Libyan authorities can help facilitate the development of the sector and create a localized industry. Specifically, there is need to develop the nascent RE sector in Libya to generate electricity in order to ease the burden on the state electricity generation sector which has been struggling since the 2011 revolution to meet peak demand. With this regard, the state needs to prioritize the sector by making the opening of Letters of Credit for the import of RE related equipment, knowhow and material more readily available. Libya is currently in the midst of an acute economic and financial crisis. Demand for LCs at the official exchange rate (LD 1.40 per US dollar) outstrips the availability of foreign exchange in the Central Bank of Libya.

The role tasks and functions of **Renewable Energy Authority of Libya (REAoL**) require translating theory in to practice with in legal frameworks and official goals. Based on UN good practices, the REAOL needs to adapt, adopt and develop Renewable Tech "Delivering as One initiative builds on efforts to increase coherence and effectiveness of client operations at country level. Learning from "One UN", the aim of this initiative is to drive collaboration and create efficiencies within the "UN family" and the NGOs they cooperate with.

Finally, Libya need to grasp cash offers from donors like German GIZ that has rightly and timely initiated a 1,000 Roofs Program, which seeks to install 1,000 PV roof-top systems with a total capacity of 3 MW. No wonder, these Installations can be on-grid and off-grid to have the potential to offer a basis to establish further support instruments, such as a feed-in tariffs.

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MANAGING OCCUPATIONAL HEALTH & SAFETY IN SMALL AND MEDIUM SIZE CONSTRUCTION COMPANIES IN HYDERABAD

Rameez Saqib Khan [a], Ammara Kaynat [b], Ali Raza Khoso, Aisha Anis Sakrani, Azizullah Channa.

[*a Post] Graduate Student, MUET, Jamshoro,
[b Graduate] Student of Architecture Department MUET, Jamshoro,

[b] Corresponding Author
E-mail: ammarakaynat92@hotmal.com
Tel: +923313690063

ABSTRACT:

Issues on the construction site related with health and safety have continuously been key problems. Reliable records show that building site is the most dangerous task for health and safety management, mainly in UN-industrialized countries. Measures have been taken to solve this problem, but outcomes are still unsatisfactory. Pakistan is enjoying a strong construction development, but unfortunately, nearly all sectors of construction industry suffer from poor health and safety management. It may be claimed that related guidelines are out-of-date and unrelated in day-to-day construction processes. The aim of this research is to characterize present practices related to health & safety control in Pakistan. In following these objectives, multiple tactics, are used, whereby a walk-through survey, a check-list and a questionnaire survey for selected site was conducted. Whereas, the total number of respondents on all 4 sites were 201. Furthermore, for questionnaire survey purpose sampling is applied, to obtain the health, safety, and environmental procedure sat present used on construction sites. Results showed that most workers have a poor understanding of risk and don't look to take health, safety, and environment as an important issue, which results in high rate of minor injuries. In the same way, lack of health and safety management plan, in adequate first aid facilities, lack of personal protective equipment's and absence of the accident reporting system were also observed. This research will help in highlighting the issues and giving the practical solutions for each problem

INTRODUCTION:

Construction sites are the most significant part for social and economical life of a country it is significant in developing & developed part of the world, because its effect economically and socially, but, these are also known as the most hazardous place for workers at the same time. Although continuous improvement was taken in recent times, but the safety implementation in the construction industries is still very poor. (Rizwan, 2008). The literacy ratio of Pakistan has been just 57.7 percent. (Farooq, 2011), in addition, the absence of strong legislation, these two are key reasons considered for lacks safety culture. Moreover, high work-related fatalities justify that the Pakistan has been unsuccessful in reducing the working accidents and injuries. Most of the construction firms, see this subject as an obligation or an obstacle for them in achieving their proficient commitments and goals. Personal protective equipment (PPE) provided to labour, were primarily refused by them to use, because they don't feel relaxed to work with PPEs. (Seema et al 2014).

Subsequently, 2003 to 2009, fatal incident cases ratio was 2,836 reported in Pakistan (Awan, 2007). This was just a little part represented of 55 million the total labor force of Pakistan. The construction sector has just 6% of the total labor, this means that 3.33 million workers are linked to the construction industry. Now consider 6% of 2,836 incident cases, it means only 170 accidents were reported out of 3.3 million workers during the years 2003-2009. This shows either 99% health and safety implementation which is obviously impossible or very poor reporting of fatal or injury incident system in Pakistan. This is all because of non-seriousness of government authorities and construction companies. The casualty rate/ 1 lac is 20.7 which is much more than well-off nations. In comparison with a fatal accident ratio of London is 0.55 per 100,000 workers (Azim ,2010).

The construction environment in Pakistan cannot be considered as workable because of high consumption of energy, material, and water. Furthermore, technologies used in the construction industry are outdated & maintained improperly, which results in the high feeding of fuels and more release of toxic gases. There isn't any perception of utilizing pre-fabricated items, mostly building parts shaped on site. Ultimately, all these practices increase the cost, time and usage of water and energy. In contrast, water wastage is the key disadvantage of construction industry because it is the basic ingredient of concrete. In this regard a proper health & safety plan for labor must be implemented to make the work place convenient for labor.

PROBLEM STATEMENT:

We can experience the imbalance between anticipated and actual progress in the development of urban construction projects which shows that there are various obstacles and risks which not only results in unsustainable urban management, but it also threatened the reconstruction and development of urban spaces. The most hot favorite risk in construction companies is delays in the payment of contractor, these risks also includes claims and statements due to the lack of handling financial instruments, the governance of relationships rather than rules in the tenders resulting from employer actions, low commitment to the quality of work provided by their subcontractors, failure to complete the detail engineering by foreign contractors on time, weaknesses in contractors' financial resources, and offering lower prices than reasonable by contractors to win the tender.

RESEARCH AIMS AND OBJECTIVES:

The Research paper lies in suggestion the safe environmental conditions for the construction workers. To achieve the research goals author proposed following objectives:

- To identify some major hazards and their risk quantification in construction at Hyderabad.
- To identify factors behind health and safety concerns in construction sites of Hyderabad.
- To develop Behavioral Based Safety plan for implementation of effective health and safety of labor, involve in construction practices.

LITERATURE REVIEW:

For a wider approach, author go through several research papers, which clear the picture to the author regarding the hazards, risks, factors behind health and safety of labor at construction sites, these research paper also help the author in finding the solution for the problems present at the construction site, the summary of all the research paper along with the reference in discussed below:

- **IDENTIFICATION OFSOME MAJOR HAZARDS AND THEIR RISK QUANTIFICATION IN CONSTRUCTION PRACTICES:**

In 2015 an author Muhammad with his research team proposed that construction sites require special attention as the health and safety risks are important at social level. There must be some practical solutions for eliminating or reducing risks in high-risk areas which have been offered to provide tranquility for contractors and employers.

- **IDENTIFICATION OF FACTORS BEHIND HEALTH AND SAFETY CONCERNS IN CONSTRUCTION SITES:**

In 2017 Nil gun and Ferdi stated that the construction sites are now days known as a major economic contributor as well as a most hazardous part of all the industries for workers. The construction accidents not only affect a worker physically, but such accidents arise adverse impact on production, quality, and time frame which ultimately generate the high-cost ratio. Most of contractions site neglects health, safety, and the environment and on a very rare basis, it is managed by them. On the other hand, a managed safety program can prevent the huge cost rises with a single accident. The recommendations were to provide complete safety training to all workers because well-managed training can save the physical and economic cost of construction sites.

- **DEVELOPMENT OF BEHAVIORAL BASED SAFETY PLAN:**

In 2014 Arshad and Javid described behavioral based safety plan as an effort for the adoption and development of current techniques of health and safety for the betterment of construction sites. Challenges for the improvement of safety includes poster campaigns but results show that such campaigns are not long-lasting on fatality and accident rates. Another scheme such as increment, and bonus systems can be utilized as to fast up the work progress, but these are also not safe precautions because for a time being it will speed the progress of work nut in the future these can be major factors for hiding accidents and incidents.

- **REVIEW OF OTHER CONSTRUCTION HEALTH AND SAFETY RISK:**

Salman and Rafiq in (2016) present research which was an observed safety management plan framed after the measured safety behavior. The consequences of their case study presented a method-based background, to achieve goals and response; it is stated as an effective control of safety behavior if appropriately applied by the devoted administration. It can recover safety presentation expressively in construction site atmospheres. Results verified that BBS management practice can be useful for any country.

Azhar et al (2016) stated that the implementation of health and safety policy on construction place is extremely less in Pakistan. Measures for implementing, prepared, and searching safety policy and rules are pathetic, in addition to the execution of the safety organization method does not take place in the majority construction sites. The paper presents a detailed plan to improve the health and safety culture, laws, and practices in Pakistan.

Vwila et al (2015) stated that a significant amount of accidents recorded in small and medium size (SMS) construction companies. Procedures utilized to overcome this in large industries is not to work most of the period in the SMS enterprises. Therefore, the technique of attempting health and safety in these corporations must include systems and tools exactly planned for them. This can happen by means of the risk approximation tool exactly intended for small and medium-sized construction companies.

Vitharana et al (2015) proposed that the most serious requirements with respect to the construction industry were the improvement professionals' interests in active safety management. The consciousness of probable risk issues and data of how to decrease these risk factors between workers and contractors will improve site safety.

Kamar et al (2014) proposed that the overall management of any industry can be subdivided into several departments, including occupational health and safety department that

enables the whole management from the risk and cost of any unwanted accident.

Seok et al. (2013) stated that the construction sector is a project-based industry, but work-related victims were varying from project to project. In next level observation the multinational firms in South Korea were aware of the need for occupational health and safety management system, while small and medium size, construction sectors were at their basic level of understanding the importance of health and safety management system.

MATERIAL & METHODS:

For focusing the research, author go through several journal papers, seminar and conference articles, paperwork and reference books. Methods which are involved in research include study that begins with a detailed literature review on health and safety in the construction industry focusing firstly on the nature of the scope of the construction industry and the most activities that involve dangerous operations. Moreover, an overview of occupational injuries and fatalities occurring throughout the world are researched to point out the huge importance of managing health and safety performance. Table # 1 provide list of all the research methods and materials which author adopt for visualizing the problem easily. The detailed and structured description of research procedures is given below:

TABLE # 1: Research methodology adopted by author.

OHS risk in small construction companies in Hyderabad	
Literature Review	
Site visit (case studies)	
Identification of Hazard	Tangible
	In-tangible
Risk Quantification	Risk Matrix
Identification of factors	
Development of behavioral based safety method	
Results	

CASE STUDY:

Fig # 1 Shows the Google map of all the sites, which author visited at the time of survey. The study was conducted for vast research and it was conducted in four different regions of Hyderabad. For the collection of occupational health and safety data from small and medium size construction sites. The construction project selected from each region was different in size, and the key description of each construction building is given in Table # 2, while the images of each sit, taken by author at the time of case study is taken, are also given below. Fig # 2 ,3 ,4 & 5 are the pictures which author taken at the time of survey, these are the pictures of all the visited sites. The Detailed summary of case studies is given in Table # 2.

Fig # 1: Google map of all the visited sites.

TABLE # 2: Key description of Surveyed sites.

Project	Location	# of employee	Size Sq. ft.	Build type	Structure	Longitude	Latitude
Residence	UNIT # 3 LATIFABAD	21	4000	Double story House	Under construction	25.37	68.33
Commercia l	UNIT # 3 RCHS LATIFABAD	36	8200	Triple Story Building	Under construction	25.37	68.33
Residence	KOSHAR HOUSING PHASE 2	64	5200	Double Story	Under construction	25.33	68.36
Residential & Commercial	MAIN AUTO BHAN ROAD LATIFABAD	80	9000	Double Story	Under construction	25.37	68.34

Fig # 2: Residential Building at Kosher

Fig#4: Residential Project at unit # 3

Fig # 3: Commercial Project at unit # 3

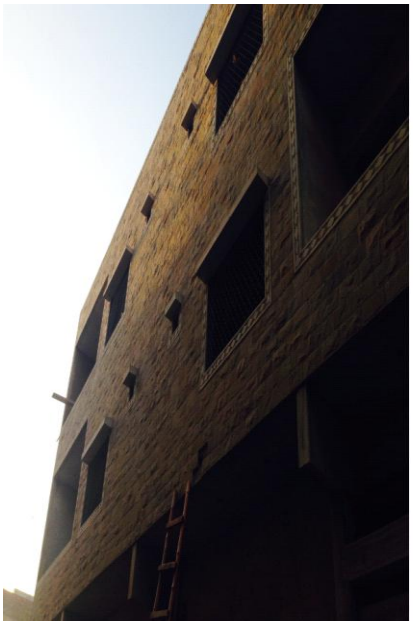

Fig # 5: Multipurpose Building at Main autobahn road

IDENTIFICATION OF SOME MAJOR HAZARDS:

Risk Quantification of Hazards

The risk related to each identified hazard in the walk-through survey is quantified using standard matrix method. This is internationally considered as a proper method for risk quantification by different organizations such as IOSH, NBOSH and OSHA. Table # 3 shows standard risk matrix and table # 3.1 shows the risk quantification of hazards. The risk factor can be calculated with the help of following formula;

Risk Factor = consequence Score × Likelihood

or

Risk Factor = Probability × Severity

Whereas Risk factor between 1 to 8 is low, 9 to 15 medium and 16 to 25 high.

Table # 3 Standard Risk Matrix

Consequences	5	15	15	20	25
	4	12	12	16	20
	3	6	9	12	15
	2	4	6	8	10
	1	2	3	4	5
	Probability				

Table # 3.1 Risk Quantification of Hazards

Likelihood →	**1**	**2**	**3**	**4**	**5**
Consequences score ↓	**Rare**	**Unlikely**	**Possible**	**Likely**	**Almost certain**
5 Catastrophic	**5**	**10**	**15**	**20**	**25**
4 Major	**4**	**8**	**12**	**16**	**20**
3 Moderate	**3**	**6**	**9**	**12**	**15**
2 Minor	**2**	**4**	**6**	**8**	**10**
1 Negligible	**1**	**2**	**3**	**4**	**5**

- **Questionnaire Survey**

  Author conducted close ended - questionnaire survey to examine the intangible hazards. It consists of 14 questions. The questionnaire help the author in getting the knowledge about job type, work experience ,health issues ,provision of occupational health and safety ,workers perception about the presence of major hazards on site ,monthly income ,working hours , accident verification ,root cause of accident ,safety inspection ,usage of safety shoes & helmets ,use of personal fall arrest system ,measures for broken ladder , accident report system ,views regarding health and safety, issues while working under contractors , adoption of shortcuts, identification of workers who do not follow health, safety and learning system. The answer of each question was assumed 1 if answer was yes and 2 for no, while through a statistical method the data of this questionnaire was analyzed, and the sub-functions of this statistical method were mode, median, minimum, maximum, and standard deviation.

- **IDENTIFICATION OF FACTORS BEHIND HEALTH AND SAFETY CONCERNS IN CONSTRUCTION SITES OF HYDERABAD.**

The study was conducted in the all four-selected small and medium-sized construction sites. Construction staff was structured at 3 levels, viz: manager/owners, supervisor and labor. Their period of experience at the construction sites ranges few months to 20 years. Workers in each section were subjected to different hazardous conditions and the work task vary from labor to labor. There were several factors that arise several hazardous conditions on all four selected sites and these factors were obtained from two methods including walkthrough survey & questionnaire survey. The second phase of objective was the review of health and safety policies of the government of Pakistan and labor laws, in this assay reviews of health and safety laws, the factories act 1934 of Pakistan, and Pakistani labor policy 2010 were followed.

- **DEVELOP BEHAVIOUR BASED SAFETY PLAN FOR IMPLEMENTATION OF EFFECTIVE HEALTH AND SAFETY PRACTICES**

It is a proactive element of HSE Management System. The key of eliminating workplace incidents, injuries and illnesses are to modify employee behavior - reducing unsafe acts and conditions and increasing safe work practices and habits. The objective of this study was to pursue this goal by observing employees as they work and talk with them to encourage safe work practices and eliminate at-risk behaviors. Based on above walk-through and questionnaire survey a plan was designed that can be implemented on any construction site for the betterment of health and safety.

RESULT AND DISCUSSION:

Results and discussion demonstrates the results of all objectives. Firstly, some major identified hazards and their risk quantification in construction practices at Hyderabad, secondly Factors identified during the study. Lastly Behavioral Based Safety plan for implementation of effective health and safety in construction practices.

- **IDENTIFICATION OF SOME MAJOR HAZARDS AND THEIR RISK QUANTIFICATION IN CONSTRUCTION PRACTICES AT HYDERABAD**

Initially, the walk-through survey also called an observational survey covered A to L most important trends with 64 different observations, that all were the tangible hazard. The trends were general questions related to Safety equipment's, Safety management, Safety attitude, and Safety training, while each

factor was divided into further sub factors which were measured as standard risk matrix 1 negligible, 2 minors, 3 moderate, 4 major and 5 as a catastrophic trend. These all hazards can be categorized as the tangible hazards.

- **Tangible Hazards and Their Risk Quantification**

At the time of walk-through survey Tangible hazards were found which were quantified through standard risk matrix. During the survey of construction sites, a very poor situation of health and safety was found. The tangible hazards were observed and characterized through several examinations. The major hazards were based on general issues related to health and safety, emergency procedures, scaffoldings, ladder, work at height, excavation and working in trenches, manual handling, vehicle movement on site, waste management, lifting operations, workplace welfare, electric equipment, and PPE as shown in the table.

- **General Issues Found at All Sites**

The general issues observed on each site was the unavailability of health and safety policy that was high on sites 1, but on site 2, 3, 4 it was found high. While preconstruction information was medium on site 1, and 3, and high on site 2, and 4. The Permit system including safe work permit, excavation permits, and confined space entry permit was in very worst condition on all sites with the risk factor of high. The signing and posting system and entry to work and exit were totally unsatisfactory with highest risk factor as compared to other issues as shown in table # 4.

General Issues	Risk Factor = probability × severity							
	Site 1		Site 2		Site 3		Site 4	
	Probability	Severity	Probability	Severity	Probability	Severity	Probability	Severity
The company health and safety policy are available to all.	4	3	4	4	4	5		5
	12		16		20		20	
The Pre-Construction Information is available on site.	5	3	4	4	5	4		3
	15		16		20		15	
Safe work permit procedures followed. Excavation permit procedures followed. Confined space entry permit procedures followed.	5 4 3	4 4 4	5 4 3	2 3 3	4 5 3	3 4 4		5 3 2
	20 16 12		10 12 9		12 20 12		15 15 10	
Appropriate site safety signage is in place	5	5	5	5	5	5		5
	25		25		25		25	
There is a system in place to monitor the presence of out of hour's workers.	5	5	5	5	5	5		5
	25		25		25		25	

TABLE # 4 General issues found at all sites.

- **Questionnaire Survey (Identification of Intangible hazards)**

This session contains questionnaire regarding type of work, age of workers, health conditions, physiological and mental capabilities of workers, gender, work experience, information related to accidents, salary, duration of work. This questionnaire was circulated in between all 188 workers and data was collected. Table # 6 shows Detail of respondents from all the four sites.

TABLE # 5: Detail of respondents of questionnaire at the time of survey.

SERIAL #	SITE # 1	SITE # 2	SITE # 3	SITE # 4
NO. OF SUPERVISOR	-	01	01	01
NO. OF MASON WITH HELPER	05	06	13	13
SHUTERRING LABOR WITH HELPER	02	03	07	09
CARPENTER WITH HELPER	01	03	05	07
WELDER WITH HELPER	02	02	05	07
PLUMBER WITH HELPER	02	03	05	07
ELECTRICIAN WITH HELPER	02	03	05	08
EXCAVATION LABOR	03	05	06	08
TROLLEY DRIVER WITH HELPER	02	03	06	07
COLOR LABOR WITH HELPER	02	07	11	13
TOTAL LABOR	**21**	**36**	**64**	**80**

- **TO IDENTIFY FACTORS BEHIND HEALTH AND SAFETY CONCERNS IN CONSTRUCTION SITES OF HYDERABAD**

There was a list of factors which were influencing the present condition of health and safety in the construction sector. These factors were determined by using a walkthrough and questionnaire survey on all sort of construction projects and the review of the government of Pakistan policies and labor laws. The factors obtained through all three tools are given below.

- **Identified Factors**

The results indicate the most critical types of accident are fall. While the most significant factor that affects safety performance were (1) awareness; (2) not well educated, (3) differences in age, with different level of awareness, (4) no safety meeting (5) management talk on safety, (6) provision of safety booklets, (7) provision of safety equipment (8) providing safety environment and (9) appointing a trained safety representative on site. Thus, the suggestion to minimize accidents caused by poor safety performance is also by increasing the level of awareness through commitments from the highest level of the company by ensuring that the employees make proper use of all necessary practicable measures. Regular meeting before work commences should be practicable as it is one of the ways for information to be conveyed to the workers related to hazards or any other difficulties they faced. Apart from that, by increasing the number of safety signage to ensure that the staffs and visitors are aware of the dangers and hazards ahead in certain situations or environments.

- **BEHAVIORAL BASED SAFETY PLAN**

Table # 6: Behavioral based safety plan

Foundation: The most significant factor that affects safety performance are awareness, not well educated, differences in age, no safety meetings, management talk on safety, provision of safety booklets, provision of safety equipment, providing safety environment and appointing a trained safety representative on site.	
GOALS	Appreciate safe behaviors and discourage unsafe practices and behavior.
Policy: To provide safe working place helpful to the physiological, psychological and behavioral capabilities of workers and to eliminate all behavioral constraint in implementation OHS practices.	
Procedure: The following procedure outlines the process.	Monthly safety awareness meetings and tool box talk. Daily inspection of all equipment uses in work and schedule-based inspection of machines. Presence of safety representative should be mandatory on construction sites according to nature of work.
Recognition Guidelines: A safety appreciation certificate can be awarded to the worker/unit in a group meeting.	
Behavior Guidelines:	1. Administrative observation on unsafe acts. 2. Make behavioral exceptions clear. 3. Shifting the way you regularly do your job to a safer method. 4. Instantly talk on non-compliance. 5. Reminding co-workers about taking safety measures and constantly using your PPE's. 6. Regularly using safety program procedures and safe work practices. 7. Reminding co-workers for the use of PPE's or fallow a safe work practice (especially when observe an unsafe behavior). 8. Feedback on proximity to goal accomplishment.
Participation: Everybody has clear duty for safety and is likely to practice the "highest degree of safety. Databases: Database is planned to help us in changing our understandings so that safety turn out to be part of the standard operating method and is broadly valued across all construction units.	

TABLE # 7 Implementation of BBS plan

Implementation of BBS Plan			
Before Allocation on Job	Identification of behavior constraint through interview by behavioral expert		
Trainings	Motivational presentations		
	Videos and Guide Lines		
	Counseling		
Job Allocation based on physiological capabilities			
After allocation	The worker will be continuously monitor about behavior constraint		
	Minor	Moderate	Major

Based on above results a behavioral based safety plan was presented to each selected construction site for the implementation. Table # 6 shows detailed discussion of behavioral based safety plan and Table # 7 shows the implementation of the proposed plan.

DISCUSSIONS:

The overall research can be summarizing in the given discussion:

- Author aimed to examine the present practices related to health and safety in small and medium-size construction sites of Hyderabad, Sindh, Pakistan. Focusing on the identification of some major hazards and their risk quantification in construction practices.
- Walk-through survey shows several poor trends and high-risk factors on all sites. Basic general

issues of health and safety were lack, which include emergency procedures, scaffoldings system during construction, placement of ladder, mitigation for work at height, excavation and trenches safety, manual handling safety, collection and disposal system of waste, lifting operation, workplace welfare, electrical safety and use of PPE.

- The majority (85%) of tabor don't think that PPE affects the productivity. Only 74% of labor is familiar with pre-construction information plan but all of them are unaware of construction phase health and safety plan. Recording of accidents and safety visits were answered as 30 - 40%.
- The managers and supervisors were more educated as compared to workers and had a good knowledge of health and safety. 92% of them attainted training related to health and safety earlier. 54% observed workers were involved in a major accident, 100% of them also observed minor injuries related to their works during performing construction job.
- 84% of managers and supervisors agreed with the wearing of PPE affects the productivity and 70% of them were familiar with pre-construction safety plan. Only 20% of them knows about construction phase health and safety plan. 79% and 90% of them had knowledge of accident reported during their job and about the safety visits done by them.

CONCLUSION:

Being involved in construction industry the author can easily judge the issues regarding health, safety of labor. Hyderabad is under developing city, with more than 25 high raised projects but the necessary institutional frame work for effective management of occupational health and safety is missing which causes many accidents and fatalities at site. There is a serious need of occupational safety management plan. It should be a legal requirement for all businesses in Hyderabad to consult with employees on workplace health and safety which may affect them in the workplace. Consulting with employees and having a formal mechanism to do this is an effective way of involving employees in workplace safety. There are several law and orders present in favor of health and safety of labor, but the implementation is invisible. the need of hour is to implement all those laws which help in managing the health of labor, who work day and night and should release the burden of work place from their shoulder.

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Sustainability of Green Buildings; Opportunities and Challenges

Shahzeb Memon[a, *], Raisingh Rajput[a], Shumaila Shaikh[a], Pervez Hameed Shaikh[a,b], Ghulam Yasin Shaikh[c]

[a] Department of Electrical Engineering, Mehran University of Engineering and Technology, Jamshoro, Pakistan.
[b] Office of Research Innovation and Commercialization, Mehran University of Engineering and Technology, Jamshoro.
[c] Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Jamshoro.

[*] Corresponding Author
E-mail: memonshahzeb73@gmail.com
Tel: +923003020261

Abstract
Green building is one of the viable solution been put forward to counter the significant impacts of the building stock on the environment, energy resources and wellbeing of the residents. However, there is lack of knowledge about benefits of green buildings and the lack of systematic review. This paper aims at carrying out systematic review of existing knowledge of green buildings and finds common issues and barriers that resist the development of green building. In this study, many articles related to green buildings were reviewed and it is found that green buildings can help in reducing the environmental impacts, saving of diminishing natural energy resources, and reducing health hazards of occupants or tenants. This paper also reviews the currently operating rating systems and found that most of the rating systems do not follow a uniform procedure to check the standards of a building. This paper also discusses the challenges and opportunities associated with the development of green buildings. The main challenge for the government is the promotion of development of green buildings that can be done by providing incentives to developers. For future, review on economic benefits of green buildings can be carried out.
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Keywords: green building; rating systems; benefits; challenges; opportunities.

1 Introduction

The conventional buildings have significant impact on global level, whether it is environmental conditions, social and socio-economic impacts or human health. Ever growing rate of population and economy have drastically increased the conventional building construction. The conventional buildings have severe impacts on environment as well as on living-being, which has raised concerns in global market. These impacts may be environmental like green-gas emission, pollutions, environment degradation, depletion of energy resources as the existing building stock accounts for 30% of total energy consumption [1], or social problems like economic conversation or health of occupants living in such buildings.
Many policies and plans have been audited so far to enhance more sustainable and economic development in construction industry to curb these severe impacts. Green building development paves the way to the use of more energy efficient materials which plays a prominent role in energy saving (i-e using renewable energy resources and reducing dependence on fossils fuels) [2], reduction in green-house gas emissions, sustainable economic development and reduction in other pollutants. The choice of material for building construction is key-role playing factor in this direction. Moreover, the health and comfort zone of occupants living in green building is being observed as much more satisfactory than that of the conventional ones.
The green building construction revolution is under way; many certification ratings for green technology have been started. LEED (Leadership in Energy and Energy Design) is a rating system aims to provide the "Green" certification. Design, maintenance, and operation of green buildings are classified in terms of rating credits which decides whether

the building is certified "GREEN" or not. Besides LEEDS, many other "green" certification provider rating systems.
Moving forward, though Green construction is facing some barriers, it is a viable solution to ever persisting globally recognized impacts of the conventional buildings. The challenges, that green construction industry is facing, should be recognized and measures should be taken to publicizing the "green" awareness.

2 Green Building Assessment and Aspects

2.1 Green Building Philosophy

In research, there are several definitions available that explain about Green Building. The research indicates such as "sustainable, healthy and resource efficient exercise of creating environmental-friendly structures that is resource saving and health-friendly through a building's lifecycle from construction to demolition'' [3][4][5].
It is multidimensional approach of defining green building. It can also be defined in many other ways. The term 'Green Buildings' widely used in literature and used interchangeably with 'Sustainable Buildings' [3].

2.2 Environmental Impacts

After the 19th century the world has witnessed rapid growth in population and urbanization throughout the globe. The growing urbanization and population speed up the construction of houses, industries, workplaces etc. These factors adversely affect the environment by emitting greenhouse gases, deforestation etc. To resist the degradation of pollution, more efforts are essential to save the environment from more deterioration so it is better to go for Green buildings.
The research indicates that there are many benefits related with the Green Buildings. From environment point of view, Green building practice is one of the best possible solution to improve the urban biodiversity, carbon dioxide emission that protect the eco-system by effectively utilizing the land in a sustainable way [5][6][7].
In china, it is estimated that the building sector alone will consume about 1/3rd of the total world energy by 2020 and will produce significant adverse effects on environment [8][9]. In comparison with other conventional buildings, green buildings provide higher performance as reflected from energy efficiency (including electricity efficient), water efficiency (water can be recycled) and reduction in carbon dioxide emission. Though the sustainable materials (as wood, glass, fiber ceramic) to achieve sustainability and reduced environmental impacts [4].

2.3 Green Building Rating System

Green building construction, planning and designing varies from place to place. For the areas where the sunlight is available for substantial portion of day time; the Green building planning, construction and designing would be different, and for those areas where the sunlight is available for only small portion of day time the above-mentioned factors would be different. This is the only one factor but there are several factors that should be considered before planning, designing and constructing a Green building. To overcome these issues the GB rating systems are designed. The rating systems are designed in such a way as to assess and analyze the sustainability and greenness of Green building [10].
Following are the aspects on which the rating systems are based;

i) Life cycle assessment
ii) Life cycle costing
iii) Energy system design
iv) Performance evaluation
v) Productivity analysis
vi) Indoor environmental quality (including air quality)
vii) Operation and maintenance optimization
viii) Building design
ix) Resource saving and optimization assessments (including; water saving, electricity saving etc.)

Currently there are many rating systems available but following are the some operating in different countries as listed in table.1;
There are many rating systems but following are the most widely adopted rating systems

i) BREEAM
ii) USGBC-LEED
iii) GBCA-Green Star [11].

2.3.1 Leadership in Energy and Environmental Design (LEED*)*

LEED, the rating system, introduced by the United States Green Building Council (USGBC) in 1990, has been evolved over the time since its first project in 1998. Many new and updated versions of LEED have been introduced over the time as 1.0, 2.0, 2.1, 2.2 to version-4.

2.3.1.1 How LEED works

In this system, the points/credits are distributed such that they depend upon potential environmental impacts and human benefit of each point/credit with respect to set of impact categories. In LEED, the buildings are certified/labeled as Platinum, Gold, Silver or Certified based on the points/credits achieved as listed in table.2. [12].

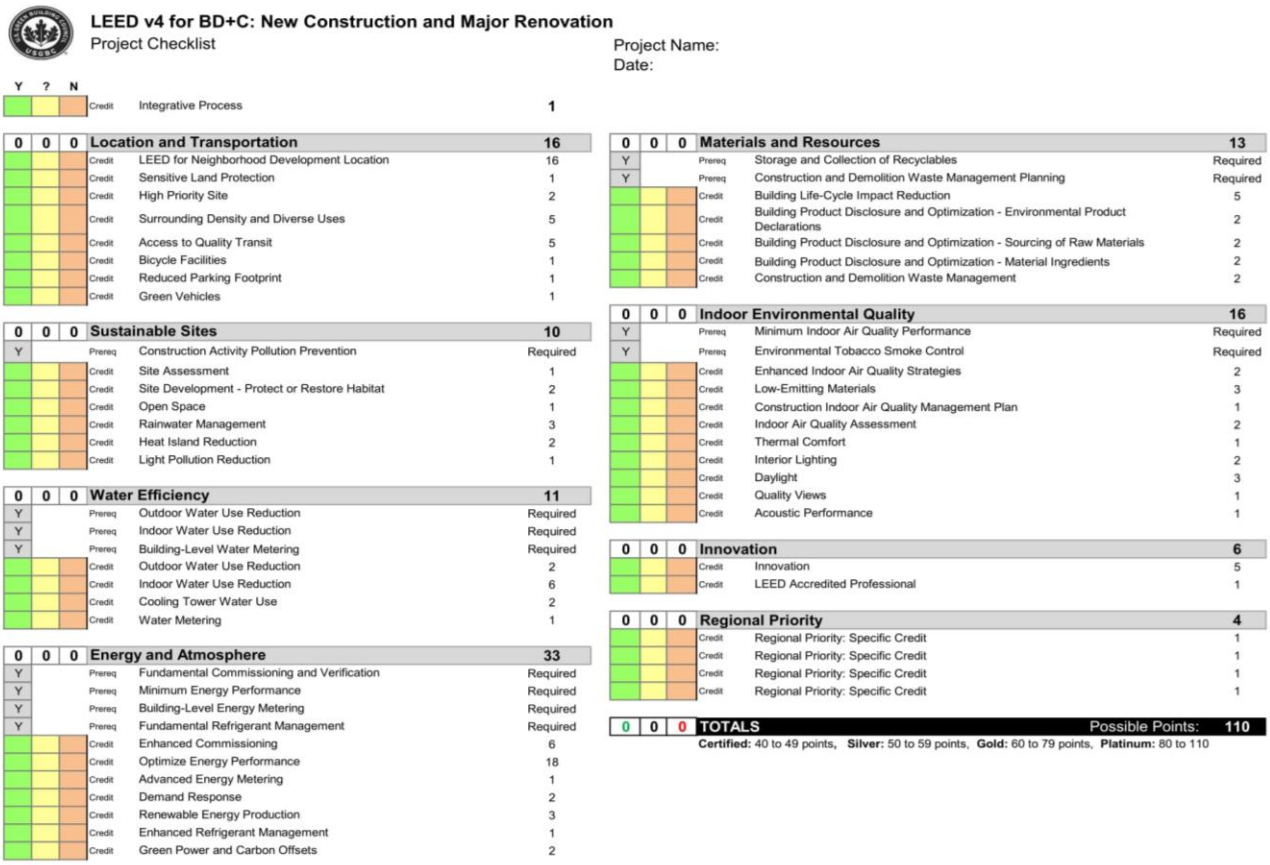
Category	Credits
Platinum	80 to 110
Gold	60 to 79
Silver	50 to 59
Certified	40 to 49

Table 2: Categories vs Credits

Country	Rating system
US	LEED
Canada	LEED-Canada, Green Globes
India	LEED-India, Indian Green Building Council (IGBC) Rating system
UK	Building Research Establishment Environmental Assessment Method (BREEAM)
Australia	Green Star
New Zealand	Green Star-NZ
China	Three-star system
Germany	German Sustainable Building Certification
Japan	Comprehensive Assessment System for Building Environmental Efficiency (CASBEE)
Malaysia	Green Building Index
Singapore	Green Marks
South Africa	Green Star-SA
Norway	EcoProfile
Finland	Promise
Hong Kong	HK-BEAM and Cepas
Sweden	Environmental Status

Table 1: Different rating system operating in different countries.

The developer is required the meet the minimum credits/points for certification as Green Building. The more the credits achieved by building the more it possesses green degree and sustainability. The buildings like New construction and Major renovation, core and shell, Schools, Retail, Data centers, warehouses and distribution centers, Hospitality and health care can be certified under LEED. In LEED, nearly 8000 projects are participating across 162 countries, including more than 32,500 certified commercial projects [13].



LEED v4 for BD+C: New Construction and Major Renovation
Project Checklist

Project Name:
Date:

Y	?	N			
			Credit	Integrative Process	1

0	0	0	**Location and Transportation**		16
			Credit	LEED for Neighborhood Development Location	16
			Credit	Sensitive Land Protection	1
			Credit	High Priority Site	2
			Credit	Surrounding Density and Diverse Uses	5
			Credit	Access to Quality Transit	5
			Credit	Bicycle Facilities	1
			Credit	Reduced Parking Footprint	1
			Credit	Green Vehicles	1
0	0	0	**Sustainable Sites**		10
Y			Prereq	Construction Activity Pollution Prevention	Required
			Credit	Site Assessment	1
			Credit	Site Development - Protect or Restore Habitat	2
			Credit	Open Space	1
			Credit	Rainwater Management	3
			Credit	Heat Island Reduction	2
			Credit	Light Pollution Reduction	1
0	0	0	**Water Efficiency**		11
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
			Credit	Outdoor Water Use Reduction	2
			Credit	Indoor Water Use Reduction	6
			Credit	Cooling Tower Water Use	2
			Credit	Water Metering	1
0	0	0	**Energy and Atmosphere**		33
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
			Credit	Enhanced Commissioning	6
			Credit	Optimize Energy Performance	18
			Credit	Advanced Energy Metering	1
			Credit	Demand Response	2
			Credit	Renewable Energy Production	3
			Credit	Enhanced Refrigerant Management	1
			Credit	Green Power and Carbon Offsets	2

0	0	0	**Materials and Resources**		13
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
			Credit	Building Life-Cycle Impact Reduction	5
			Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
			Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
			Credit	Building Product Disclosure and Optimization - Material Ingredients	2
			Credit	Construction and Demolition Waste Management	2
0	0	0	**Indoor Environmental Quality**		16
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
			Credit	Enhanced Indoor Air Quality Strategies	2
			Credit	Low-Emitting Materials	3
			Credit	Construction Indoor Air Quality Management Plan	1
			Credit	Indoor Air Quality Assessment	2
			Credit	Thermal Comfort	1
			Credit	Interior Lighting	2
			Credit	Daylight	3
			Credit	Quality Views	1
			Credit	Acoustic Performance	1
0	0	0	**Innovation**		6
			Credit	Innovation	5
			Credit	LEED Accredited Professional	1
0	0	0	**Regional Priority**		4
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
0	0	0	**TOTALS**	Possible Points:	110

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

Fig.1: Credits table of LEED for New Construction. (Source: www.usgbc.org/leed)

2.3.2 BREEAM

This certification/rating system, owned by Building Research Establishment (BRE)-UK, is the most widely used environmental assessment method for sustainable buildings. It certifies many projects like New construction, Refurbishment and in use. Currently there are more than 562,000 BREEAM certified developments, and almost 2,265,600 buildings registered for assessment since it was first launched in 1990.

2.3.2.1 How BREEAM works

The BREEAM assessment process evaluates the planning, design, construction and operation of a building/development that are based on performance credits/indicators.

Assessment of buildings/developments is carried out by the licensed experts. The buildings/developments are rated as Pass, Good, very good, Excellent, and Outstanding according to the credits achieved. Credits are awarded in ten categories; the respective categories are; Energy, Health and Wellbeing, Land use, Materials, Management, Pollution, Transport, Waste, Water, and Innovation [14].

Respective categories weightage is shown in table 3.

Category	Weightage (%)
Energy	19
Health and Wellbeing	15
Materials	12.5
Management	12
Land use	10
Pollution	10
Transport	8
Waste	7.5
Water	6
Sub-total	**100**
Innovation	+10
Total	**110**

Table 3. Respective categories and their weightage [15].

2.3.3 GBCA-Green Star

Green Star rating system was launched in 2003 by Green Building Council Australia in a bid to develop and enhance sustainable property market in Australia to move towards green practice. Its main objective is to bring and promote Green Building practices in Australia to make the country more sustainable [16]. Currently there are 1462 Green star rated projects.

2.3.3.1 How GBCA-Green Star works

In this system, the credits are awarded with respect to the categories of impact. The various categories and associated credits are listed in table 4.

The buildings are rated in various categories based on credits achieved as shown in table 5.

Category	Credits
Management	14
Indoor Environmental Quality	17
Energy	22
Transport	10
Water	12
Materials	14
Land use and Ecology	6
Emission	5
Sub total	**100**
Innovation	+10
Total	**110**

Table 4. Various categories and associated credits.

The credits achieved by a building shows the green degree and level of sustainability.

2.4 Green Buildings & Health

2.4.1 Effects of conventional buildings on health and indoor environment

Fast growing human population and economic actions have increased building construction. For example, rapid construction of conventional buildings in Germany after World War II, resulting severe health effects from exposure to construction materials' chemicals spurred the Building Biology field of study [18]. Reconstruction of buildings and fast shifting in such buildings have several adverse impacts to human health and environment. These buildings have poor indoor environmental qualities which includes low ventilation rates, CO2 emission and low VOCs (Volatile Organic Compounds) level, low air quality, unpleasant odor, thermal comfort, noise and lightening.

Conventional buildings have severe environmental and health effects on human health as well as on environment. Green buildings are employed to reduce these effects through the reduction of water and energy usage and minimizing environmental disturbances. These buildings aim to improve human health by designing a healthy indoor environment. It is common fact that we spend 90% of our time indoors [19-21].

2.4.1.1 Factors influencing human health

Key factors that are considered hazardous to human health living in conventional buildings are:

- Environmental hazardous, (radiological, chemical, biological, physical) [22]
- Building design, (ventilation, pressurization, filtration, lightings, acoustics) [22,23]
- Social factors, (location, safety) [24]
- Behavioral factors, (curriculum, work activities, wellness programs) [25]
- Psychological effects
- Adjacent land use and architectural design

Score/Credits	Rating	Category
10-19	One Star	Minimum Practice
20-29	Two Star	Average Practice
30-44	Three Star	Good Practice
45-59	Four Star	Best Practice
60-56	Five Star	Australian Excellence
75+	Six Star	World Leadership

Table 5. Credits achieved and categories. (Source [17]).

Other adverse effects that indoor exposure poses are radon and lung cancer, phthalates and asthma, and second-hand smoke and increased risk of premature death [26].

2.4.1.2 Health and Environmental certification

The green building construction revolution is under way; many certification ratings for green technology are started. LEED (Leadership in Energy and Energy Design), enacted in 1998, have certified more than 69000 projects in over 150 countries, covering area of 3.6 billion square feet [27]. LEED aims to reduce the environmental footprint of buildings while simultaneously protecting occupant's comfort and health along with reducing environmental chaos. Design, maintenance, and operation of green buildings are classified in terms of rating credits which decides whether the building is certified "GREEN" or not.

In LEED Certification Program, IEQ (Indoor Environmental Quality) category have many occupant's health related credits. IEQ links health related credits as ventilation rates that meet ASHREA (standard) [28], control of environmental tobacco smoke and cleaning practices to limit biological and chemical exposure, use of low emitting materials (i-e low Volatile Organic Compound, VOC paintings and furnishes), indoor quality monitoring, thermal comfort, interior lightening and green cleaning [29]. Another standard is the WELL Building standard, started in 2014, particularly focuses on human health [28]. Besides these, the Living Building Challenge (LBC), started in 2006, is another health-focused green certification program [31].

2.4.1.3 IEQ and Health in Green buildings VS Conventional Buildings

Recent researches have demonstrated that for IEQ in green buildings as compared to non-green buildings or conventional buildings have lower level of VOCs, formaldehydes, NO2 and allergens. IEQ benefits tend to better self-reported health perceptions like fewer sick building syndrome symptoms, fewer respiratory symptoms reported in children and better physical and mental health. Green buildings provide low CO2 concentration, improved Indoor Environmental Quality (IEQ) and reduction in air movement, chemical odor, tobacco smoke odor, dryness and elevated temperature among occupants living in green building. As compared to conventional buildings, green buildings have reduced respiratory, eyes and skin viral infections, cognitive and sensory symptoms. Provision of "green certification" as given by LEED and such rating systems reduce psychological effects and CO2 concentration as exposure to latter had direct effect on heart rate. Working productivity of occupants has improved effects living in green buildings. Many researches have showed that in hospitals, converted in green, have improved quality of care, fewer blood stream infections, improved record keeping and lower patient mortality.

2.5 Green Buildings, Policies and barriers

The policy of green building can be defined as the policies that affect the entire life of building, from planning, design and construction to operation and demolition. The policies of green buildings are instrumental in analyzing the problems like market failures, information asymmetries, and economic externalities and often help in successful and desired outcomes. Before developing any type of policy, we must identify the barriers that often pose threat to the development of green buildings. The following can be the barriers:

- Commodity-related barriers

This may involve barriers such as improper understanding of definition of green buildings, quantification of benefits, lack of knowledge and awareness, funding issues, split incentives and appropriability, and risk and uncertainties.

- Process-related barriers

This may involve barriers such as lack of measurable requirements, lack of communication among project team members.

- Organizational and Personal behavior barriers

This may involve barriers such as lack of commitments from the administration, lack of communication between

the public and government administration, and lack of availability of incentives. [32]

Different countries and different rating systems may have different approach and policies to counter these barriers. There are no uniform policies across the world that is the reason there is slow rate of increase in the development of green buildings. In the development of policies, the government and administration has got a vital role. The policies are set by the government and implemented so the governments must consider this issue. The governments should set and form the policies such that it must encourage the public to go for green buildings rather than conventional buildings.

3 Challenges and Opportunities

There are many challenges and opportunities associated with the development of green buildings. The challenges can be such as to provide incentives and promotion to people so that green buildings may become attractive choice for people. While the opportunity can be the savings of diminishing energy resources helping in conservation of energy resources.

3.1 Green Buildings Incentives and Promotions

Green building incentives are important for the promotion of green building. The green building incentives are classified into two categories

3.1.1 External Incentives

It can be defined as the forced choice in which beneficiaries are required to fulfill specific conditions or requirements before getting any kind of benefit. These kinds of incentives are usually provided by the government. It differs from internal incentives in a sense that in this the occupant or the beneficiaries must fulfill certain conditions or requirements provided by the government to get the incentives. As the government provide these kinds of incentives so the government itself must check whether the correct procedure or due process is followed or not. The government plays a vital role in the promotion and development of green buildings [33,34,35]. These can be subdivided into;

Financial Incentives: In this type of incentives the developers are directly supported through the grants, tax exemption, and discount in development charges [34,36,37,38]. Take the example of tax exemption, in this the developer is either provided with the facility to pay reduced taxes or completely exempted from the tax [39,40]. Tax incentives can work positively as well as negatively. If any developer does not follow the requirements, then that developer may be charged extra tax [41]. One study suggests that the financial incentives forces the developer to take decision [41]. In 2010, a soft loan incentive scheme was announced by the government of Malaysia named as Green Technology Financing Scheme (GTFS), to attract the developers and users to green technology. This incentive culminated in increasing green buildings construction [34], with the increase in green buildings certification from 1 to 137 just in the period of 4 years (from 2009 to 2013) [42].

Non-financial incentives: These kinds of incentives do not provide any financial assistance to developers/users but these incentives may provide technical assistance, guarantee programs, regulatory relief, marketing assistance, business planning and green management teams in building and planning departments [43]. In fulfilling these incentives, the government provide some extra rights to developers to fulfil certain conditions [44]. These incentives may help in reducing the completion time of the project ultimately cost of the project is reduced to a certain extent [45].

3.1.2 Internal Incentives

These can be defined as the incentives received by the beneficiaries because of the appeal of the benefits of the green buildings. It is found that complementary incentives are needed because government itself cannot force whole the society for green buildings. These include numerous benefits such as resource efficiency, increased marketability and enhanced social reputation. These incentives relate to the person's feelings or connection about certain activity [46]. As humans spend most of their life time inside buildings so higher building comfort, healthy indoor environment may be the internal incentive. Green buildings rental charges are higher, so this may be one of the internal incentives because it will help owner in earning more money than conventional buildings due to the higher demand and benefits of green buildings [47,48]. Internal incentives are helpful in promoting the development of green building as these incentives are directly related with developer/owner/occupants.

3.2 Impact of Green Buildings on Energy Resources

In comparison with the other artificial and manufactured products, buildings have got longer life and utilize natural energy resources for decades [49]. This means that they affect the natural resources to great extent [50]. Thus, buildings have long term impacts on the energy utilization. In China alone the energy consumption stands for 1/3rd of the total energy demanded by the 2020 and will produce significant impact on natural energy resources [51]. It has been found that it only took China 20 years to double its energy demand with a growth rate of 3.7% [52]. Similarly, the energy consumption of all the countries is increasing day by day. Improving energy consumption in buildings is important for developers and market participants at national, industry and company and at every house level. Energy saving can be an opportunity for developers and investors that they can exploit to take advantage from. It has been found that Green building practice is a viable option in energy savings. Findings also suggest that 43% annual reduction in terms of energy consumption and energy expenditures is observed in America for a typical

home with green building technologies [53]. For the energy saving activities two factors are important i-e building design, and building material. For the electricity supply to buildings, alternative and renewable energy resources can be used to light the green buildings. PV cells can be installed at roofs of the green buildings to make them more energy efficient. Similarly, wind energy can also be used to make the green building more energy efficient. In review, it has been found that implementation and practice of sustainable and green buildings can reduce energy consumption during the operation phase and can significantly contribute in saving of diminishing energy resources.

4. Discussions

This paper undertakes a systematic review of the green buildings and associated aspects. This study focused on the environmental aspect, rating systems, health benefits and tried to find the challenges in development of green buildings and opportunities that the developer could exploit and take benefit from. As the world has seen rapid urbanization and population growth since 19th century so the has led to the rapid construction of buildings. As the review suggests these buildings has severe impacts on environment, natural energy resources and occupants living in these buildings. Occupants living in conventional buildings have often complained about health-related matters like concentration problem because of acoustic noise, lack of proper ventilation, low air quality, unpleasant odor, thermal comfort and lightening. The study also suggests that human health has been influenced by the building material and design. These issues; energy consumption at large scale, environmental problems and health related can be solved by using green building practices. Many green policies and plans are established for green buildings. Green buildings may be of different standards depending on the design and material used. For this different ratings system have been devised to check the standards and certify the buildings as green buildings. Most widely used rating system are BREEAM, and LEED. Review suggest that the different rating and green certification systems analyze buildings from various aspects like energy consumption, pollution, waste, water efficiency indoor environment quality and other associated aspects. Buildings are certified into various categories, to show how much the building is green, based on weightage of each aspect. Main aspect that many rating systems lack is the health weightage. The challenge that the green industry is facing is the higher initial cost of construction and development. As the green building construction is bit more expensive than the conventional buildings so the developers avoid green building practices because of higher initial cost and lack of awareness of the benefits of green buildings. To attract the developers for green practices the government should take initiative and promote green buildings, provide incentives to the developers by means of direct financial grants and indirect benefits, and devise developer-friendly policies so that the barriers could be overcome that resist the development of green buildings.

5. Conclusion

This research paper reports overall view of the existing studies about green building. The results observed conclude that main reasons of shifting the buildings to green buildings are environmental deterioration, increasing demand of energy, and diminishing energy resource. Many literatures reflect the importance of green building. Rating tools such as LEED, BREEAM and GBCA takes the responsibility of analyzing green building. Residential buildings and commercial buildings needs a healthy environment as people are spending their many hours in these buildings it is necessary to maintain physical and mental health by converting these buildings into green buildings. Research highlights that people living in these green buildings are healthier. Green buildings need to be future proofing because in future weather conditions can be extreme and the capital cost of these buildings is high so to gain more profit these should be future proofing. Green buildings are energy efficient due to which they can use the power produced by its own. Solar and wind plants can be installed on these buildings resulting in low running cost, water saving and pollution free. The government can use incentives to promote development of green buildings.

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Home Area Networking and Energy Monitoring using Power Line Communication

Waleed Sohail; Mohammad Adnan Gulshan; Shahroz Mubashir; Raja Ehsan Tassawar; Dr. Sajjad Haidar Zaidi

Department of Electronics and Power Engineering, Pakistan Navy Engineering College, National University of Sciences and Technology, Karachi, Pakistan

* Waleed Sohail
E-mail: waleed.ee@pnec.nust.edu.pk
Tel: +923009046939

Abstract:
In our daily life we see energy being wasted due to lack of structured consumption, because of this we are not only burdening the natural resources but also doing our part in increasing the greenhouse gasses. This article aims to provide a cost-effective solution for home area networking using the existing power lines. This will allow us to remotely switch the electronic devices within the boundaries of a residential facility, the real time monitoring of the power consumption of appliances will help us save energy resulting reduction in monthly electricity bills considerably. The solution will not only be easy to use for technically challenged individuals, but will also increase out accessibly in different parts of a house. The use of existing power lines as a means of data communication justifies the cost effectiveness of this solution.

Keywords: home automation; energy efficiency; power line carrier communication; power monitoring

1 Introduction

Energy plays a vital role in our lives. Every year the population of world increases exponentially and so does the energy demand. To cater to the ever-increasing energy demand, new power plants are built which mostly rely on the fossil fuels which is why they are depleting very quickly. This in return increases the greenhouse gasses which is damaging the environment. Therefore, it is very important for us to realize the importance of using energy efficiently which starts with how we can aid to the process individually. Home automation with energy monitoring is one way in which we can play our role individually towards a green environment, and when summing up the collective efforts as a society we can have a lot of savings which can be spent else ware.

In the 21st century the advancement in technology is shaping itself around the convenience, ease and betterment of mankind, which is empowered by innovation. The world is on the verge of automation, home automation will not only increase our accessibility in different parts of our home simultaneously but also allow us to manipulate the controls remotely. So far, the development and research that has been done in this domain will soon in the near future allow us to have our very own smart home. But for now, the equipment that we have is very costly and accompanied with separate installation. For this purpose, our objective is not only to build a system which will be well known for its kind but will also be cheaper and installed with the existing power circuitry of a house.

We need an automation system that will reduce our mobility and control the home appliances with single touch of a finger, this will in turn provide benefit to the senior citizens and technically challenged people also because it will be easy use. Constant monitoring of the home appliances will help us save energy and reduce electricity bills considerably. This will be a huge step towards a green environment.

1.1 What is Home Automation?

Home automation has been around for many decades, the only difference is that the technology which more or less was intended to provide the facilities to mankind that would reduce their mobility in terms of switching, controlling and monitoring of appliances, was expensive at the time. The technology around the world has evolved, allowing the equipment required for this purpose to be accessible and cheaper. Because of this, luxury of home automation is accessible to the lower middle class.

The science of home automation basically deals with controlling and monitoring of our home appliances. All

intended to bring comfort to human life. This involves the remote controlling of out lighting, heating and cooling systems, security, refrigerators, dryers etc. All of these home appliances can be linked to a smart device which steers how you comfort yourself. It is significant for these devices to be able to communicate with each other, Internet is a widely chosen medium for their communication. All home appliances can be connected to the internet, for example, a sensor in our bed can communicate to a coffee maker which tells what time to make the coffee in the morning. These little things when communicate intelligently can make our lives much easier.
The home automation market has a lot of potential, it was worth US$5.77 billion and is expected to rise US$12.81 billion in 2020 [1].

1.2 Energy Monitoring

Home Automation can provide us comfort we need as well as it can be made accessible to as many people as possible but alone this interaction of different technologies cannot provide us with a monetary benefit, not only to reimburse what we have spent but also to have a greater impact on the society. This can be done through energy monitoring, it is like having an eye on what our devices are consuming.
It is important for us to realize how much energy we are consuming and at what time of the day. Energy monitoring incorporated in home automation is a good way to save money. Constant energy monitoring will help us act upon loads that are not needed for the time being. It will provide us with the information we need to relate the real time usage of devices to the power consumption statics, which will help us decide what load is best for what time. Collectively this effort will play a part in reduction in electricity bills.

2 Solution Design and Implementation

In this solution, there are two types of communications, one is wireless and the other is wired. From Fig. 1, it can be seen that from the mobile app to the rooms, the communication is wireless. The control operation in a room are controlled by an android application. The control signals generated from the mobile travel through a Wi-Fi hotspot, which is a router in this case, and are received by a Wi-Fi module which is present in each of the rooms. The switching operations are performed accordingly, by relays which are connected to appliances and are controlled by the Wi-Fi module.
For power monitoring, the current of every appliance in a room is sensed through a current sensor. For all the appliances in a room the data of their current sensors is gathered into an Arduino Uno micro controller where it is processed and converter into power. This information of power consumed is communicated to the main server through the existing power lines of the house, using a Power Line Carrier Communication (PLCC) transceiver module.
The main server is an Arduino Mega microcontroller, which will display the power consumed for each of the rooms as well as communicate this data to the smart meter using the existing power lines.

2.1 Android Application

The android app is considered as the “steering wheel” of this network. It will be directly in control of the user and how this solution can be a step towards energy efficiency depends all on how the system is controlled. The app will be sending control signals to the Wi-Fi module though which devices will be switched.

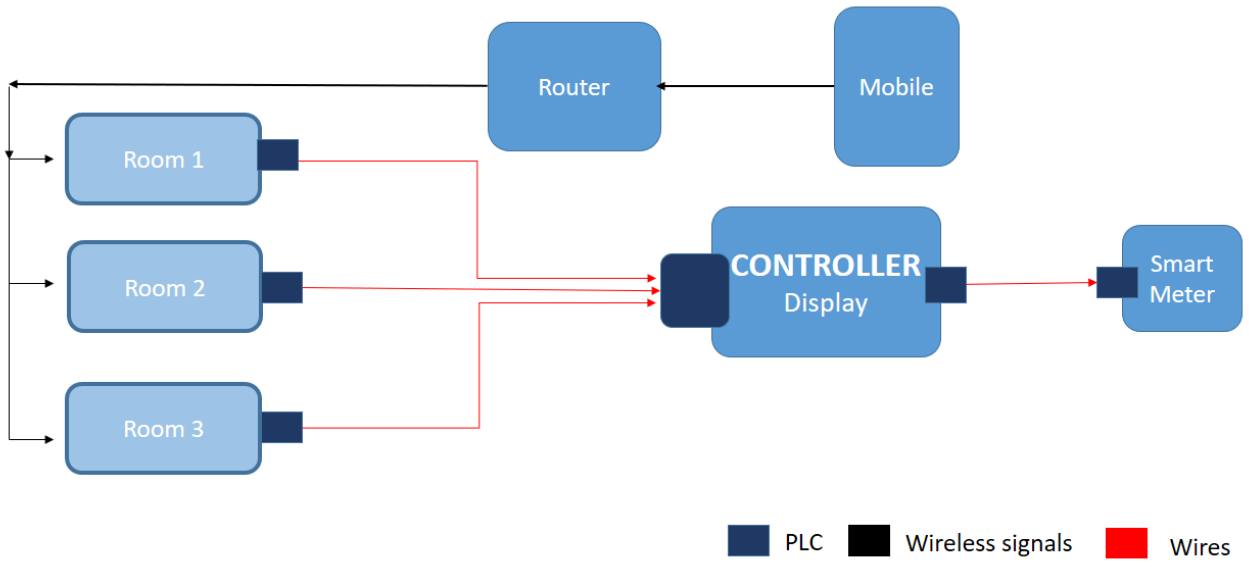

Figure 1 Solution Architecture

The android app is built in android studio because it is open source and the libraries are easily available. The language used for development is Java. Features that the app offers include the switching of devices, suggestions to reduce electricity bills and information about peak demand factor.

2.2 Node MCU ESP8266 Wi-Fi module

The Node MCU Wi-Fi module has Transmission Control Protocol/Internet Protocol integrated on its chip, it is also a self-contained source code. This module can easily be connected with a Wi-Fi network, it can also host an application or off load all networking functions of a Wi-Fi from another application of a process. It can also be programmed using Arduino Integrated Development Environment (IDE).

It can be seen in the Fig. 2 that the ESP8266 Wi-Fi module is the main controller for every room which receives command from the mobile application. For this solution, the module requires a Wi-Fi hotspot which serves as the medium of communication between the mobile app and the Wi-Fi module.

This module is directly hooked up with NPN transistor driven relay modules. The base of the transistor is driven by the digital pins of the Wi-Fi module. When it receives a signal to turn a device on, it sends a high signal to the base of the transistor due which the transistor saturates. The saturation energizes the coil of the relay and switches the device. For this solution there are three rooms and for each room five devices can be controlled. Variation in the number of rooms and appliances to be switched can be programmed accordingly.

2.3 Current Sensing

Current sensing is one of the most important aspects of this solution. This involves the use of a current sensor. In this research project we have used the ACS712 Hall Effect current sensor. The current to be measured is passed through a copper conduction which is present on the sensor. The flow of current produces a magnetic field around it. The hall effect IC present on the sensor produces an analogue voltage signal corresponding to the magnetic field. This output voltage signal varies linearly corresponding to the magnetic field. This sensor requires a 5V supply of DC voltage and a ground. It is capable of measuring both AC and DC current. The voltage signal produced can easily be interfaced with Arduino microcontroller. The different variants present in the market can measure current up to 5A, 20A, 30A. in this project 5A rating of ACS712 is used [2].

The voltage signal produced as a result of current sensing is feed to the analogue pins of the micro controller. It is connected in series with every appliance for which power is to be monitored. After the current has been measured for every appliance, the voltage signals are interpreted by Arduino Uno which them converts the readings into power after processing. This power is summed which then gives the power consumption for each room.

The reason this sensor is used because it is cost effective, easily available in the market, it can bear an over current which is five times greater than the nominal value and can easily be interfaced with Arduino Uno.

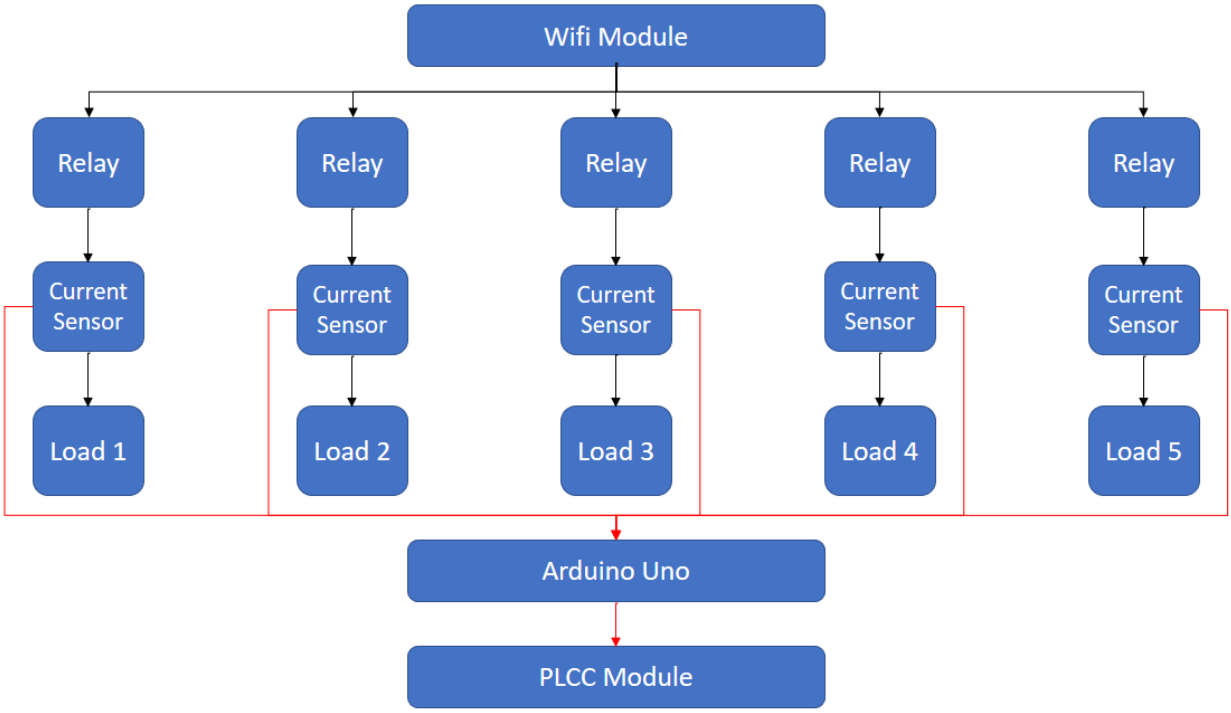

Figure 2 Smart switch board assembly per room

2.4 Power Line Carrier Communication (PLCC)

Over the years wired communication has evolved keeping in view the cost, convenience, and the amount of noise that the medium injects into the message signal. Power Line Carrier Communication is one way of wired communication which allows the use of existing power lines for the transfer of digital or analog information. PLCC has many applications ranging from communication in the electrical smart grid systems to the electric cars which have introduced a new era for fuel conservation. The advancement in the PLCC technology is generally motivated by the requirement of robust means of communication between the energy generation and consumption devices in the power sector [3].

2.4.1 PLCC Methodology

Every communication system has four major parts i.e. transmitter, communication medium, receiver and the signal itself. As seen in the Fig.3, the message signal to be communicated is modulated using any of the popular modulation techniques. In this case the message signal is digital so it's preferred to modulate it using Frequency Shift Key (FSK) modulation. After the relevant frequencies pass through the filter, they are amplified. Then the line matching unit matches the impedance of the transmitter with the impedance of the power line.

It is very important that impedance that the signal sees when it is transmitted into the power line matches the impedance of the transmitter circuit. Impedance of the power line changes every time a new device is connected to the power outlet. If the impedance that the signal sees, matches the impedance of the transmitter circuit then the power that the signal is transmitted with will be greater. If there is a mis matching of the two impedances then the power of the signal will be less [4]. Because of this reason the circuitry of the line matching unit might vary in order to ensure maximum matching of the impedance. Some of the techniques include the use of capacitor banks, tap changing transformer with special coupling circuitry at the secondary side etc. [5]. After impedance matching the signal is coupled into the power lines using coupling capacitors

At the receiver side when the message signal is received, it is amplified, demodulated and then amplified again.

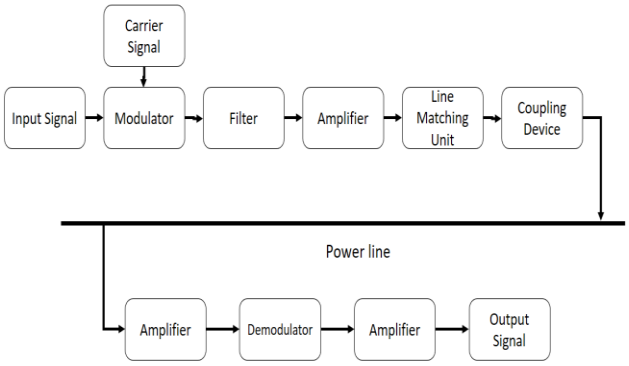

Figure 3 PLCC block diagram

2.4.2 Why PLCC?

There are a few very strong reasons why we used PLCC in this solution which are:

1) PLCC is preferred over other communication technologies like Satellite, Wireless and Optical fiber communications as power lines are one of the most widely available communication medium [6].
2) PLCC is more secure than wireless, and telephone line communication [7].
3) Unlike wireless solutions, PLCC does not have limitations of line-of-sight and short transmission range.
4) PLCC is also a cost-effective and easy-to-install technology for many applications. It is expected that with mass production requiring no expensive RF components, the cost of the PLCC cards will be about 50 percent that of comparable wireless cards. Moreover, the cost of a required 802.11b base station is high (more than $150). 100BaseT Ethernet has the highest performance/cost ratio, but requires new cables and expensive installation [8].
5) With just a simple set up of a transmitter and receiver and ensuring equal phase supply, one can control a host of devices and eliminates the need for additional cables.
6) PLCC has bidirectional communication which allows the receiver to send an acknowledgement after successful reception of data.

2.4.3 KQ 330 PLCC Module

This module provides a robust means of communication over the existing power lines. It can be interfaced with Arduino, transmit and receive data through the serial port with minimum distortion and good speed. The purpose of this module in this project is to communicate the information regarding the power consumption of a room to the central server. Below are some specifications.

- Working frequency: 120~135KHZ
- Interface baud rate: 9600bps, the true baud rate is 100bps
- Power: DC +5V

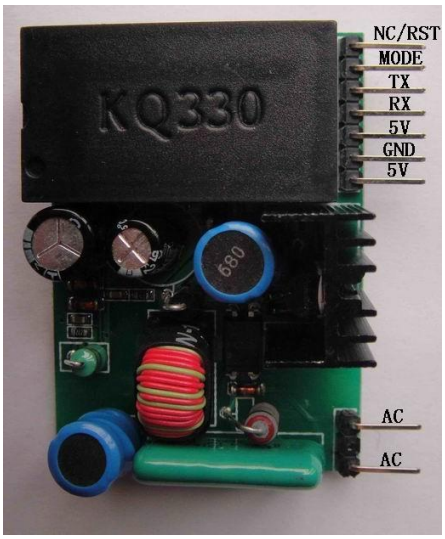

Figure 4 KQ 330 (courtesy reference [12])

2.5 Central Server

This is the place where all the data from every room regarding power consumption is gathered. For this research project the central server is an Arduino mega, which has a single receiver KQ 330 module connected to it. Once the server has received the data, it is displayed on a screen which lets the user decide which light to turn off. It also displays the monthly target bill which the user does not want to exceed and compares it to the real time total cost of the power consumed. This data once gather is sent to the smart meter

Conclusion

Through this research project we have provided normal people with the means with which they can make their life more comfortable. The accessibility that one will feel with single touch of a finger is truly magnificent. This project is designed to be user friendly, any person who knows how to use a smart phone will be able to remotely control appliances in a house. The fact that it is incredibly easy to install makes us realize the market potential this solution has. The use of existing power lines for communication is not only safe for you and your appliances but is also reliable and robust. This solution has provided people with the ways on how to use energy efficiently, this is not only going to benefit them directly by reduction in electricity bills, but will also register their effort in making the world a better place for our future generations to live.

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Simulating a Simplified model of a Biodiesel Production plant Using COCO ChemSep; Software Analysis

Micaiah Das, Saeed Gul

[a]Department of Chemical Engineering, University of Engineering and Technology, Peshawar, Pakistan

* Corresponding Author
E-mail: micaiah.das@hotmail.com
Tel: +923339998003

Abstract
Due to the limitations of COCO as an open source software, the simulation of complex chemical processes and operations becomes somewhat of a challenge.
This paper investigates whether it is possible for the transesterification process – a process that converts raw vegetable oil (edible or otherwise) having high viscosity to a lower viscosity oil useful as a competitive fuel source – to be simulated on such a software
This paper investigates whether it is possible for the transesterification process – a process that converts raw vegetable oil (edible or otherwise) having high viscosity to a lower viscosity oil useful as a competitive fuel source – to be simulated on such a software. The process of transesterification uses complex chemical compounds not all of which may/may not be available inside the COCO ChemSep Compound library. Ranging from Component availability to reactor availability, the study showed – after selecting approximate assumptions – it is possible to achieve simulation of the Transesterification Process and allow for parametric study of the process, whether the existing real life biodiesel production plant, can be improved or not.

Keywords: COCO Components, Component Addition, Reactor Selection, Reaction Setup

1. Introduction

A Simulator is a program that mimics or tends to mimic conditions from real life applications, providing knowledge about a certain process or operation. COCO is an open source chemical engineering process simulator, that allows studying of various chemical processes such as separation, reaction, mixing, heating/cooling etc..
Due to the limitations of COCO as an open source software, the simulation of complex chemical processes and operations becomes somewhat of a challenge.
This paper investigates whether it is possible for the transesterification process – a process that converts raw vegetable oil (edible or otherwise) having high viscosity to a lower viscosity oil useful as a competitive fuel source – to be simulated on such a software.

2. Literature Review

The process of transesterification uses complex chemical compounds not all of which may/may not be available in the COCO ChemSep Compound library [1]. Transesterification is an oil treatment process that reduces the viscosity of inedible oil to an extent where they are ready for use in a diesel engine. For the process to occur, the oil is treated with an alcohol in the presence of a catalyst, to Fatty acid alkyl ester (Biodiesel) and Glycerol. The FAAE is the desired product, biodiesel, from the reaction [2]. The reaction is as follows

$$\begin{matrix} CH_2OCOR''' \\ \vdots \\ CH_2OCOR'' \\ \vdots \\ CH_2OCOR' \end{matrix} + 3ROH \xrightarrow{\text{catalyst}} \begin{matrix} CH_2OH \\ \vdots \\ CH_2OH \\ \vdots \\ CH_2OH \end{matrix} + \begin{matrix} R'''COOR \\ \\ R''COOR \\ \\ R'COOR \end{matrix}$$

Oil Alcohol Glycerol Biodiesel

3. Methodology

Data required for the study, starts from knowledge about the composition of triglyceride in extracted Jathropa oil to the effect of operating parameters on the reaction. Although data collection is also important, one also needs to be able to interpret the results obtained.

3.1. Raw Material

Transesterification reaction is the reaction between an ester and an alcohol to produce another ester, of lower viscosity and glycerol. The following simulation makes use of the Triolein component of Jathropa oil for simplification purposes [3]. Table 1 lists the various components of the Jathropa seed oil and their respective percentage relative compositions.

Table 1: Triacylglycerol (TAG) composition of Jathropa Oil. O;Oleic acid, Ln:Linolenic Acid, P;Palmitic Acid, S;Stearic Acid, L;Linoleic Acid

Triacyl glycerol	% Relative Composition	Triacyl glycerol	% Relative Composition
OOLn	22.94	SOO	2.48
OLnLn	17.90	PLnP+MOP	1.85
MPP + OOO	16.65	POP	0.91
POLn	14.95	POS	0.59
POO	9.72	MM	0.48
PLnL+MOLn	7.08	CC	0.44
Nd	3.60	PP	0.38

As evident, the majority content of Jathropa seed oil constitutes of Triglycerides composed of oleic and linoleic acid. Triolein is one of these components composed mainly of three molecules of Oleic acid attached to a glycerol chain.

3.2. Simulation Material

3.2.1. Software

The following study uses an Open Source Chemical Simulation Software – Cape Open to Cape Open (COCO). Various components of this particular software are as follows [4]:

1- COFE

The CAPE-OPEN Flowsheet Environment is an intuitive graphical user interface to chemical flow sheeting as shown in Figure 1. COFE has a sequential solution algorithm using automatic tear streams. It contains stream properties, deals with unit-conversion and provides plotting facilities. These flowsheets can be used as CAPE-OPEN unit operations i.e. one of the Flowsheets can be used as unit operation inside COFE itself (flowsheets in flowsheets) or inside other simulators.

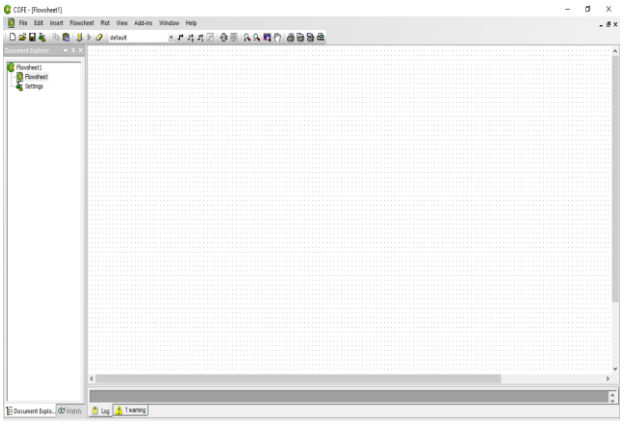

Figure 1: COCO COFE Simulation environment

2- TEA

COCO's Thermodynamics for Engineering Application, Figure 2, includes a data bank of various components around 450 in total. It includes more than one hundred methods for calculating properties of various compounds along with their analytical or numerical derivatives.

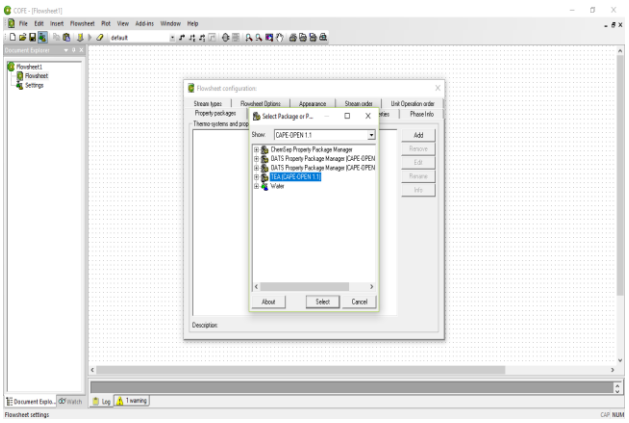

Figure 2: ChemSep thermodynamic Library

3- CORN

The CAPE-OPEN Reaction Numeric, Figure 3, package helps simulate various kinetic or equilibrium reactions. Simple reactor units, like conversion reactors, CSTRs and plug flow reactors that can use the CORN package come with a separately built-in COUSCOUS package.

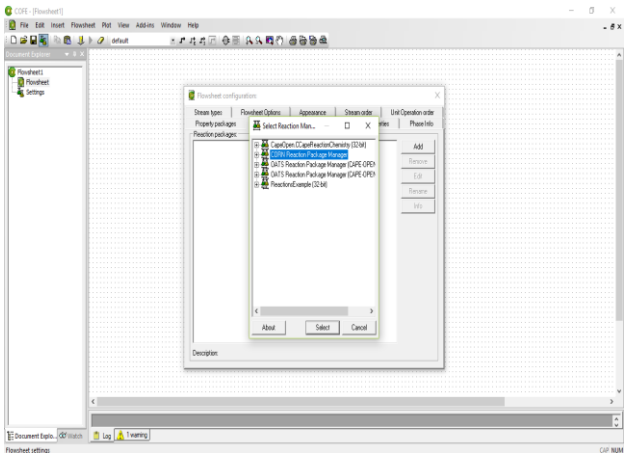

Figure 3: COCOs' Reaction Package

4- COUSCOUS

The CAPE-OPEN Unit-operations Simple package, Figure 4, is a built-in feature of COCO. It contains heat exchangers, pumps, splitters, mixers and reactors amongst other unit operations. ChemSep-LITE, a limited version of ChemSep with a maximum of 40 compounds and 300 stages, can serve as an equilibrium distillation operator in COCO.

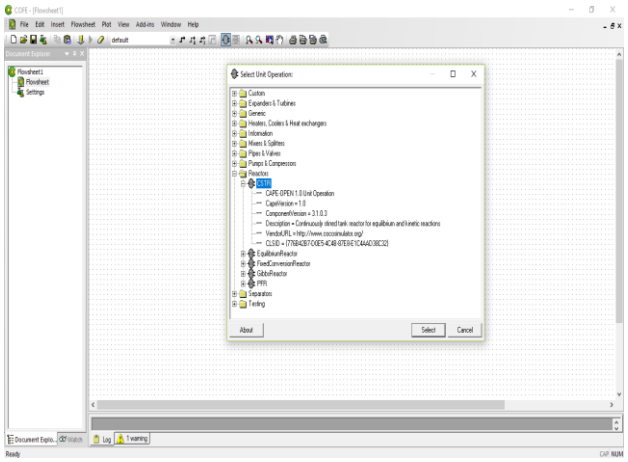

Figure 4: List of integrated Unit Operations in COCO

3.2.2. Component Database

The component database or the compound library included inside COCOs' installation software is a mere list of 430 compounds. To carry out the desired simulation, it was necessary to add compounds integral to the study using the pure component database manager. A. J. de ASSIS et al. [1] provided sufficient data for the desired components, Figure 5. Compounds selected are as follows:

- Triolein (Reactant)
- Di-olein (Intermediate Reactant)
- Mono-olein (Intermediate Reactant)
- Methanol (Reactant)
- Methyl oleate (Product)
- Glycerol (By-product)

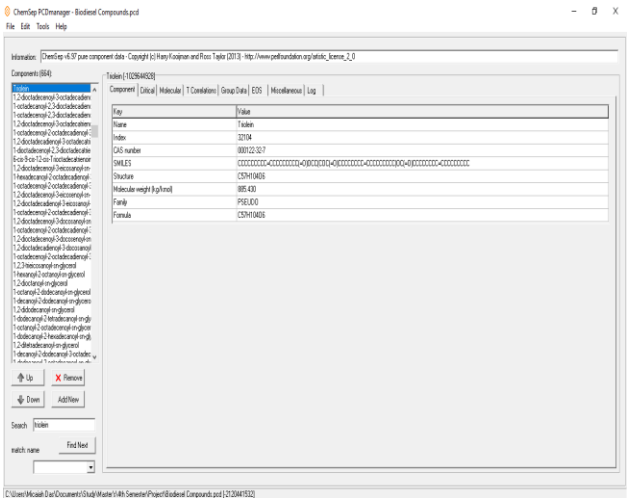

Figure 5: PCD Manager: Compound Database, courtesy of A. J. de Assis et al.

3.2.3. Property Package Selection

Various property packages are available in the COCO TEA library; however, these property packages are only for compounds that are already present in the TEA library – by default. For compounds added using the PCD manager, there will be some error due to data missing from the integrated packages. So amongst the following packages most suitable for the transesterification process, the study moved forward with the UNIFAC VLE property package. The UNIFAC method (UNIQUAC Functional-group Activity Coefficients)[5] is a semi-empirical system for the prediction of non-electrolyte activity in non-ideal mixtures. Where data for the UNIQUAC model is not available, as is the case in the present study, it is advised to make use of its counterpart package i.e. UNIFAC.

3.2.4. Reaction Setting

Using the CORN environment, transesterification process was selected to consist of three equilibrium reactions and a single overall reaction as well. Simulations on the reactions settings were carried out separately as a trial and error method to see which reaction setting would produce the most accurate of results.

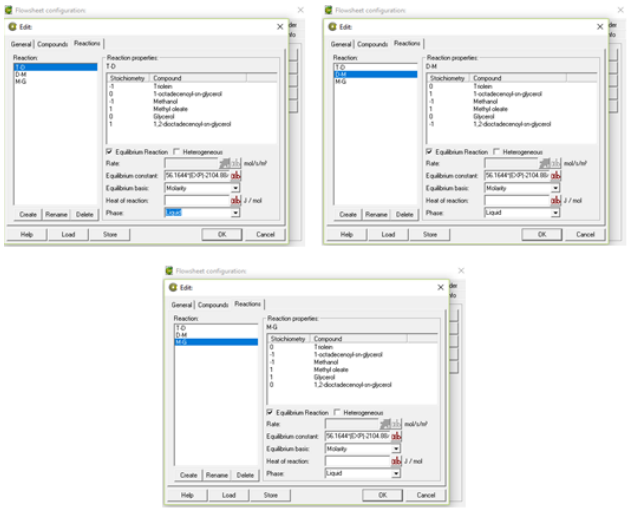

Figure 6: Stepwise Transesterification reactions setup in CORN

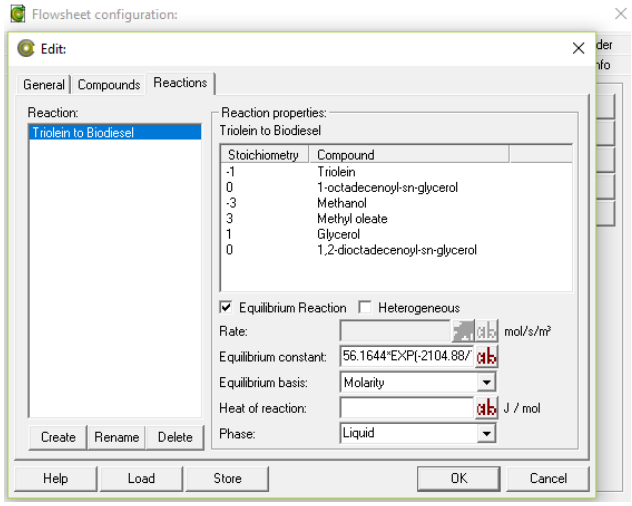

Figure 7: Single step Transesterification Reaction

The equilibrium constant is calculated as a function of Temperature using the Arrhenius equation based on Le Chatelier's principle.

Streams Setting

Stream settings were as follows – two process streams – one containing methanol and the other one containing Triolein as shown in Figure 8

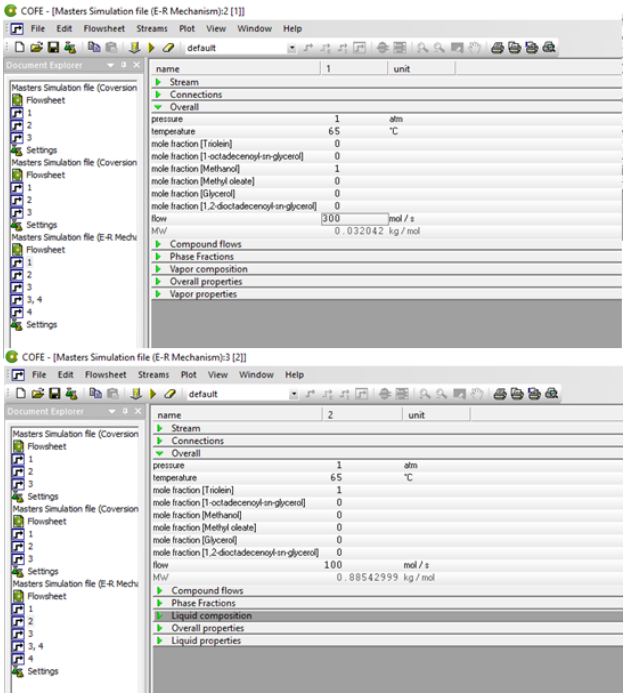

Figure 8: Stream settings; pressure, temperature, flow and mole fractions

3.2.5. Unit operation setting

The following unit operations were set up for the scope of the study, details provided in the following subsection, under respective headings.

a) Mixer Setting

Mixer was setup as shown in Figure 9. Mixer setup just required for two incoming ports and one outgoing port to be specified. Assuming ideal mixing with no pressure drop, mixer setting was quite facile.

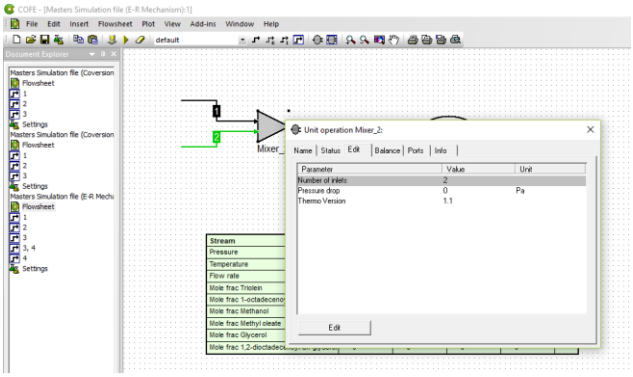

Figure 9: Mixer setting inside COFE

b) Reactor Setting

a. Reactor selection

Following reactors are present in the COCO COUSCOUS library:

1- **Equilibrium Reactor:** The reactor, Figure 10, uses a simplified version of the CSTR and used mainly for processes where the equilibrium reactions can be specified. It calculates both the phase and reaction

equilibrium. It is used only for equilibrium reaction sets. If the reaction phase, as specified, in the reaction window is not present, the reaction will not take place.

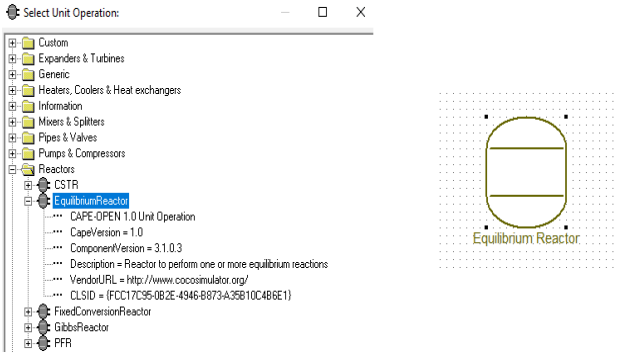

Figure 10: Equilibrium Reactor

2- **CSTR:** The Continuous Stirred Tank reactor, Figure 11, is used when dealing with heterogeneous catalysis/adsorption mechanisms, kinetics or reverse kinetic reactions. The CSTR is primarily used for liquid reactions. The reaction phase for the reactor must be specified as it will only allow for reactions in the specified phase to occur. The CSTR model also takes into account stirring parameters.

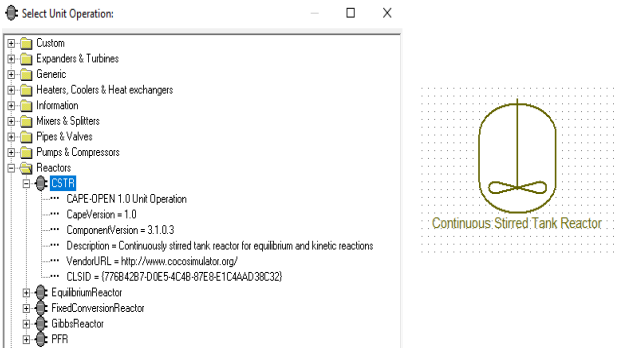

Figure 11: Continuous Stirred Tank Reactor

3- **Fixed Conversion Reactor:** This type of reactor, Figure 12, deals with conversion reactors and is used only when the conversion of the undergoing reaction is specified. It can handle reactions both simultaneously and sequentially.

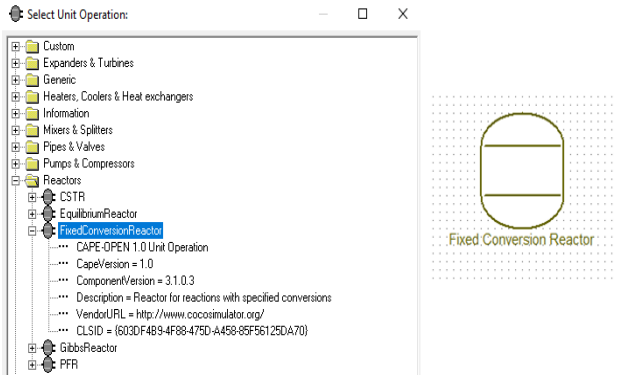

Figure 12: Fixed Conversion Reactor

4- **Gibbs Minimization Reactor:** The Gibbs reactor, Figure 13, has a unique reactor model working behind the screens. This type of reactors does not require a reaction set for it to work. An advantage of this type of modelling is that, you do not need to specify equilibrium constants for the reactions. It uses its modelling parameters to apply its energy minimization technique for the attached reactions. However, it requires integration of the enthalpy and entropy to work properly.

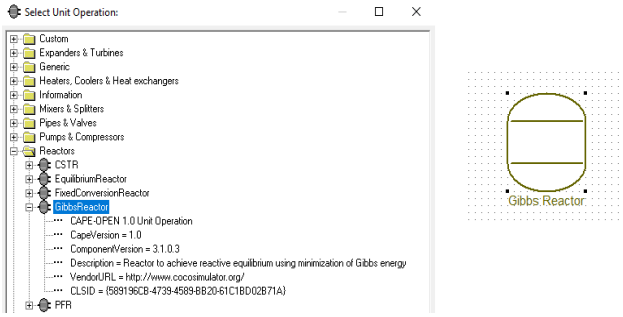

Figure 13: Gibbs minimization Reactor

5- **Plug Flow Reactor (PFR):** The PFR model, Figure 14, has almost the same operation as the CSTR and the model is effective only along the length of the reactor. Every point inside the reactor operating under constant operation i.e. the temperature, pressure, concentration and velocity of the reactive phase do not vary along the cross section. There is no back mixing.

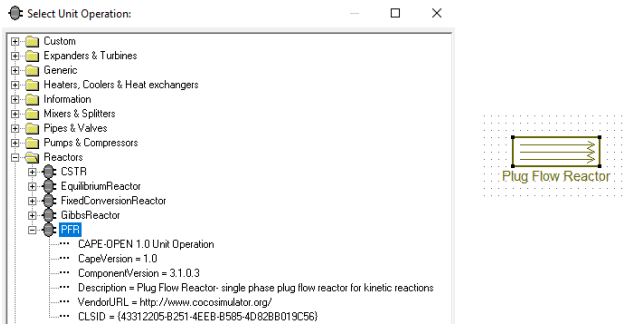

Figure 14: Plug flow Reactor

For simplicity of the simulation, the following assumptions were considered:

- The presence of excess methanol reactant minimizes the reversibility of the transesterification reaction, assumes the reaction as a pseudo first order reaction.
- The reaction mixture is assumed to be a homogeneous phase. Solid catalyst is in powder form and at very low concentration in comparison to the whole volume of the reaction mixture.
- Reaction mixture volume is assumed constant.
- Reaction temperature is assumed constant.

Based on these assumptions, simulations were performed on an equilibrium reactor.

b. Assigning reaction package to the reactor unit

This step involves assigning the reaction package set up in CORN component of COFE to the COUSCOUS component of COFE. It integrates the data from one component into another component of COCO as necessary; shown in Figure 15.

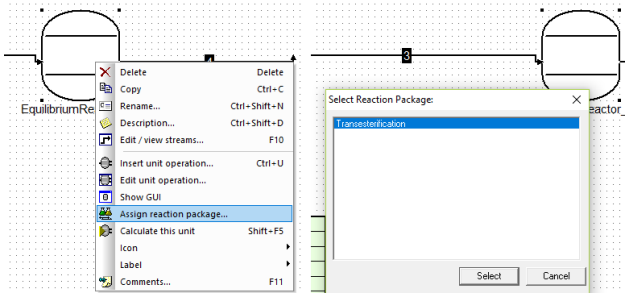

Figure 15: Assigning Reaction Package in COCO

c. Specifying reactor operating conditions

The reactor was set to operate at isothermal operating conditions with zero pressure drop as shown in Figure 16.

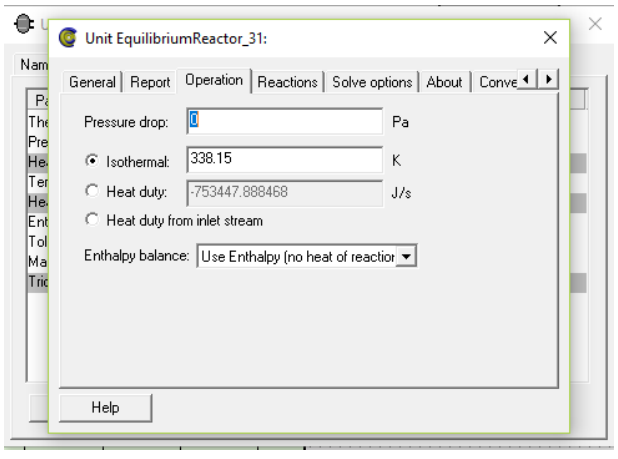

Figure 16: Operating Conditions setup

d. Specifying reactions taking place inside reactor

This step involves adding any reaction that will take place inside the reactor. It is possible to add every reaction specified in the reaction package or just a select few, as can be seen from Figure 17. The reactor will simulate only those reactions that are added in this section of the reactor setup.

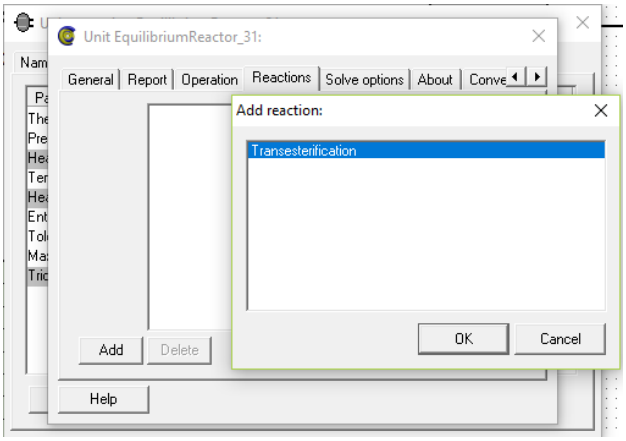

Figure 17: Adding reactions inside the reactor environment

e. Specifying conversion values

This section, after simulation defines conversion values for the specified reactants. For this study, the specified reactant was triolein whose conversion requires investigates as shown in Figure 18.

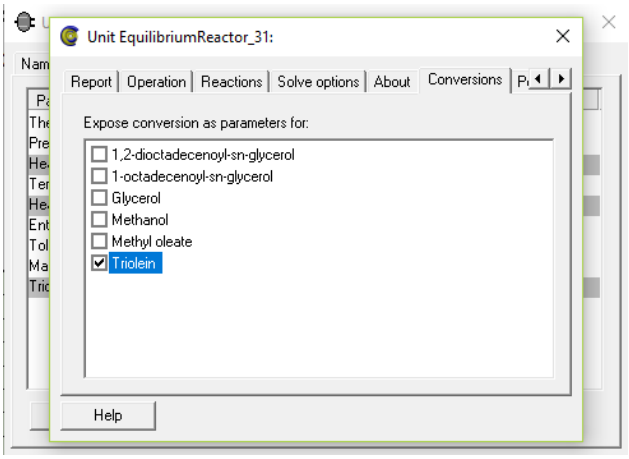

Figure 18: Setting triolein conversion as set parameter against which to investigate the effect of varying parameter

4. Results and Discussion

Figure 19 shows the flowsheet employed for this process before and after simulation. The flowsheet consists of a simplified version of the biodiesel production plant; a mixer and a reactor.

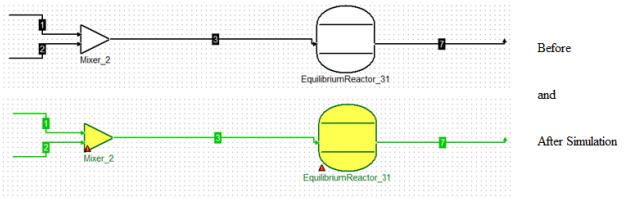

Figure 19: Simulation of a simplified model of a biodiesel production plant

The red sign is a warning sign. The sign poses no vital threat to the simulation; it just notifies that the value used for the heat of vaporization is out of range for the specified temperature. Since the reaction takes place in liquid phase this sign is of no consequence for this simulation.
The simulation was tested for the effect of temperature on triolein conversion and the results of the simulation validated via comparison with lab results. The results are tabulated in Table 2 and the validation and comparison shown in Figure 20.

Table 2: Lab results

Lab Results	
Temperature	% Conversion
55	66
60	78
65	86
70	67
75	58

Table 3: Simulated Results

Simulated Result	
Temperature	% Conversion
55	35.514
60	36.0668
65	36.6072
70	37.1352
75	37.6508
80	37.6508
85	26.098
90	21.4764

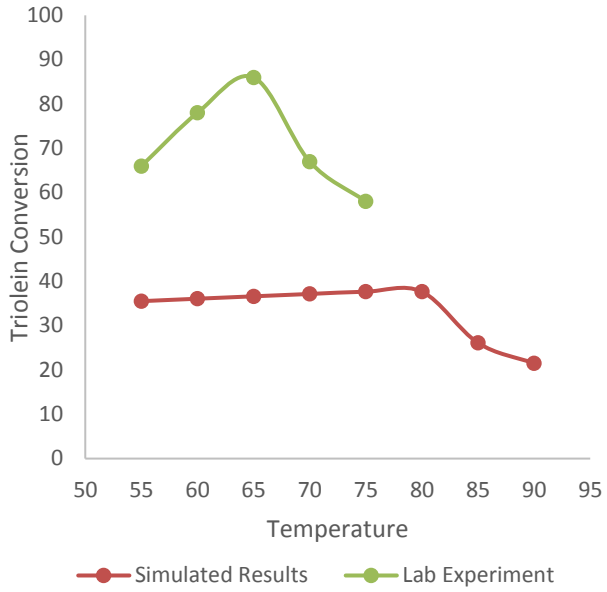

Figure 20: Comparison of lab results and simulated results to validate the applicability of COCO in demonstrating the Transesterification process.

Figure 20 shows comparison between results obtained from lab experiments and the fact that the obtained plots mimic each other quite remarkably. Apart from this, the deterministic coefficient for the plots was obtained as shown in Figure 21.

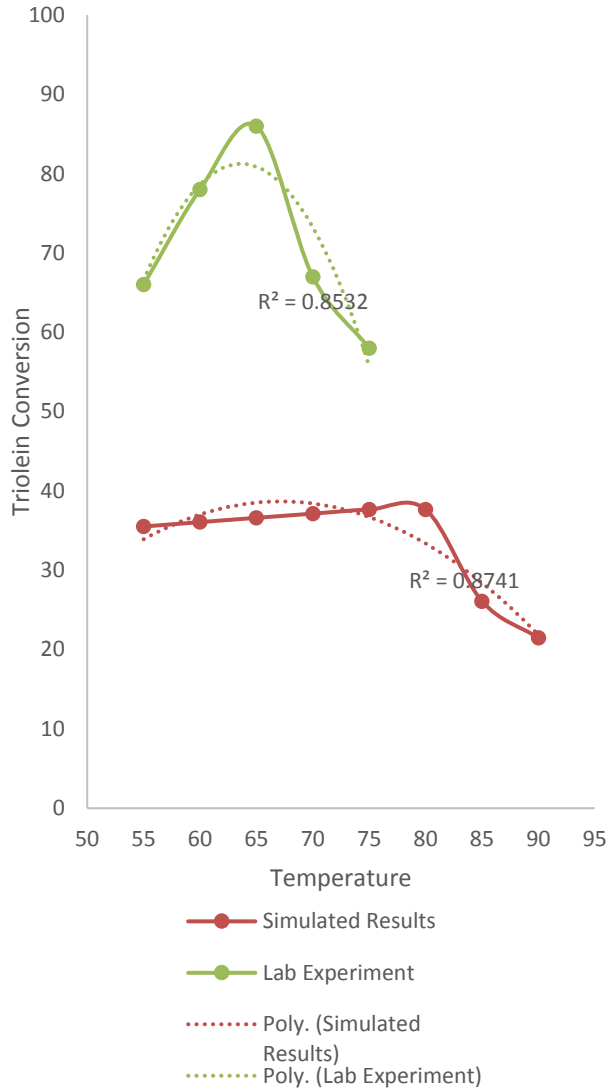

Figure 21: Comparison and validation of data through R-squared value.

An R-squared value close to 1 shows the accuracy of the fitted data line. For both the trends, the R-squared values gives quite a handsome number and is in proximity to each other. The simulation clearly produces realistic results, mimicking those obtained from lab experiments. Hence, proof that the approach used to simulate the transesterification process was successful.

5. Conclusion

To conclude, analysis of the Chemical Simulation software COCO, to check whether it can simulate the transesterification reaction for the production of biodiesel proved successful – not only in terms of successful simulation but also in terms of the comparison of results with those obtained from lab experiments.

ACKNOWLEDGMENT

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A Review on Renewable Energy Integration's Effect on Frequency and Power System Stability

Rida Fatima[a*]; Mamoona Khalid[a]; Dania Khan[a]; Hassan Abdullah Khalid[a]

[a]Department of Electrical Energy Engineering, Center for Advanced Studies in Energy, NUST, Islamabad, Pakistan

[*] Rida Fatima
E-mail: fatimamajeed22@gmail.com
Tel: +923454551733

Abstract
This literature review presents the frequency stability challenges of conventional power plant with the integration of renewable energy sources and its mitigation. Frequency stability in power system is of prodigious significance, so for pledge of stable power system, load and demand should be balanced. Conventional generators can easily takeover frequency instability by droop or inertial control of automatic generation control. However, power system with renewable integration can barely support frequency instability. Various control strategies are anticipated in this paper to overcome the frequency instability in power systems.

Keywords: *frequency stability; renewable integration; demand side control; battery energy storage system*

1 Introduction

THE system frequency varies continuously in response to the fluctuation of generation and demand. Frequency instability is the main gauge of power system disparity. If at any instant in power system when the supply exceeds demand, frequency rises. Conversely if demand of power system exceeds supply, frequency falls. The frequency control is more challenging in case of renewable energy sources integration due to the uncertainty and variability of renewable sources.

Increasing demand, increases frequency fluctuations in power system and demand is an uncontrollable parameter of power system. Similarly, with integration of renewable energy sources, issues like weather variation, seasonal changes and low inertia can create frequency fluctuations. Moreover, the major drawback is the control of these parameters [1]. Frequency regulation of a power system ventures to balance supply as meticulously as promising to the fluctuating demand. Frequency harmonization is accomplished by spinning reserve invention on the bars. Uncertainty because of renewable integration increases reserve capability of power system. Numerous control techniques are deployed to overcome frequency instability issues in power system. Demand side control and battery storage devices are particularized sketchily in this article.

Remaining article is constructed as follow: segment 1.1 anticipates the challenges of frequency in conventional and distributed generation power system. Segment 1.2 anticipates control strategies for frequency instability and mitigation of frequency challenges by demand side control and battery storage system. The conclusion is delivered in segment 1.3.

1.1 Frequency Stability Challenges

Power system stability has proven to be the most imperative and consistent challenge for the secure system since 1920. It is apparent that the increasing demand of electric power with growing industries has steadily increased the size of electricity generating systems [5]. From the traditional perspective, power system instability can be viewed as loss of synchronism; where some synchronous machines may lose step when the system is subjected to a specific unsettling influence. The power system is an exceedingly nonlinear system that works consistently in a varying environment; where generator yields, load demand, and several other prime parameters change consistently. At the point when subjected to a deviation, the dependability of the system relies upon the underlying predetermined working state; along with the way the unsettling nature carry its influences, be it large or small. Load experience small disturbances occurring predominantly; therefore the system capable to calibrate to the changing conditions and demonstrating optimum operation is required. It must

remain sustained toward multitude severe nature distortions, catering loss of a large generator potentially able to affect base load, or transmission line carrying a short circuit, or a disturbance, which may lead to adaptions in the structures as the faulted elements face isolation.

The concept of frequency stability does not have a universally accepted definition. However, we understand that it is the electric power system's ability, for a defined condition for initial operation, to retrieve a state of operating equilibrium after undergoing a disturbance; provided most system is grounded so that the system as a whole practically remains intact. The term 'frequency stability' suggests the power system to regain the equilibrium state when followed by severe disturbance having the potential to cause imbalance between the load and generation significantly. The ability of the power system network to remain in equilibrium, where a successive system variation is followed, is termed as steady state equilibrium. The fundamental classification of power system stability can be viewed from Figure. 1.

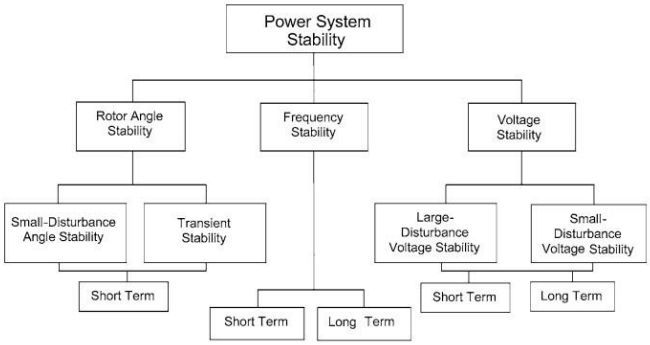

Figure.1 Classification of power system stability

When a certain power system is at equilibrium, its design for a measureable (large) distortion is expected to remain stable and unstable for another. However, these systems render fluctuations of small magnitudes with no particular damage. We therefore acknowledge it is practically not feasible and economically insufficient to design power system that is stable for every possible disturbance. Where there is a high probability for a contingency to occur, the design will be dependent based on these occurrences. As for power quality stability, the generation regulation depends widely on those of loads. At the time of minimum load, there occurs the generation loss. Hence, unlike small disturbances, large disturbance stability will delineate predictable scenarios in terms of more of robust in design. While there are frequency excursions, the device characteristic time actively participating will vary from fraction of seconds commensurate with under frequency (i.e. load shedding), whereas several minutes for protection of generations; where load voltage regulators and prime mover are active to supply systems. Hence, frequency stability entrench both long and short-term phenomena. Island system is moreover the short-term frequency instability when the system is under frequency (load shedding), causing the frequency to decay hereby the island caters blackout for a few seconds. There may occur more perplexing circumstances in the instability resulted by steam turbine over-speed controls lasting the disturbances from seconds to minutes. While frequency trips, voltage essentially may fluctuate, particularly to islanding conditions, which are more vulnerable to load shedding. The change in voltage may be more detrimental consequently resulted by frequency deviation.

1.1.1 *The Need for Renewable Energy System*

The challenge with the conventional fossil-fueled power systems is its depleting nature that the resources running systems are not replenished in nature with the similar rate as these are being consumed. Environmental pollution, poor energy efficiency and depleting resources have led the power systems to introduce new power grid, integrating the non- conventional Renewable Energy Systems (RES) such as photovoltaic panels, wind turbines, fuel cells etc., called micro grid. The micro grid concept was developed to connect large number of distributed power generation sources, including renewable energy sources, within a network to reduce the need of transmission and high voltage distribution system, to supply for the growing electricity need and to improve energy utilization efficiency and reliability. However, integration of the distributed renewable energy sources into the grid has proven a unique challenge as demands for reliability and power quality remain, whereas renewable sources continue to exhibit an intermittent nature.

1.1.2 *Challenges with high Renewable Energy Systems penetration*

While the renewable generation penetration in power systems is increasing, renewable units are displacing a considerable part of conventional synchronous units providing inertia response and PFR. However, wind and solar units typically provide low to zero inertia response because of their non-synchronous connection to a power system. The increasing penetration of renewable generation thus reduces the total inertia of the system, and consequently poses a major challenge to the frequency dynamics management and compromises the operating stability of the system [14], [15]. First, the RESs typically have low or non-existent inertial responses. High penetration level can undermine the stable operation of the system by contributing to a reduction of the system's inertia response. Once RESs are linked to the main grid in place for the conventional generators, they will cause a larger and faster frequency deviation. If the main grid offers insufficient regulation capability, the resulting frequency deviation will offer load shedding, moreover a system to collapse. Wind power plants deploy variable speed wind machines. On an event where a certain contingency occurs, these plants play role in frequency regulation [2]. For variable speed wind turbines, the power converters vitally do the decoupling between the mechanical part of prime mover and the electrical part,

synchronous generator. As these physical laws do not inherently know synchronous generators, the power system inertia faces reduction, resulting in fast frequency reaction, i.e. decline, to the imbalance between generation and the load. Term inertia in power systems may be defined as rotating generator's and motor's overall kinetic energy [3]. The wind synthetic inertial response minimizes Rate of Change of Frequency (ROCOF) and reduces system frequency (nadir) when there occurs a generation loss, constituting into one of the key challenges for power system [14]. Variable speed wind turbines may also effectively decouple the wind turbine inertia from mitigating system transients. Therefore, replacing conventional sources with RESs will reduce the inertia of the whole power system. Due to this inertia reduction, the ROCOF of the power system will be high enough to activate the load-shedding controller, even at small magnitudes of imbalance. Second, an increase in the penetration level of the RESs decreases the number of generation units providing reserve power for primary and secondary control. The high ROCOF does not only threaten the system's stability but potentially also initiate tripping of the adjacent synchronous generators. Therefore, as sensitive as the system becomes, it is subjected to load shedding more favorably, rising the occurrence of black out. The low inertia of system could be led by cascading failure in the system, while there is high availability of PV or wind generators, which favors the synchronous system to drop, the total inertia is compromised. Therefore, for an unacceptable frequency deviation, the failure of cascading can be another reason [13].

1.2 Control Strategies for Frequency Instability

This literature review anticipated several control strategies for frequency instability. Figure. 2 exhibits the control scheme followed cater frequency instability.

1.2.1 *Demand Side Control*

In [16], a concurrence based demand side controller along with automatic generation control restore system frequency after disturbance has been proposed. It is a double-edged controller that varieties manageable load collectively with generators to reestablish the system frequency swiftly after a real power divergence occurs in the grid. Secondly, it renovates manageable loads to their Optimal operational environments. Objective of proposed controller is abrupt restoration of frequency by governable load and afterward restore controllable load to nominal values. Communication between controllable loads is available via communication network, which helps controllable load to react to the frequency deviation. It improves system transient response. It helps automatic generation control to moderate the largest frequency deviance and make it in tolerable region throughout the completely transitory interval after a disruption and

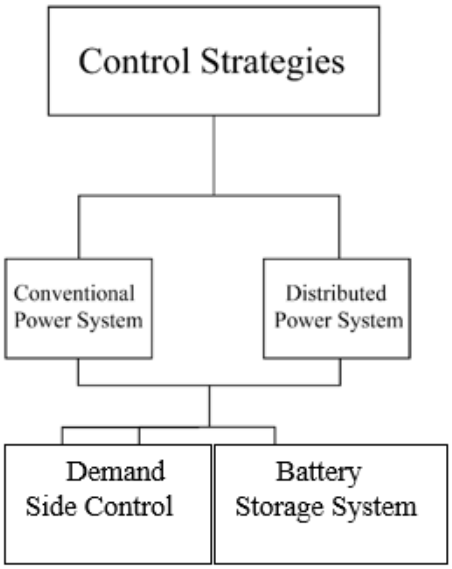

Figure.2. Control Scheme for frequency instability

underrates the influence on end users. Manageable load stakes the total power disproportion in a tactic that the disruption will not impact any solo load rigorously, but the total consequence of entire manageable loads has a system level reparation to the disruption.

In [17], the vibrant features of Aluminum Smelter Loads (ASL) are modelled based on field experimental data. Grounded on the anticipated vital model considering load-side involvement by ASLs, a model predictive control - based frequency controller is framed, which can consider the system limitations unambiguously. In accumulation, the controller grosses prophesied crescendos of the system into contemplation, which is vibrant for frequency regulation in remote system under a huge disruption. Model predictive controller is used to control frequency deviation in collaboration with aluminum smelter load. The model predictive control based frequency controller permits the ASLs to contribute in frequency directives. ASLs power change with variation in system and returns to its nominal value once disturbance is settled down. The main advantage of MPC-FC is reduction in fossil fuel consumption but it's not user friendly and cost effective.

In [18], a systematic method to design cut-and-dried uninterrupted rapid interim distributed load regulator for crucial frequency control in power system is proposed by framing an optimum load regulation delinquent where the purpose to curtailment is the cumulative cost of tracing an operative point focused to balance power in the network. It is proved those fluctuations and the outlet power drifts, together with frequency-dependent load regulator, assist as a disseminated primal-dual method to solve optimal load control. A universal asymptotic power of a multi-machine system is established in such kind of load-side crucial frequency control. These outcomes involve that the confined frequency abnormalities on each line deliver

accurately the accurate statistics about the universal power discrepancy for the loads to mark discrete conclusions that emanates to be comprehensively optimal.

In [19], two-stage load regulation scheme for unembellished under-frequency circumstances is proposed. The designed scheme consists of event-based under-frequency load shedding in the first stage for initial and immediate system protection and model predictive control using interruptible loads in the second stage, which recover frequency to nominal value with coordination of automatic generation control. Feeder is disconnected in case of severe under frequency condition and decision is obtained by solving load-shedding optimization and mixed integer programming. System dynamics in load shedding optimization are approximated with linear constraints based on trajectory sensitivity analysis. In real time, the event based under frequency condition program directly takes the remedial action according to the lookup table once an analyzed event is detected, to maintain system stability and protect turbine-generators. Quick frequency recovery load control is available at many locations.

In [20], adaptive neuro fuzzy system regulator is utilized for moderating the load frequency regulation concerns in a two-region hydrothermal power unit in decontrolled situation. To expand the load frequency regulation enactment, grouping of Super Conducting Magnetic Energy Source (SMES) and Thyristor Controlled Phase Shifters (TCPS) are involved in its regulating region. The deployment of SMES–TCPS arrangement captures preliminary descent in frequency and tie line power abnormalities after abrupt load disruption. Load discrepancy disturbs the frequency and tie-line power deviates. To upend the region frequency deviations and tie-line power contacts, power unit with SMES-TCPS unit is presented, in which SMES units are located in both the regulating areas and TCPS unit is positioned beside tie line. TCPS varieties the phase angle among voltages to control the real power flow over designated ways to alleviate the frequency fluctuations and recover the system permanence bounds while SMES liberate huge extent of energy in a diminutive extent of time. Adaptive neuro fuzzy system controller gives improved performance than a PI controller. Stabilize the load frequency issues effective in settling frequency disturbance.

In [21], a multifactorial control scheme is projected for frequency directive of source-grid-load systems, with participation of power grids, power sources and loads to achieve the objective. The projected control scheme comprises of two level operations, upper and lower level operation. Upper levels for model predictive regulation of generators while the lower level for distributed spearhead subsequent consent control scheme for numerous energy storage units. Grid responsive appliances are coupled to grid, which can deliver frequency-controlling services. Leader-following compromise procedures are premeditated to assign the excess or undersupplied active power accommodatingly between all energy storage units. The supportive aim is to make each energy storage unit; part a shared ratio of obligatory active power it offers to concentrate active power it can deliver throughout peak load time. Model predictive controller is better than conventional PI controller is. It provides system frequency control with lesser fluctuations and lower generating productions of conventional generators.

In [22], a distributed frequency regulator for bitumen tanks was established to let the tanks to adjust their power consumption in amount to the abnormalities of grid frequency. Each tank has an equivalent chance to be swapped on/off and react to frequency deviances. The frequency regulation does not inhibit with the actual regulation and henceforth temperature of the reservoirs. Well-insulated tank is used to store liquid bitumen. Heater using hysteresis control maintains temperature of tanks. Comparison of two triggering frequencies, one is grid frequency and other is nominal frequency, generates control signal. If it is beyond F_{on} the reservoir will be activated ON by the frequency increase. If it is under F_{off}, the reservoir will then be prompted OFF by the frequency drip. Advantage of tank is faster frequency control and faster loads change following the frequency deviation but poor safety.

In [23], primary frequency regulation grounded on voltage contingent noncritical loads that can stand by widespread deviation of source voltage is proposed. The noncritical load can be controlled by consuming series of reactive compensator to eliminate the load from main to arrange a smart load for frequency regulation of mains. Focus of this paper is mainly on reactive compensators while upholding the quadrature, which helps to determine an upper bound on penetration level. The maximum allowable penetration level of micro grids is determined by new indices. 16-machine, 68-bus system and the IEEE 50-machine systems are used for demonstration of proposed indices. Results of simulation of the proposed indices for large power system with high stiffness reveal that based on operating condition, the minimum instantaneous frequency and 15-second rolling window could affect the maximum penetration level, while minimum instantaneous frequency could be effective only for low stiffness systems the loads to mark discrete conclusions that emanates to be comprehensively optimal in voltage tolerance for the noncritical loads and a minor reactive compensation in smart load.

In [24] this article explains a consideration of a Variable Speed Heat Pump (VSHP), which responds to Direct Load Control (DLC) indications to deliver Grid Frequency Regulation (GFR) auxiliary provision, while guaranteeing the security of constructing inhabitants. The DLC arrangement is then experimentally pragmatic to the VSHP to appraise its Demand Response (DR) competency. For a useful execution of the DLC-enabled VSHP, two control methods are imitated and additional upgrading of the DR competency, correspondingly. Furthermore, a minor-signal exploration is expending the accumulated vibrant response of a number of DLC-enabled VSHPs to scrutinize their involvement to GFR in remote power grid. As

communiqué with buildings is conceivable via the internet, the power intake is unswervingly manageable in real time under the regulation of a central load-transmitting center or local regulator centers. It safeguards the well-being of building inhabitants. The prototypical model is simple, yet still adequately inclusive to investigate the operative features of the VSHP.

In [25], frequency sustenance by vigorous demand based on multi-agent framework on efficacy expansion is anticipated. The multi-agent framework contains two parts. First, one is responsible for the concurrent procedure, whereas other part is liable for a concurrent forecasting of the ingestion strategy. With the algorithm stimulation of primary and secondary reserves, the client welfare remains highest. Utility functions of devices are used to identify the value of received energy. Through the recommended control agenda, the primary and subordinate frequency regulation by a conventional generator can be imitative. A developing perspective regulation is pragmatic to describe a consumption strategy that exploits the load aggregators' revenues. The regulator interprets the tapered spinning reserves to assurance their accessibility in the forthcoming period. The framework provides primary and secondary control but load aggregator that provides reserves for the frequency control needs to manage cluster of load, which is problematic.

1.2.2 Battery Storage System

In [26], advance frequency control based innovative approach is proposed to assimilate storage in frequency regulation. The aim is to divide the chore of harmonizing frequency abnormalities lead by renewable energy source (RES) and load deviations rendering to the proficiencies of storing and generators. Conventional generators equalize low-frequency modules of renewable energy source while high-frequency disparities are balanced by energy storage strategies.

In [27], undersized term frequency regulation approach for micro grid is presented by integrating battery energy storage system. In conventional power, system short term frequency is stabilized by inertial action of generator however renewable energy sources based distributor generator is not able to support to frequency disturbance. The anticipated system is presumed to provide response to both undying abnormalities and to rate of change of frequency by combining inertial response and droop control. Integration of proposed system noticeably spectacle improvement is frequency deviation but penetration level is still restricted due to economic issues.

In [28], cooperative control by utilizing differential games is suggested as a promising solution to load frequency control in power system, which uninterruptedly requires control area to stake the burden via tie line. The load frequency control is even more problematic with integration of renewable energy sources. Load frequency control is modeled by three equilibrium solutions, which are derived from Distributed generator theory. Unlike conventional proportional integral and optimal controller, Cooperative controllers allocate the credible amount of load frequency regulation to each control area to assure even and stable implementation of control. Cooperative control is providing stability to the power system but the computational complexity makes its implementation problematic.

In [29], applications of battery energy storage projects along with power conversion and control is demonstrated in this paper. Frequency regulation, power eminence, consistency, and renewable energy leveling can be achieved by anticipated projects. The study also suggested technical practicability and influences on power grid. A set of new battery energy storage systems are modeled that are used for system influence and transmission studies. Although battery energy storage provides fast frequency regulation but there are, some constrains of battery storage systems. Storage unit must be equal to the largest generating unit and that will increase the cost of system. In addition, storage devices have limited lifetime.

In [30], an innovative frequency dynamic inhibited unit commitment comprising remedial whereabouts of battery storage strategies for dynamic frequency provision is projected. An interval-based optimization technique is used to handle with the influence of wind vagueness on unit forecast and system frequency subtleties. In anticipated model, nonlinearity is controlled by using a reformulation-linearization procedure. The competence of dynamic frequency regulation from storage elements condenses the system operational cost, evades wind curtailments and assures frequency sanctuary is demonstrated by case study. The suggested procedure is also appropriate to the abrupt interruption of large loads. In mandate to demonstrate the over-frequency vibrant concerns, the emergency reserves must be completely effective by exploiting the charging of batteries in case of excessive generation

1.3 Conclusion

Power system is the mainstay of emerging economy. Any kind of interruption in power system stability May leads to load shedding and in worst-case blackout, which is not desired. This paper-appraised timeline of frequency defies and its extenuation measures in power system. Imbalance between load and demand originates instability in a power system. In addition, renewable energy integration makes instability shoddier. Various control schemes accessible to astound these deviations were anticipated and equated centered to feasibility, accuracy and cost effectiveness. Accomplishment of any scheme depends on the system reliability and consumer satisfaction. Advance studies on Demand side load management and battery storage system integration in smart grids can subsidize power system stability improvement.

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Lithium Ion Cell Modeling for Electric Vehicle: A Step towards Zero Carbon Emission

Rida Fatima[a*]; Mamoona Khalid[a]; Abdul Kashif Janjua[a]; Hassan Abdullah Khalid[a]

[a]Department of Electrical Energy Engineering, Center for Advanced Studies in Energy, NUST, Islamabad, Pakistan

[*] Rida Fatima
E-mail: fatimamajeed22@gmail.com
Tel: +9203454551733

Abstract

High specific energy density, extensive range of operational temperature and safety benefits makes Lithium-ion battery a promising technology for energy storage especially in electric vehicles. Due to lack of supplied information by battery producers and independent verification of Li-ion battery, demand of accurate simulation and modeling scheme of Li-ion battery is increased. In this paper, a comparative study on several Li-ion cells is conducted, considering the tradeoffs between thermal runaway and energy density. Various Li-ion cells' performance, cost, nominal voltages, temperature ranges and the discharge rate is studied. Selection of Li-ion cell is based on the comparative study and it is determined that equivalent Electrical Circuit Modeling (ECM) provides accurate results and fast convergence. Both dynamic and steady state characteristics of Li-ion cells are modeled using ECM. Model parameterization is done by experimental results of pulse discharge tests and lookup tables for circuit elements. The results establish relation between battery parameters and factors that affect performance of battery.

Keywords: *equivalent circuit model; lithium-ion-battery; SoC (State of charge) estimation; OCV (Open Circuit Voltage) estimation; electric vehicle battery modeling*

1 Introduction

The electrochemical storage techniques play an evident role by providing efficient energy, reducing oil consumption and dangerous greenhouse gas emissions [1]. Due to high energy density, high voltage, zero memory effect, maximized life cycle, lower weight and volume, makes lithium-ion cell an ideal candidate for electric vehicles. Because of aforementioned characteristics Li-ion cells are used in multi-level applications. Despite numerous advantages, different environmental conditions and aging problems can limit the application of Li-ion cells. Therefore, description of internal state of Li-ion cell accurately is the key issue.

Due to non-linearity and chemical phenomena, modeling of Li-ion cell is a complex task. Different modelling approaches exist in the literature [2] [3] [4] [5]. They can be broadly categorized as electrochemical, electrical and physics-based models. The electrochemical model is mainly used in design process and optimization of cell's performance. These models are comparatively complex in their structure because of material parameters and chemical reactions inside a single Li-ion cell [6]. Physics-based models can predict wide range of operating conditions and internal state of cell. However, slow simulation convergence and robustness issues make it less favorable for modeling of Li-ion cell [7]. Equivalent Electrical Circuit Modeling (ECM) is computationally more efficient and robust than abovementioned models [8] [9] [10]. ECM is based on "double layer theory" proposed by Gouy and chapman [11]. The basic equivalent circuit consists of one internal resistance and one RC branch. The modeling of circuit parameters is done by experimental data obtained under different operating conditions. Parameter estimation technique is used to extract the required parameters for circuit model [12].

Lithium-ion cells first become commercially accessible in 1991. Today, there are diverse cell manufacturers that offer wide variations of cells depending on usage and preferences. Comparison in Table 1 shows that Lithium-iron phosphate provides wide range of operating temperature ranges and cycle count [13]. Besides these advantages, flat voltage profile of Li-iron phosphate cell provides constant power within tight voltage window to 80% of state of charge with minimal impact on cell life. Li-iron phosphate is considered as an ideal candidate for grid

voltage stabilizers, power tools, hybrid vehicles, naval and air operations [14]. In our further discussion and experimentation, we will use Lithium-iron phosphate.

Table 1. Comparison of Li-ion cells

Type of Batteries	Cost	Energy/weight	Application type	Cell voltage	Max. Charge And discharge rate	Thermal Runaway	Cycle count
Lithium-Cobalt oxide	High	150-200 Wh/kg	Cell phones, laptops, Cameras	3.0-4.2 V 3.60V (nominal)	0.7-1C (charge to 4.2 V) (1C max) 1C(2.5V disc)	150°C	500-1000
Lithium-Titan ate	Lowest	70-80 Wh/kg	Mitsubishi-I-MiEV, Electric Vehicle	1.8-2.85 V 2.40V (nominal)	1C (charge to 2.85 V) (5C max) 1C(1.80V disc) (10C max)	-40°C Safest	3000-7000
Lithium-iron Phosphate	High	90-120 Wh/kg	Power tools and medical Equipment's	2.5-3.65 V 3.30V (nominal)	1C (charge to 3.65V) 1C(2V disc) (25C max)	270°C	1000-2000
Lithium-nickel Manganese cobalt oxide	High	150-220 Wh/kg	Power tools, e-bikes, electric power train, Industrial	3.0-4.2 V 3.60V (nominal)	1C (charge to 4.2 V) (1C max) 1C(2.5V disc) (2C max)	210°C	1000-2000
Lithium-Manganese Oxide	High	100-150 Wh/kg	Hybrid Vehicles, cell phones, Laptops	3.0-4.2 V 3.80V (nominal)	0.7-1C (charge to 4.2 V) 3C (Max) 1C (2.5V disc) (10C max)	250°C	300-700
Lithium-nickel cobalt Aluminum oxide	Low	200-260 Wh/kg	Medical Devices, industrial, electric power train (Tesla)	3.0-4.2 V 3.60V (nominal)	0.7 (charge to 4.2 V) 3C (Max) 1C (3.00V disc) (10C max)	150°C	500

1.1 Li-ion Cell Modeling

1.1.1 Equivalent Electrical Circuit Model

Lithium-ion cells can be modeled easily with electrical modeling but some of the material properties cannot be considered through this method. However, the effect of those parameters on battery performance is negligible, so it is insignificant to model them. There are many cell models as discussed in [15], [16], [17], [18]. The model proposed in this paper is based on Randle's second order circuit. Temperature, state of charge and C-rate of battery can be modeled using this circuit. Figure 1 shows the basic ECM. V_{oc} is open circuit voltage, R_o is the input resistance of cell, which shows the voltage drops when it is under load, parallel RC sub-circuit shows the dynamic behavior of the cell. When a cell is allowed to rest after discharge, its voltage does not immediately return to Open Circuit Voltage (OCV), but decays gradually. This phenomenon is caused by slow diffusion process of cell and can be represented by RC circuits. All the elements in circuit below are a function of temperature, state of charge, voltage and current. Transient response dynamics and voltage hysteresis make parameter extraction a complex task but it is necessary to model the battery because it can assist in optimization of physical structure of cell and its management control system.

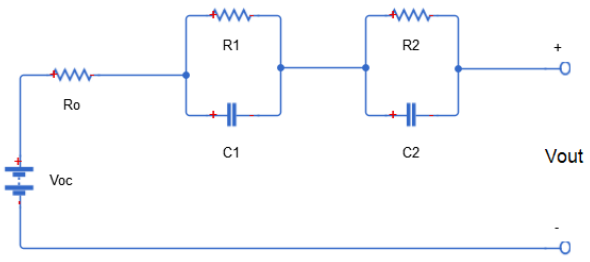

Figure 1 Equivalent model of li-ion cell (courtesy MATLAB R2016)

1.1.2 Pulse Discharge Test

For lookup tables, data acquisition from experimental results is necessary. Pulse discharge test is conducted to get the desired data about the performance of cell at different points of state of charge. The test offers significant information about the open circuit voltage and cell dynamics. Figure 2. shows the result of pulse discharge test.

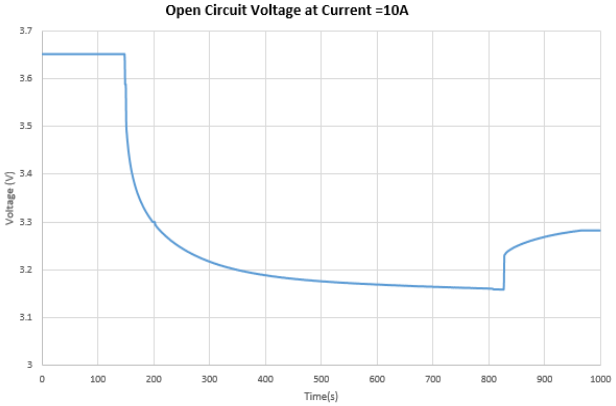

Figure 2. Pulse discharge test (courtesy EXCEL 2016)

Other factors, such as temperature, was assumed constant while performing the test. Dynamic behavior of the cell can easily be seen from the above one pulse discharge test. The battery establishes a new voltage level after being discharged for few hours. The new voltage established can be used to estimate state of charge of cell.

1.1.3 Optimal Equivalent Topology

For parameter estimation, it is essential to determine the number of RC branches in equivalent circuit. RC branches give an acceptable representation of battery. To determine the number of RC branches, we examine the data in relaxation time. When the current discharging pulse was removed, there was instantaneous change in voltage and

that change is because of dynamic response of battery, which is modeled by RC branches. Curve fitting toolbox was used to fit one or more exponential equations to the data. Number of the curves obtained by curve fitting toolbox shows the number of RC branches, which can depict the acceptable battery representation. The result is shown in Figure 3 and it can be seen from the figure below that there are two curves, which mean the equivalent circuit will consist of two RC branches.

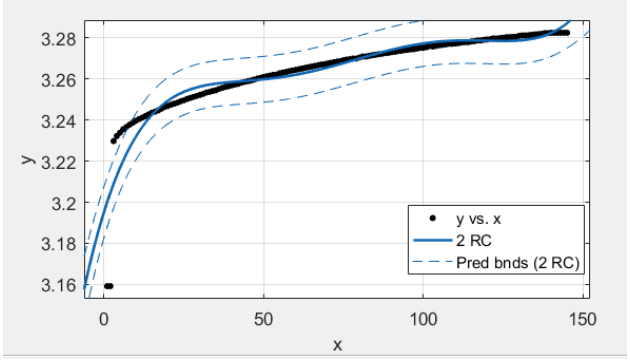

Figure 3. Curve fit for RC branches identification (courtesy MATLAB R2016)

1.1.4 Model formation in MATLAB

Based on the two RC branch circuit shown in Figure 1, Simscape [19] model shown in Figure 4 is created. The Simscape language is used to create the custom components containing lookup tables. Simulation results were used to optimize the parameter values of cell.

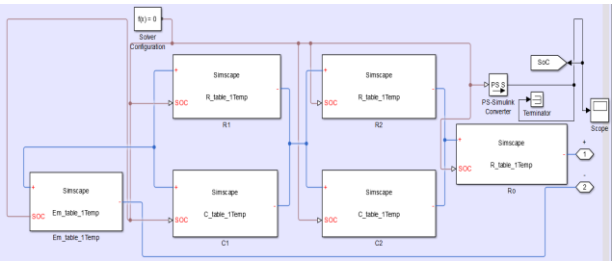

Figure 4. Equivalent circuit with 2RC branches (courtesy MATLAB R2016)

The above MATLAB model consists of five parameters, which are a function of multiple operating conditions. In this case, only one temperature and one discharge current pulse is used. Multiple operating conditions will make the look up table quite large. In Figure 5, complete RC circuit with sensor measurement is shown. Signal builder used in a circuit provides charging and discharging pulses of current to controlled current source. Controlled current source maintains the specific current regardless of the voltage across it. Voltage sensor is used to convert voltage measured in between any electrical component to the physical signal proportional to the voltage. The circuit below can be used to establish a relationship between different parameters of cell.

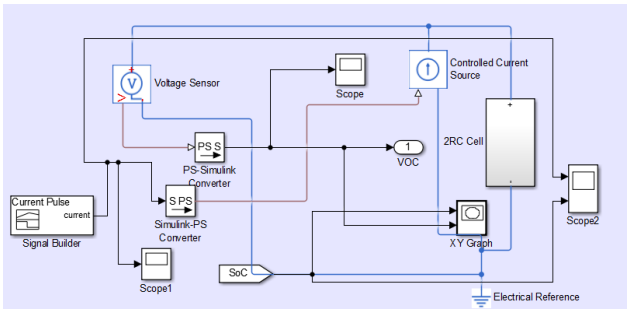

Figure 5. Complete circuit with current and voltage sensor (courtesy MATLAB R2016)

1.2 Results and Discussion

In this paper, pulse discharge test was performed on SP-LFP 100AHB cell with a constant current pulse. Initially, the cell was fully charged at 3.65V and later it was discharged at a pulse of 10A with a width of one hour. After discharging, the cell was at rest for about two hours to stabilize its voltage. The test was used to obtain multiple data points for modeling of equivalent cell circuit. Using the data from experimental results, the number of RC branches were selected. Moreover, equivalent circuit was also modeled using the data obtained from the experiment. The experimental result can be used to show the relation between state of charge and open circuit voltage. Figure 6 shows the relation between SOV and VOC.

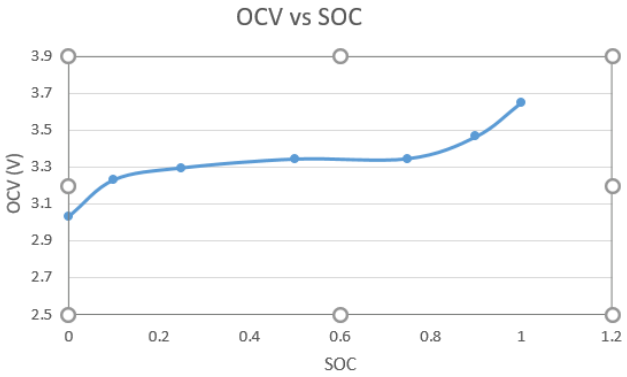

Figure 6. SOC vs VOC (courtesy EXECL 2016)

It can be seen from the above result that as the state of charge decreases, open circuit voltage will decrease accordingly. At 100%, the SOC voltage is 3.65V and at 50%, SOC open circuit voltage is 3.3V. In Figure 7, it can be seen that the initial state of charge of cell was 50%. In first 5000 seconds, charging pulse of 20A was applied to the cell so that cell is fully charged. After cell is fully charged, there is rest time for few seconds and then multiple discharging pulses are applied to the cell. With each current pulse, SOC will keep on decreasing. The same trend can be observed from the experimental results.

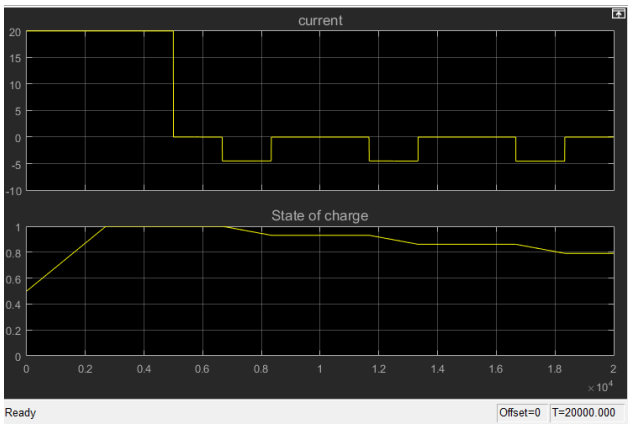

Figure 7. Current vs SOC (courtesy MATLAB 2016)

Similarly, the OCV of the cell was low as the state of charge of cell was initially low. As we charged the cell, OCV also kept on increasing. Results can be seen in Figure 8. When the discharge pulse is applied to the cell, the OCV will decrease and during rest time cell will establish a new OCV, which will be slightly lower than initial voltage.

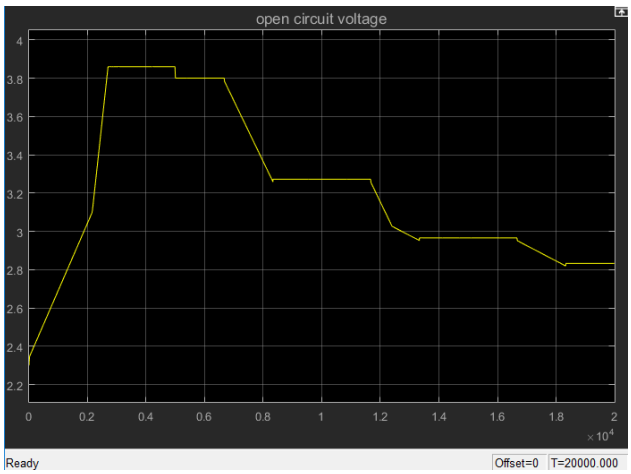

Figure 8. OCV vs Time (courtesy MATLAB 2016)

If we zoom in the above image, we can see the dynamic behavior of the battery, which is almost the same behavior that is obtained by the experimental results. Results are shown in Figure 9. The dynamic behavior obtained by the simulation is not exactly the same as actual dynamic behavior obtained by the experimental results. However, the addition of more RC branches to the circuit can provide more accurate results which are same as the experimental results.

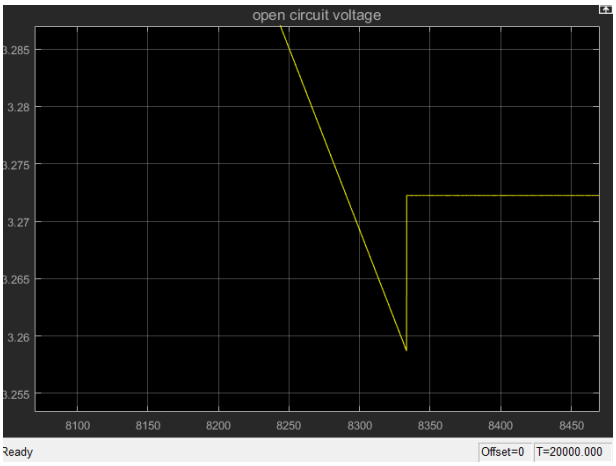

Figure 8. Zoomed in OCV vs Time (courtesy MATLAB 2016)

1.3 Conclusion

An equivalent electrical model of Lithium-ion cell is acquired from the existing literature and an effort has been made to condense the parameters in the model, thereby dropping the complication of the system. This developed model can be deliberated further for building thermal model and the entire battery. The experimental setup can be used to perform tests under different conditions in future such as under different temperature ranges and multiple driving profiles. Aging and some other chemical degradation parameters of cell are not considered in this study. These parameters can be modeled in future cell modeling.

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Development of Talc as an alternative of Zirconium silicate in ceramic tile glaze

Murtaza Khan[a,*]; Nisar Mohammad[b]; Zahid Ur Rehman[b]

[a]Department of Chemical Engineering, University of Engineering and Technology, Peshawar, Pakistan
[b]Department of Mining Engineering, University of Engineering and Technology, Peshawar, Pakistan

[*] Corresponding Author
E-mail: murtaza_forte@yahoo.com

Tel: + 92 3339343174; 03339052959

Abstract
This paper presents utilization of talc in substituting zirconium silicate in ceramic tile glaze as opacifying agent. Usually, in ceramic tiles industry zirconium silicate ($ZrSiO_4$) is used as opacifier so for. However, the high cost of zirconium silicate limits its uses. In this research work, alternative glazes with better whiteness and opacity were found using talc ($Mg_3Si_4O_{10}(OH)_2$) as opacifying agent and by gradually substituting talc content in the glazes in place of zirconium silicate. Six samples of glazes (including reference sample) were prepared, sprayed and fired in single fire roller kiln under the industrial environment. The Scanning Electron Microscope (SEM) and Energy Dispersive X-Ray (EDX) were used in order to find the surface morphology and mineralogical composition of the samples. Various physical tests were also done on all the samples of glaze. Results indicate that talc is a very suitable alternative of zirconium silicate which makes the ceramic glaze more economic, better in fluxing properties and opacity.

Keywords: Talc; opacifier; Zirconium silicate; glaze.

1 Introduction

To provide opacity to glaze various opacifiers just like Titanium dioxide (TiO_2), Zinc oxide, Tin oxide and Zirconium Silicate are usually used. The opacity is achieved by scattering and reflecting the incident beam of light to glazed surface of tile. Therefore, opacity is directly related to the index of reflection of opacifying agent present in that ceramic glaze matrix. Among the various opacifiers used in floor tile glaze, the zirconium silicate is predominant [1]. But when it used in huge quantity it affects the quality of the product. However, the high cost of zirconium limits it uses in various ceramic glazes [2]. Commercially $ZrSiO_4$ is substituting by different oxides but it has been found that those opacifying agents affect the glossiness of glaze. For example the use of TiO_2 reduces the brightness of glaze with increasing the firing temp [1].
In this research work talc ($Mg_3Si_4O_{10}(OH)_2$) is used as opacifier in ceramic floor tile glaze and the $ZrSiO_4$ is eliminated by talc gradually. The use of talc ($Mg_3Si_4O_{10}(OH)_2$) in the ceramics is not new however , it has been using as a fluxing agent so far [3,4]. The aim of this study is to investigate the possible effects of talc as ceramic glaze opacifier on ceramic tile and to reduce the cost of glaze by substituting economic opacifier.

2 Materials and Method

2.1 Preparation of glaze

Five sample glazes along with reference glaze sample were prepared according to their respective compositions in weight % as shown in Table 1.

Table 1 Composition of various glaze samples (weight %)

Raw material	G.ref	G.1	G.2	G.3	G.4	G.5
Frit	37	37	37	37	37	37
Potash Feldspar	25	25	25	25	25	25
Quart	17	17	17	17	17	17
Zirconium silicate	15	12	9	6	3	0
Talc	0	3	6	9	12	15
China Clay	6	6	6	6	6	6

The raw materials used for the samples preparation were potash feldspar, China clay, commercial frit, quartz, talc, and Zirconium silicate. Each sample was milled in the laboratory jar mill by wet grinding process. 40 ml of water per 100 gram of each recipe was added to the jar

mill. In order to improve the rheological properties of sample glazes, 0.07 gram of Carboxyl methyl cellulose (CMC) and 0.2 gram of Sodium Tripoly-phosphate (STPP), were added per 100 gram of each sample.

The residue of each sample glaze was kept 1% using 63 microns sieve. The density of each sample was measured by pycnometer and maintained in the range of 1800-1820 g/liter.

2.2 Method

After preparing the sample glazes, each glaze was sprayed on green ceramic tile with the help of a spray gun and dried in tray dryer at 110 C for 1 hr and then each glazed tile was subjected to roller kiln under industrial conditions for 50 minutes, having peak temperature 1120-1150◦C. After 50 minutes all sample tiles were collected at the exit of the kiln. Schematic of this process is shown in Figure 1.

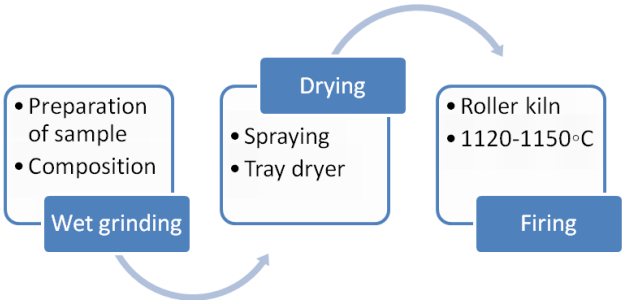

Figure 1 Schematic of process for producing glazed floor tiles

Density of all sample glazes including reference sample was measured with the help of pycnometer. The fluxing time (viscosity) for sample glazes was measured with a Ford-Cup viscometer with a hole of 3mm diameter and volume 100 ml, and kept in range 30 sec to 35 sec. To determine the susceptibility of ceramic glazed tiles, all the six samples were exposed to acidic and basic mediums. The sample tiles were tested in 5% HCL and 30 g/L KOH. In order to determine the effect of talc as opacifier, the opacity of all samples floor tiles were found by using a CM-700d Spectrophotometer (Konica Minolta) in the CIE L*a*b* system, where L, a and b represent degree of whiteness, greenness and yellowish respectively.

The surface morphology of the sample glazes was investigated using Scanning Electron Microscope (SEM) and EDX.

3 Results and discussion

In this study, the physical properties of ceramic tile samples prepared by adding various amounts of talc to standard glaze sample were investigated in relation to its opacity and whiteness. Results are presented and discussed in this section. The results of density test of each glaze are presented in Table 2 and Figure 2.

Table 2 Properties of glazed sample ceramics tiles

Glaze sample	Density (gm/L)	Fluxing time (sec)	Flexural strength (kg/cm^2)
G.ref	18 22	32	334
G1	1817	31	327
G2	18 16	32	337
G3	1813	33	340
G4	1811	33	331
G5	1808	36	337

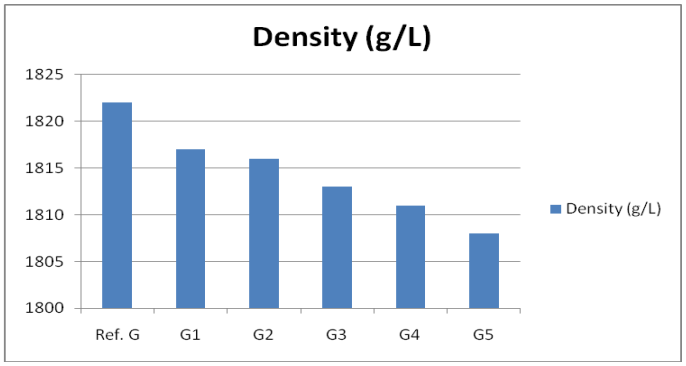

Figure 2 Density of glazed floor tiles samples

It may be observed from Figure 2 that as the percentage of talc increases the density also decreases. The density of the sample glazes decreased gradually by the addition of talc and reducing the percentage of Zirconium silicate. This change / decrease in density is the function of bulk density of talc which is less than $ZrSiO_4$ bulk density [5]. The results of fluxing time are shown in Table 2 and Figure 3.

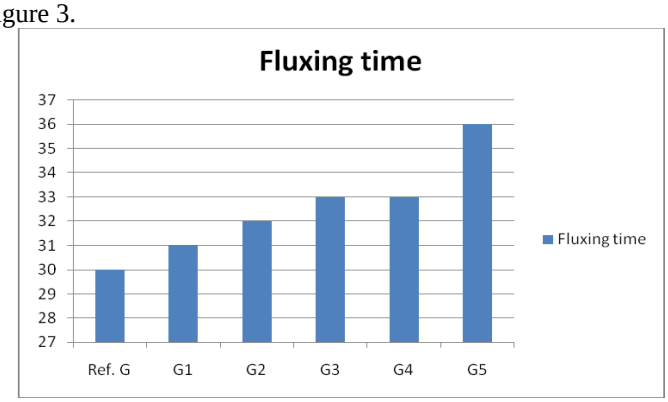

Figure 3 Fluxing time of glazed floor tiles samples

The results indicate that the addition of talc and reduction of zirconium silicate percentage, in the glaze recipes increase the fluxing time. This increase in viscosity is due to the specific rheological properties of talc [6]. Flexural strength of glazed ceramic tiles is shown in Figure 4.

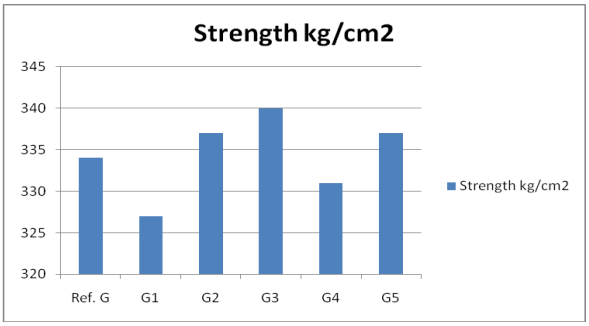

Figure 4 Flexural strength of glazed floor tiles samples

From the results of strength test, it can be clearly seen that values of strength of all fired ceramic tiles samples were found close to each other. It was also found that strength of fired samples was not affected significantly. The strength of a tile is the function of composition of ceramic bodies and the firing temperature of the kiln [7]. Since the values are in the range of 334- 340 kg/cm^2
This is also consistent with standard TS-EN 176 [8]. The color index of glazed floor tiles samples is shown in Table 3:

Table 3 Color index of glazed floor tiles samples

Glazed Ceramic tile Samples	Ref. G	G1	G2	G3	G4	G5
L*	90	90.3	90.1	90.4	91.6	92.8
a*	1.2	1.4	1.3	1.2	1.6	1.4
b*	6.9	6.9	6.4	6.4	6.6	6.5

It may be observed from Table 3 that as the value of talc increases the opacity also increases. L* value of G.5 is high as compare to G.ref where L* represents degree of whiteness, a* degree of greenness and b* yellowish.
The SEM micrograph and EDX elemental analysis is shown in Figure 5:

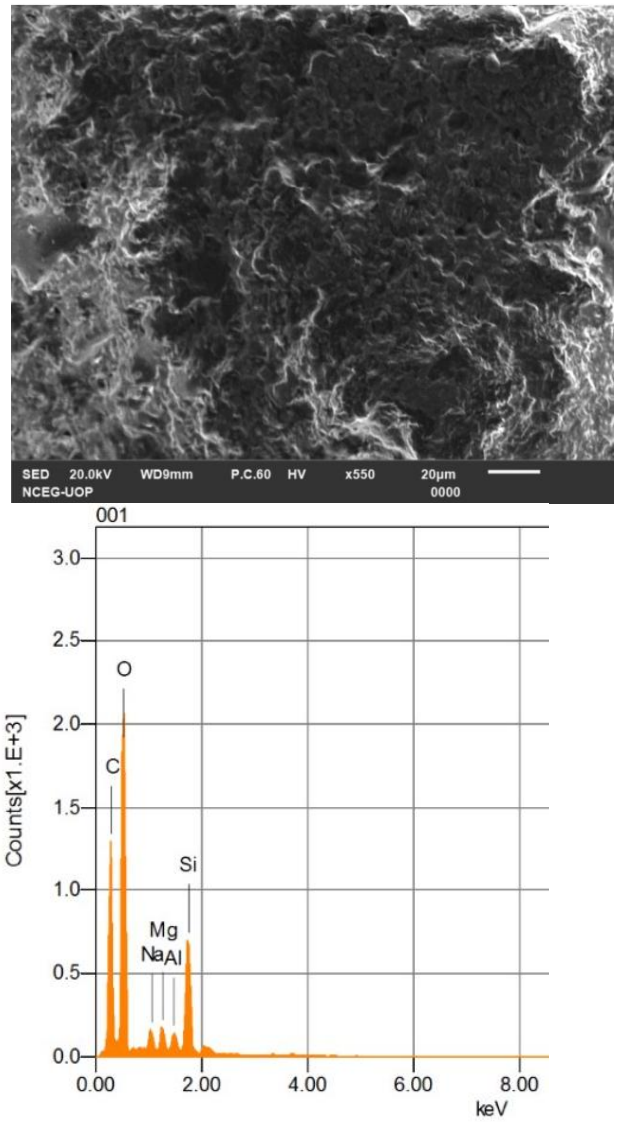

Figure 5 SEM and EDX analysis of G.ref sample of glazed floor tile

Similarly, the SEM micrograph and EDX elemental analysis of glazed ceramics tile in which Zirconium silicate has been completely substituted with 15% talc is shown in Figure 6.

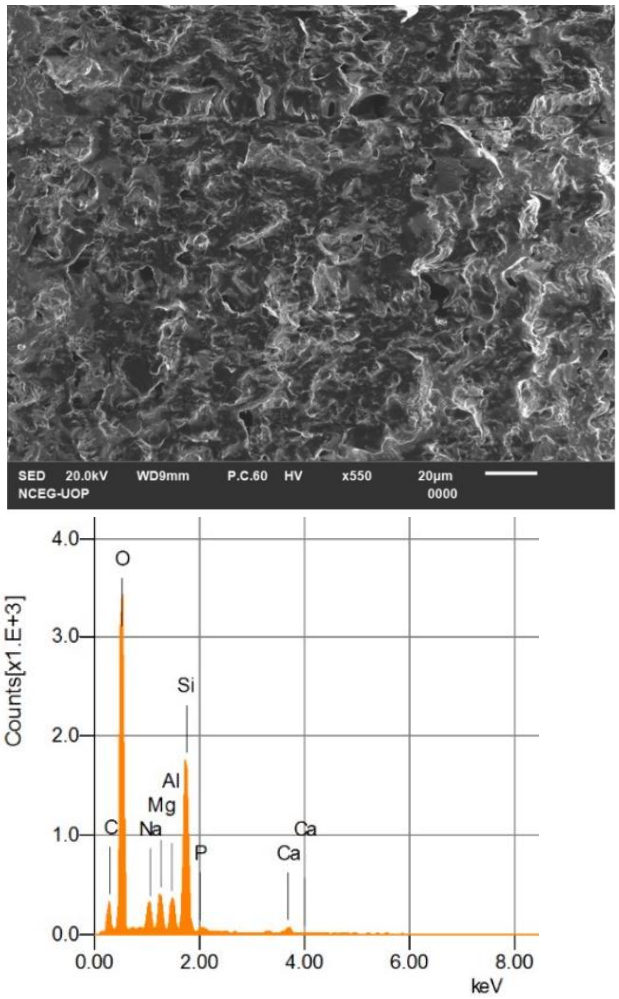

Figure 6 SEM and EDX analysis of G.5 sample of glazed floor tile

The SEM microscopic observations were taken at cross-sections of the fired glazes without polishing. A comparison of Figure 5 and Figure 6 indicates that the size of crystals in glazed floor tiles without talc is larger than the glazed floor tiles with 15% talc. This may be attributed to lower viscosity indicated by lower fluxing time. Similarly it is also observed from Figure 6 (a) that the crystals of talc are distributed uniformly. These results are in conformity with the observations of Gajek et al. [9].

4 Conclusions

In this work talc was substituted in place of Zirconium silicate for glazing of ceramic tiles. Results indicate that increasing the amount of talc by reducing Zirconium silicate decrease the density, fluxing time increased indicating increase in viscosity. Flexural strength varied but remained in acceptable limits as strength depends on composition of ceramic body. The color index indicated that same degree of whiteness can be achieved by replacing Zirconium silicate with talc.

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Design and Development of Advanced Metering Interface for Smart Grid Implementation

Ahsan Latif Abbasi[a,*]; Shaheer Abdullah[b]; Abdullah Imran[c]; Saddam Hussain[d]; Taha Ather[e]; Syed Sajjad Haider Zaidi[f]

[a,*]Department of Electronics and Power Engineering, National University of Sciences and Technology, Karachi, Pakistan

[*] Ahsan Latif Abbasi
E-mail: ahsan95@outlook.com
Tel: +923451205300

Abstract
The recent growth in demand for clean and safe energy has led to a new paradigm in Energy distribution and generation techniques. A more distributed generation system is the reason for a progressive decrease in carbon footprint in the last decade, and to keep up with such a change, utilities must enhance their management and energy distribution so as to achieve and maintain high efficiency. This is the core concept of the Smart Grid (SG). The Smart Meter is one of the most essential parts of the SG. It is a next generation Energy Meter with enhanced communication and metering capabilities. Smart Meters integrates an ability to obtain information from the energy consumer's load devices and measure the energy consumption of the end users while also having the added ability to allow for Bi-directional metering and Bi-directional communication. Data is directly communicated between utility and end users via Radio Frequency (RF) or Power Line Communication (PLC) technologies. In this paper we will look at the design of a Smart Meter which will provide 3-phase AC power reading while also integrating Power Quality Analysis and Home Area Network using Arduino platform in conjunction with Raspberry Pi 3.

Keywords: *Bi-directional Metering; Power Line Communication (PLC); Smart Grid; Advanced Metering Infrastructure (AMI)*

1 Introduction

The recent growth in demand for clean and safe energy has led to a new paradigm in Energy distribution and generation techniques. The Smart Grid is one of the largest steps towards this change in the recent past. The basic difference between the Conventional Grid and Smart Grid is the richness of information which is provided to both End user and Utility. This abundance of information regarding Energy Generation, Transmission, Distribution and Consumption has led to numerous avenues for efficient, clean and cheap energy consumption which empowers both the utility and consumer to take better decisions in relation to the power they provide or consume respectively. A more distributed generation is one such avenue that stems out from the Smart Grid concept. Distributed generation involves the integration of various renewable energy resources into the present Centralized grid (predominantly provided by Coal powered, Hydro-electric or Nuclear Power Stations).

Table 1 Comparison of Conventional and Smart Grids [1]

Conventional Grid	*Smart Grid*
Electromechanical	Digital
One-Way Communication	Two-way Communication
Centralized Generation	Distributed Generation
Few Sensors/Manual Monitoring	Abundance of Sensors/Self-Monitoring
Limited Control	Pervasive control
Few Costumer Choices	Many costumer choices

Smart Meter is an essential Part of the Smart Grid. Smart Meters possess enhanced capabilities of both metering and communication when compared to previous and even current metering devices. These next generation meters are able to perform bi-directional metering allowing seamless integration of renewable energy resources (e.g., Grid Tied Photo-Voltaic Systems) into the Grid. On the other hand, it uses an Advanced Metering Infrastructure (AMI) allowing for a Bi-directional real-time data link between end user and Utility used for meter data collection, analysis and communication while also providing more control over energy consumption.

2 Smart Metering

2.1 Need for Smart Meters

Over the past 20 years the world has seen a huge increase in power demand while our approach to Generate, Transmit and Distribute Energy has been stagnant for over a century. The need for smart meters stems from the obsolete metering infrastructure around the globe. Smart Meters allow for a superior functionality in terms of both data communication and also metering capabilities while also being able to integrate with the Smart Grid.

2.2 Traditional Methods of Metering

The three most common types of Meters in Pakistan are as given below [4]:

- Analog Meters
- Static or Digital Meters
- Automatic Meter Reading Meters (AMR)

Analog Meters are the oldest generation of meters, they are consistent of multiple gears and mechanical parts which lose accuracy over time. According to some estimates nearly half of the meters in Pakistan are of Analog type [4]. Static or Digital Meters get rid of the mechanical parts of their analog counterpart with a digital system of metering. They are highly accurate but lack data communication capability.

AMR and AMR plus meters, sometimes called semi-smart Meters, are capable of one-way communication. Digital meter readings can be send to Utility over different communication mediums (i.e. RF, Global System of Mobile Communication (GSM)/ General Packet Radio Services (GPRS). These meters cannot be integrated into a Smart Grid due to lack of bi- directional communication.

2.3 Proposed Solution – Smart Meter

Smart Meters are electronic metering devices used by Utilities to communicate information relevant to billing customers and operating their electric systems. For over a decade electronic meters have been used effectively by utilities in delivering accurate billing data for at least a portion of their customer base. At first, the use of this technology was applied only to commercial and industrial customers due to the need for more sophisticated tariff and more granular billing data requirements. Over time the use of smart meter has gradually expanded to all customer classes. This expansion of smart meter use was made possible by decreasing cost of the technology and advanced billing requirements for all customer classes. A network of such smart meters, having two-way communication capability, which connects end user to utility in a direct link is known as Advanced Metering Infrastructure (AMI). Previous systems, which utilized one-way communications to collect meter data were referred to as AMR (Automated Meter Reading) Systems.

AMI has developed over time, from its roots as a metering reading substitute (AMR) to today's two-way communication and data system. A succinct list of the benefits of a smart metering system are listed below:

- Efficient and quick fault detection
- Reduced operational costs
- More accurate/granular billing
- Save money on Human meter readers
- More Reliable Network
- Smart Grid/Renewable Resources Integration
- Time Based Tariff Implementation

2.4 Advanced Metering Infrastructure (AMI)

Advanced Metering Infrastructure (AMI) networks are the reasons for the easy integration of smart meters into the Smart Grid. AMI technologies enable a direct link between distribution system operators (DSO) and energy consumers. Countless benefits stem from this ability, such as, enabling energy analysis, monitoring, profiling, management and savings. Smart Meters are necessary for the existence of an AMI network due to their real-time or near real-time response. Load control, profiling and energy savings are targets of the smart meter which can provide for real-time consumer applications and energy management system services. One of the biggest issues with previous smart metering technologies (AMR or AMR plus) has been the lack of communication system between a data concentrator and the electrical meter. The bottle neck is that a large amount of information/data needs to be transferred and communications protocols are very time-consuming.

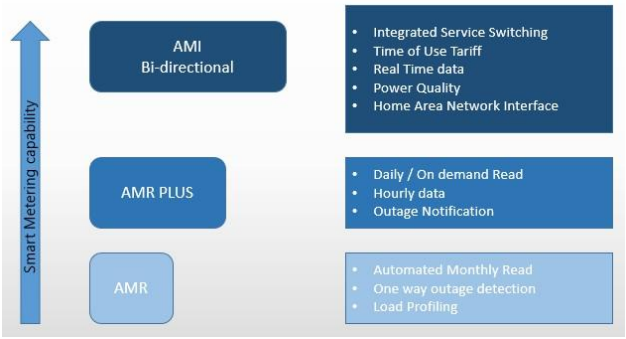

Figure 1 Smart Metering Technology Evolution, AMR to AMI

3 Project Methodology

The Smart Meter Design includes current sensing clip and a metering shield for the calculation of Real Power, Reactive Power and Power Factor. From this data we will further calculate the KWH consumed.

The Data from the Meter would be transmitted to the Data Concentrator Module and from there onwards, it would be uploaded onto a local memory and also sent to Utility via PLC.

3.1 3-Phase Metering – Theory

In this section we will look at the theoretical and practical aspect of 3 phase AC Power Metering in our project. Our Energy Meter will provide values of Real Power, Reactive Power, Apparent Power, Power Factor, RMS Current, RMS Voltage and KWH consumed.

- Real power: (also known as active power) is defined as the power used by a device to produce useful work. Mathematically it is the definite integral of voltage, v(t), times current, i(t), as follows,

  $$P = \frac{1}{T}\int v(t) \times i(t)dt \equiv V \times I \times \cos(\emptyset) \quad (1)$$

  where
  V is RMS Voltage,
  I is RMS Current,
  P is Active or Real Power.
  The Discrete time equivalent is:

  $$P = \frac{1}{N}\sum_{n=0}^{N-1} v[n] * i[n] \quad (2)$$

  Real power is calculated simply as the average of N voltage- current products. It can be shown that this method is valid for both sinusoidal and distorted waveforms.

- RMS Voltage and Current Measurements: An RMS value is defined as the square root of the mean value of the squares of the instantaneous values of a periodically varying quantity, averaged over one complete cycle. The discrete time equation for calculating voltage RMS is as follows,

  $$V_{rms} = \sqrt{\sum_{n=0}^{N-1} \frac{v^2(n)}{N}} \quad (3)$$

  RMS current is calculated using the same equation, substituting voltage samples, v(n), for current samples, i(n).

- Apparent Power and Power Factor:

  Apparent Power is calculated as follows,

  S = V * I

  And, Power Factor as,

  $PF = \frac{P}{S}$

- Reactive Power:

  Reactive Power can be calculated as,

  $$Q = \sqrt{P^2 - S^2} \quad (4)$$

3.2 3-Phase Metering – Practical

- To measure 3-Phase power, we are using 3 Arduino metering shields (EmonTX) in conjunction with the Arduino Uno microcontroller
- Three phase power measurement is equivalent to 3 single phase measurements. Current transformer and voltage monitor (to step down voltage) are required on each phase. Total Power is the sum of the 3 powers from each phase.
- Algorithms to process the current and voltage samples and provide required information have been developed and tested in simulations.

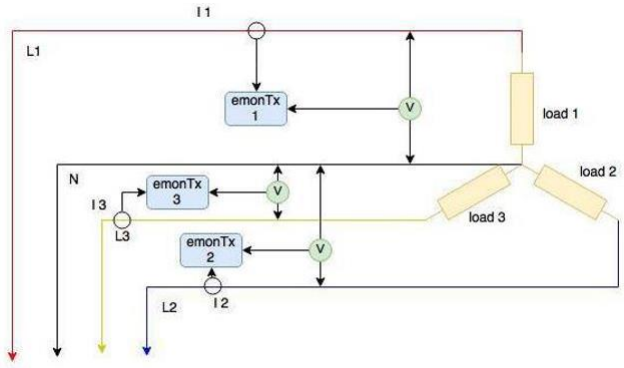

Figure 2 Connection diagram for 3-phase metering [14]

3.3 Bi-Directional Metering (Net Metering)

The purpose of adding Bi-directional metering capability into the smart meter is to allow for a very important part of Smart Grid, i.e. Distributed Generation. This will allow the meter to detect power flow and calculate net flow of power in our out of a consumer premises. If a consumer is generating electricity (via PV solar generation or wind turbine) which is not being used by the consumer, this energy can be uploaded to the grid and the Utility will compensate the Consumer accordingly.

The Smart Meter will detect the net direction of energy flow and also the amount of energy uploaded. The proposed method for this system is shown in the diagram below which will be integrated into the already discussed 3-phase metering scheme,

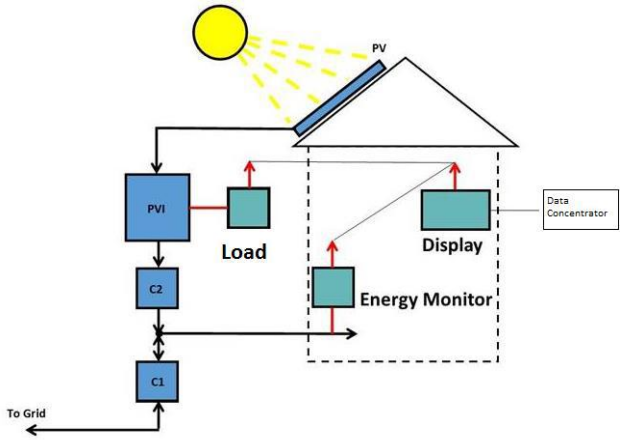

Figure 3 Overview of Bi-Directional Metering system [19]

Data from Power Quality Analysis will also be incorporated at data concentrator end to ensure the Quality of the power that is being uploaded to the grid to prevent unwanted stresses and faults on Power Lines.

3.4 Data Concentrator

The purpose of the Data Concentrator module will be to attain and log data from Home Area Network (HAN) module, Power Quality Analysis (PQA) module and the Metering module. This data concentrator will have added functionality of acting as gateway between end-users and Distribution providers.

To implement this module, we are using the Raspberry Pi 3. The Raspberry Pi is a small credit card sized computer operating on a Linux distribution called Raspbian. Technical Specifications for the Raspberry Pi 3 are given below:

- 1.2Ghz BCM2837 SoC based on quad-core Cortex-A53
- 1GB Ram, Broadcom VideoCore IV GPU supports resolutions up to 1920x1200
- MicroSD card slot
- GPIO header
- 802.11b/g/n WiFi and Bluetooth

With the addition of RFM69Pi [12] expansion board it is possible to receive and transfer data between raspberry and EmonTX shield. The raspberry pi will act as a server and Base station to log and process incoming data for visualization purposes (e.g. graphs, charts, tables of energy usage). From here data can then be transferred to the distribution provider. Data will be logged locally in a dedicated MicroSD card.

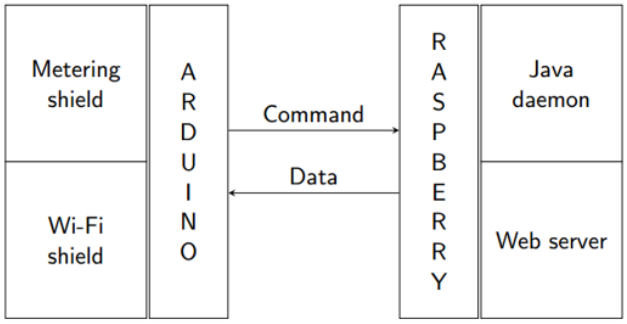

Figure 4 Block Diagram depicting the Data flow and connection between the Data Concentrator and Metering Modules [10]

3.5 Project Overview

An overview of the project methodology is shown below

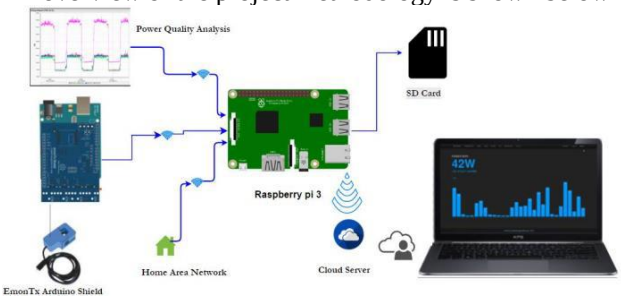

Figure 5 An overview of the project interfaces and components

3.6 Power Line Communication (PLC)

To establish a direct bidirectional data link between the Utility and Consumer a Powerline Communication link will be utilized. The basic principle of this method is to inject a signal onto the powerlines at a much higher frequency than the nominal frequency of power transferred (60Hz or 50Hz).

There are two methods which we will explore during our project to implement this system. The two proposed systems are as follows:

- The first method [18] makes use of both active and passive filters to separate signal from AC power and decode the signal. This system will use frequency shift keying (FSK) to encode data. This is done through the ST7540 modem designed for power line applications. This modem can be controlled by Arduino over Serial Peripheral Interface (SPI). This method is depicted below in figure 6.

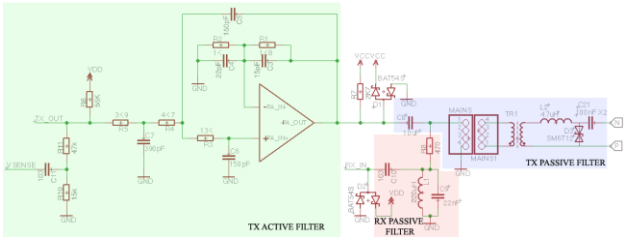

Figure 6 Power Line Communication using Active and Passive Filters [18]

- The second method is relatively simple in terms of implementation. Ethernet shield will be connected to Arduino to enable ethernet communication capability from there a Power line adapter will allow the data to be transferred through power line.

Arduino Ethernet Shield & Power Line Adapter (TP-Link AV500)

4 Simulations

In order to simulate our proposed Metering Methodology on a software level we have used Labcenter Electronics' Proteus PCB design and Simulation software platform. The results of the simulations can be seen below:

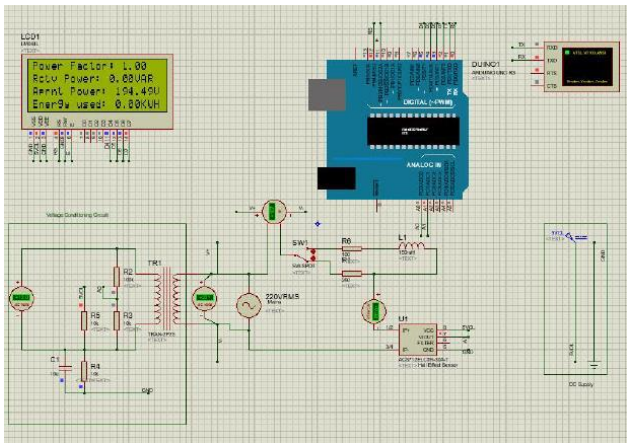

Figure 7 Simulation results with purely resistive loads

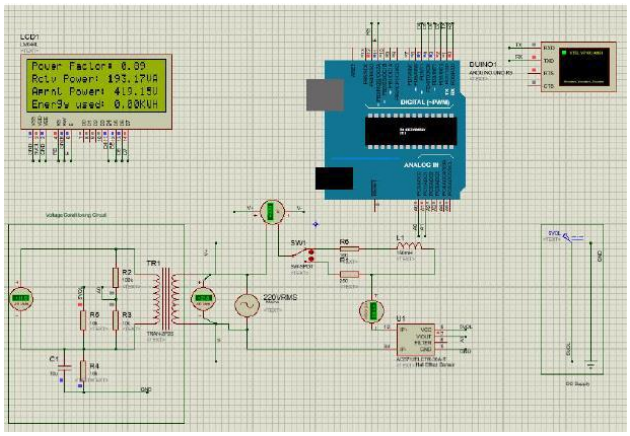

Figure 8 Simulation results with RL load

5 Conclusion

This paper reviews the concept of Smart Grid and provides a cost effective and simple implementation of the most important component of this Grid, i.e. Smart Meter. We look at how to use the Arduino Uno platform in conjunction with metering Shield (EmonTX) and Raspberry Pi to build this Advanced Metering Infrastructure.

Smart Meters have great scope in developing countries like Pakistan, especially with China taking interest in the energy sector of Pakistan due mainly to the China Pakistan Economic Corridor (CPEC).

Smart Meters and the Smart Grid are a next Generation solution to the widespread energy related problems faced by the world in this day and age. They are most definitely an essential part of a safe, clean, eco-friendly and efficient energy system, allowing the integration of renewable sources and making enabling a distributed generation system. These technologies must be researched and developed by all countries around the globe in order to promote a more eco-friendly and efficient culture of energy consumption and generation.

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Optimized Solution for PMUs Placement in a Power System for Complete Network Observability

Muhammad Awon[a,*]; Hassan Zahid Butt[a]; Hassan Abdullah Khalid[a]

[a]Department of Electrical Energy Engineering, Center For Advance Studies In Energy, NUST, Islamabad, Pakistan

[*] Muhammad Awon
E-mail: muhammadawon4@gmail.com
Tel: +92 316 4061235

Abstract
Synchrophasors are time-synchronized entities that provide wide area time synchronized view of the power system nodes at high reporting rates, capturing its dynamics very efficiently. These entities are measured by high processing power devices called Phasor Measurement Units (PMU's). PMU has become an indispensable part of the smart grid as it accurately estimates the voltages, current phasors (magnitudes and angles) and data output at a very high rate (10 to 60 frames per second) that is superior to SCADA technology. A power system is identified observable when the voltages of all buses in the power system are known. We can place PMUs on all the buses to get these voltages but due to its high cost it is needless to place PMUs on each and every bus. The paper presents a solution to the problem of locating the optimal points for placement of PMU units in the system as well as finding the minimum quantity of PMUs to make the system observable. Cost optimization problem is formulated and implemented by using Mixed Integer Linear Programming (MILP) and proposed global search algorithm in a MATLAB software and results are compared.

Keywords: *Phasor Measurement Unit (PMU); binary connectivity matrix; optimal PMU placement (OPP)*

1 Introduction

The world is shifting its focus towards smart grid as only it has the potential to cater all the abnormalities in the power system that we are currently facing and will face in the future. Smart grid manages and utilize the current energy resources in an optimized way and allow the further penetration of generation sources on distribution and sub transmission level. With real time monitoring, enhanced control and protection systems of the smart grid, power system outage could be prevented [1] and [2]. Phasor measurement unit is one of the important part of smart grid that is synchronized with time reference signal (clock) provided by global position system (GPS) to monitor and measure the state variables shown in fig. 1,

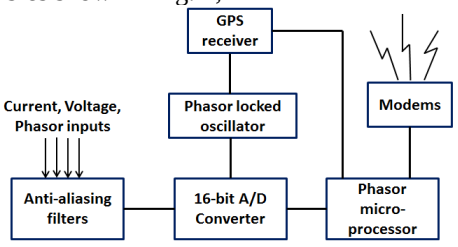

Figure 1 Configuration of a PMU

In comparison with the traditional SCADA system, PMU is much faster with the reporting rates 10/25/50 frames per second that helps to capture the system dynamics very efficiently [3] and [4]. Some other attributes of PMU is shown in table 1

Table 1 Comparison of SCADA with PMU

SCADA vs PMU	
SCADA	**PMU**
Measure magnitude only	Measure both magnitude and phase
Time synchronization not available	Time synchronization available
Focuses on local area monitoring and control	Wide area monitoring and control
Reporting rate ~ once in 4 to 6 second	Reporting rate: 10 to 60 frames per second

PMU can measure frequency, rate of change of frequency, circuit breaker status and voltage/current phasors if it is placed on power network bus[5]. Having all its measuring possibilities, magnitude and phasors of the line currents and bus voltages have quite importance. The power system

is said to be completely observable if the voltages and angles on each bus in a network is known. Placing PMUs on each bus is an option to make system entirely observable but that would give an ineffective solution due to the high cost of a PMU [6]. Because of the cost limitation, different PMU placement techniques have been proposed by different authors in literature. Traditional way of obtaining the bus voltages is presented in [7]. Iteration algorithms such as Gauss-Seidel and Newton Raphson are being used to solve the non-linear equations to converge towards the possible solution. With the advent of the phasor measurement unit, these non-linear equations have turned to linear and bus voltages can easily be found through numerical calculations.

Conventional deterministic techniques and metaheuristic algorithms have also been tested to optimize the total number of PMUs and their placement in the power systems [8]. Meta-heuristic algorithm such as Genetic Algorithm is presented in [9] but it suffered from excessive calculation if applied to a large system. Simulated Annealing based algorithm is proposed in [10] based on neighborhood search and uphill moves, but the process start from some random solution and repeat the steps unless the optimal solution is achieved. Dual search is applied in [11] and conclusion is being made that about one-third of the system buses need to be provided with PMUs for system observability while Reynaldo and Arun G. Phadke followed the concept and proposed a tree search topology with the desired depth of un-observability [12]. Nabil and Hanafay gave an optimized solution in [13] considering zero injection, PMU loss and conventional measurement using binary integer linear programing. Parth and Jigar obtained a unique solution out of many possible combinations but does not converge to the best optimized solution [14].

In this paper, problem formulation is done in section II. Optimal PMU placement is achieved from two different topologies discussed in sub-section II. Results obtained from these two methods are presented in section III.

2 OPP Method Formulation

The objective of the optimal PMU placement is to reduce the total number of PMU's by placing them in an optimized fashion giving full network observability. So the problem is formulated as to minimize the cost of PMUs in power system assuming the cost of each PMU is same.

The function to be minimized is:

$$F = cx_1 + cx_2 + cx_3 \ldots\ldots\ldots cx_N$$

N represents total number of buses in a system, c is the cost of single PMU and x is a binary variable that represents 0 or 1. If a PMU is placed on a bus i, x will be 1, if not then x will be 0. All the x variables in a power system will be 1 if the PMUs are placed on each and every bus represented by a vector X

$$X = [x_1\ x_2\ x_3 \ldots\ldots\ldots\ x_N] \quad \text{where } x_i \in 1$$

A binary connectivity matrix A is required to observe the connectivity of one bus to another.

For an IEEE 9 bus system

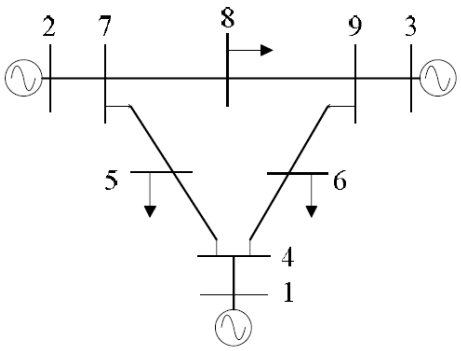

Figure 2 IEEE 9 Bus System

The A matrix will be

$$a_{ij} = \begin{cases} 1, & if\ i = j\ or\ i\ and\ j\ are\ connected \\ 0, & Otherwise \end{cases}$$

$$A = \begin{bmatrix} 1&0&0&1&0&0&0&0&0 \\ 0&1&0&0&0&0&1&0&0 \\ 0&0&1&0&0&0&0&0&1 \\ 1&0&0&1&1&1&0&0&0 \\ 0&0&0&1&1&0&1&0&0 \\ 0&0&0&1&0&1&0&0&1 \\ 0&1&0&0&1&0&1&1&0 \\ 0&0&0&0&0&0&1&1&1 \\ 0&0&1&0&0&1&0&1&1 \end{bmatrix}$$

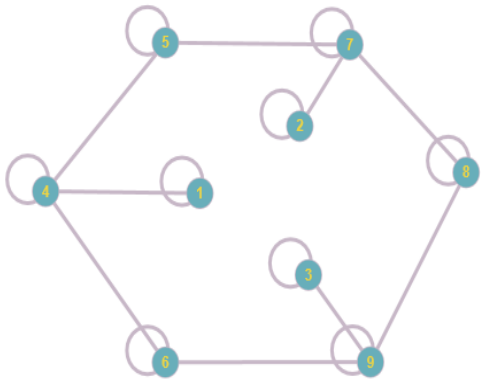

Figure 3 Graphical Representation of 9 Bus Adjacency Matrix

Now the constraint for full observability of system is that the voltages and the buses connected to that PMU bus should be known.

A constraint is defined as

$$A.X \geq 1$$

By multiplying the connectivity matrix with the Nx1 variable matrix X, we will get to know the number of connected buses to each bus.

The constraint equations for a 9 bus system will be

$$\begin{aligned}
f_1 &= x_1 + x_4 && \geq 1\\
f_2 &= x_2 + x_7 && \geq 1\\
f_3 &= x_3 + x_9 && \geq 1\\
f_4 &= x_1 + x_4 + x_5 + x_6 && \geq 1\\
f_5 &= x_4 + x_5 + x_7 && \geq 1\\
f_6 &= x_4 + x_6 + x_9 && \geq 1\\
f_7 &= x_2 + x_5 + x_7 + x_8 && \geq 1\\
f_8 &= x_7 + x_8 + x_9 && \geq 1\\
f_9 &= x_6 + x_8 + x_9 && \geq 1
\end{aligned}$$

.

2.1 Development of Placement Models

There are two methods that have been used to obtain the optimal placement results. First one is Mixed Integer Linear Programming (MILP) and the other is proposed global search algorithm. Both methods are implemented on MATLAB software and results are compared.

2.1.1 Mixed Integer Linear Programming (MILP)

A mixed-integer linear program is a problem with linear objective function, $f^T x$, where f is a column vector of constants, and x is the column vector of unknowns. According to the MILP definition, there are matrices A and corresponding vectors b that encode a set of linear inequalities and linear equalities

$$A \cdot x \leq b$$

This linear constraint restrict the solution x. The main goal of mixed-integer program preprocessing is to simplify branch-and-bound calculations. There are two possible ways to apply the MILP in MATLAB. One is to use the built in optimization toolbox app and other is to use the 'intlinprog' command in the editor. The steps for implementing the MILP model are:

1. Observe the network and define the total no of variables i. Total number of variables will be equal to total number of buses in the system.
2. Define the objective function F.
3. Form the binary connectivity matrix A. All the 1's in binary connectivity will be multiplied by -1 as the default constraint in MILP is A.X ≤ b but the desired constraint is A.X ≥ b.
4. Form the right hand side unity vector. Again all 1's will be multiplied by -1 as discussed above.
5. Run and solve the MILP program.

The objective function F, total number of variables i, the binary connectivity matrix A and the unity vector b are the inputs for the 'intlinprog' command. The output will be the total number and optimal locations of the PMUs. The optimized result for an IEEE 9 bus system is:

Table 2 Result for IEEE 9 bus using MILP

Solutions									No of PMUs
1	0	0	0	0	0	1	0	1	3

It can be seen from above table that only 3 PMUs are enough for complete network observability and their locations are at bus 1, bus 7 and bus 9.

2.1.2 Proposed Global Search Algorithm

Optimal PMU placement (OPP) is NP-complete problem with 2^n possible combinations. In the proposed model, all the 2^n combinations are being checked and the possible solutions that satisfy the constraint (A.X ≥ 1) are filtered out.

The steps are as follows:

1. Build a binary connectivity matrix A from a network
2. Define total number of combinations x that will be checked, x = $2^n - 1$ where n=total number of buses
3. Initialize vector X with all ones
4. Check A.X ≥ 1, if satisfies then store that combination, if not then perform x-1 and move to the next combination unless x becomes 0.
5. When all the combinations are being checked, the stored ones will give the full network observability.
6. Combinations with minimum number of PMUs will give the optimized result.

The optimized results for IEEE 9 bus system are:

Table 3 Results of IEEE 9 bus using Global Search

Solutions									No of PMUs
0	0	1	1	0	0	1	0	0	3
0	1	0	1	0	0	0	0	1	3
1	0	0	0	0	0	1	0	1	3
0	0	0	1	0	0	1	0	1	3

There are total 4 possible solutions through this approach while MILP just give one solution. Here all these 4 solutions are valid and give full network observability.

3 Results and Discussion

Table 4 Results of IEEE different bus system using MILP

Test System	No of PMUs	Location
IEEE 7 Bus	2	2,4
IEEE 9 Bus	3	1,7,9
IEEE 14 Bus	4	2,8,10,13
IEEE 30 Bus	10	3,5,8,9,10,12, 19,24,26,29

Table 5 Results of IEEE different bus system using Global Search

Test System	No of PMUs	Location
IEEE 7 Bus	2	2,4
		2,5
IEEE 9 Bus	3	3,4,7
		2,4,9
		1,7,9
		4,7,9
IEEE 14 Bus	4	2,6,7,9
		2,6,8,9
		2,7,10,13
		2,8,10,13
		2,7,11,13
IEEE 30 Bus	10	3,5,6,9,10,12,18,23,25,30
		3,5,8,9,10,12,19,24,26,29
		1,7,8,9,10,12,18,24,26,29
		3,5,6,9,10,12,18,24,26,29
		1,7,8,9,10,12,15,19,25,27
		2,3,6,9,10,12,19,23,26,27
		2,3,6,10,11,12,15,19,25,30
		3,6,7,9,10,12,15,19,25,29
		3,5,6,10,11,12,15,19,25,27
		2,3,6,9,10,12,19,24,25,30
		3,5,6,9,10,12,18,23,26,30
		1,5,9,10,12,15,19,25,28,30
		1,5,6,10,11,12,15,19,25,29
		1,2,6,9,10,12,15,19,25,27
		3,5,6,9,10,12,18,24,26,29
		1,7,8,9,10,12,15,19,25,27
		3,5,9,10,12,18,23,25,28,30
		3,5,10,11,12,15,20,25,28,30
		1,2,6,9,10,12,15,19,25,29
		1,5,6,9,10,12,15,20,25,27
		2,4,6,10,11,12,15,18,25,29
		1,5,6,9,10,12,19,24,25,29
		3,6,7,10,11,12,18,24,25,27
		1,6,7,10,11,12,19,23,25,29

Solutions marked with red in table 5 are same that is obtained using MILP. The only difference is the global search gives many possible solutions providing complete network observability while MILP gives only one solution. But the purpose of both programming techniques are to achieve the minimum number of PMUs and their optimal placements. Table 4 and table 5 validate the above objective.

3.1 Conclusion

A cost effective unique solution has been presented in this paper by keeping the system observable but with minimum number of PMUs. Not only the number of PMUs has been minimized but their optimal location is also identified. The proposed optimization algorithm checked all the possible combinations and converged to possible solutions. Simulations are tested on IEEE 7, IEEE9, IEEE14 and IEEE 30 bus system. The proposed global search algorithm takes more time for higher bus system but despite the time taking process, the accuracy of the method remains unchallenged even at higher bus systems. The implementation of such systems is part of a detailed planning process where as the cost of PMUs is very high thus usage of this accurate technique is very effective for calculation of PMUs in the grid network

ACKNOWLEDGMENT

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Performance of Second Order Generalized Integrator based Phase Lock Loop for Single Phase Grid Connected PV Systems

Hassan Zahid Butt[a,*]; Muhammad Awais Amin[a]; Hassan Abdullah Khalid[a]

[a]Department of Electrical Energy Engineering, Center for Advanced Studies in Energy, NUST, Islamabad, Pakistan

[*] Hassan Zahid Butt
E-mail: hzbutt120222@gmail.com
Tel: +923218370727

Abstract
Frequency, phase and amplitude of the utility's voltage are the critical parameters required for the synchronization of a grid connected distributed generation. Various algorithms for the synchronization of grid with the distributed generation system have been proposed in the literature. This paper presents a Synchronous Reference Frame Phase Lock Loop (SRF-PLL) technique for the grid synchronization of a single-phase grid tie PV system. Second Order Generalized Integrator (SOGI) is used to convert the grid voltage into orthogonal components which is then used by the SRF-PLL. The significance of the SOGI based PLL is the simple implementation and the adaptation to frequency changes in the grid. The results of SOGI based PLL on a grid connected PV system is simulated in MATLAB/Simulink environment. The results verify the performance of the system when subjected to frequency and voltage deviations.

Keywords: *grid tied inverter; distributed generation; PV; SOGI; SRF-PLL*

1 Introduction

The modern power system network is a mixture of renewable and conventional energy sources. Sun is the biggest source of renewable energy. So, its energy is being harnessed from across the globe. With the increasing trend towards Distributed Generation (DG) systems, the household consumer has now become able to change its status from load to source as well among which the solar system is the most favored given its size and potential [1]. The DG network however is a sea of fluctuations and transients [2]. So, an efficient system needs to be implemented that feeds quality power to the distribution feeder. The solar photovoltaic grid connected system contains the following units: The PV array, a power processing unit, inverter, filter and a transformer, the block diagram of which is shown in Fig. 1. Modern grid connected inverters now come with a transformer-less configuration, hence reducing the cost and weight of the system [3].

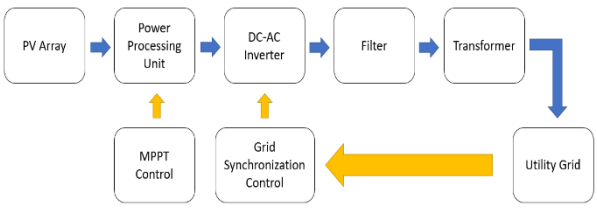

Fig. 1 Grid connected PV System block diagram

The Maximum Power Point Tracking (MPPT) is used to extract the maximum energy from the PV by implementing a feedback loop. The load is varying. For optimal efficiency operation, the I-V curve of the PV cell is changed accordingly to match with the load's I-V curve via a power processing unit which is normally a DC-DC converter [4]. Several MPPT techniques have been proposed in the literature among which perturb and observe [5] and incremental conductance [6] are the most common. Several modifications of these algorithms have been done in the past years to make them more fast, accurate and adaptive to environmental conditions [7], [8], [9], [10].

The generated DC is then converted to AC via a grid tied inverter [11]. The purpose of the control system developed for an inverter is to match the frequency and phase of the inverter's output with that of the grid which is done using various techniques. In [12], a simplest of synchronization techniques known as zero crossing detection method. This technique detects the waveform's zero using the zero detector, which is basically a comparator, thus giving an output signal. But since harmonics are always present, thus the zero detector fails to track the actual zero crossing since it then tracks the surge impulses also. The phase lock loop (PLL) is the most commonly used method that has a simple structure and can be made frequency adaptive [13].

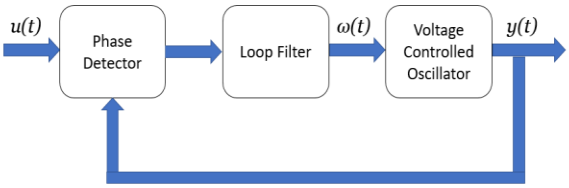

Fig. 2 Standard PLL Structure

Fig. 2 shows the standard PLL structure. The input signal is denoted by u(t). This u(t) is multiplied by the voltage controlled oscillator's (VCO) output in the phase detector block which is then passed through a loop filter, which is normally a PI controller, and the output w(t) is then passed through a VCO which is basically an integrator. The VCO generates a sinusoidal signal whose phase angle is proportional to the integral of the VCO's input i.e. $\varphi = \int\omega(\tau)d\tau$, where ω is the VCO's input and $y(t) = \cos\varphi$ is the VCO's output. The problem faced with this configuration however is the presence of double-frequency oscillations in the loop even for a purely sinusoidal input signal [14]. Several techniques to improve the performance of the PLL have been discussed in the literature among which synchronous reference frame phase lock Loop (SRF-PLL) has wide acceptance [15].

The problem faced by SRF-PLL in single phase systems however is that it uses the synchronous reference frame quantities i.e. the d-q components. In three phase applications, the grid voltage to be tapped can be converted to d-q quantities using the parks transformation. In single phase inverters however, some method needs to be implemented first that takes the single-phase grid voltage and transforms it to d-q components. This paper models a second order generalized integrator which is used to convert the grid voltage waveform into its orthogonal components. Section II presents the working and modelling of SOGI-PLL. The simulation results are shown in section III and section IV gives the conclusion.

2 System Modelling

The purpose of the synchronization control is to match the amplitude frequency and phase of the grid's voltage with that of the inverter. An SRF-PLL is widely used for this purpose that takes input in the form of d-q reference frame quantities. The general structure of SRF-PLL is shown in Fig. 3.

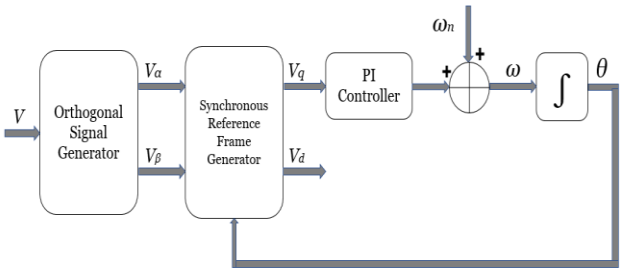

Fig. 3 General Structure of SRF-PLL

In single phase applications, a simple way to produce orthogonal quantities is to use a transport delay block. A related method to this is Hilbert's transformation as discussed in [16]. Another method as discussed in literature is the inverse parks transformation [17]. All these methods however face shortcomings regarding complexity, frequency adaptation and filtering. So, for single phase configurations, a second order generalized integrator (SOGI) is used to convert the single-phase grid voltage into orthogonal components having 90° phase shift. Fig. 4 shows the general structure of SOGI.

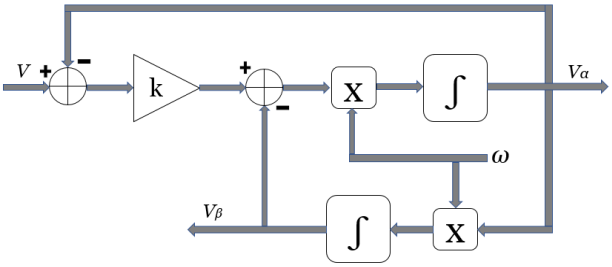

Fig. 4 General Structure of SOGI

The closed loop transfer functions, H_d and H_q are defined as:

$$H_d = \frac{V\alpha}{V} = \frac{k\omega s}{s^2+k\omega s+\omega^2} \quad (1)$$

$$H_q = \frac{V\beta}{V} = \frac{k\omega^2}{s^2+k\omega s+\omega^2} \quad (2)$$

Where ω represents the resonance frequency of the SOGI which is normally set to grid frequency ω_n = 314 rad/s and k is used to adjust the system's filtering capability.

3 Simulation and Results

Fig. 5 and 6 show the MATLAB/SIMULINK models of SOGI and SRF-PLL respectively. The input to the SOGI is the grid voltage waveform having 230V amplitude and 50Hz frequency as shown in Fig. 7. The SOGI dissolved it into its orthogonal components having 90° phase shift

between each other as shown in Fig. 8. The value of the gain k chosen for this result is 1.

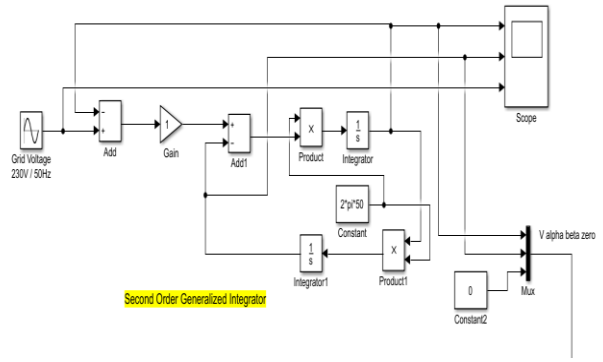

Fig. 5 Second order generalized integrator circuit diagram

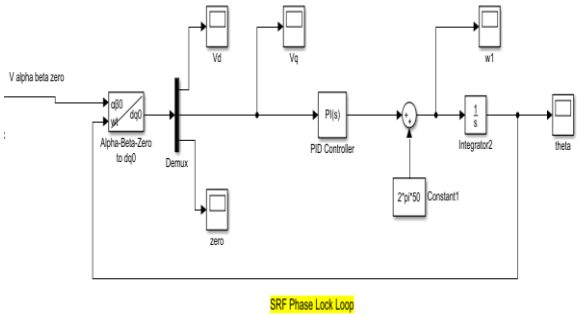

Fig. 6 Synchronous Reference Frame Phase Lock Loop

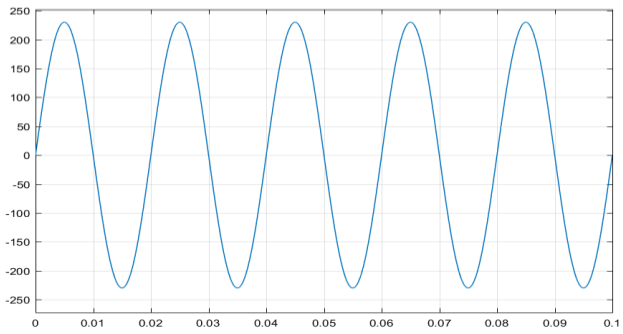

Fig. 7 Grid Voltage Waveform

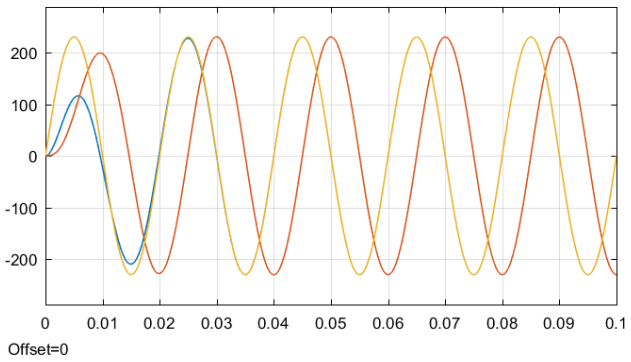

Fig. 8 Grid Voltage and its Orthogonal Components for k=1

The bode plots and the response of the SOGI with three different values of gain k are shown in figure 9(a), 9(b), 9(c) and 8, 10(a), 10(b) respectively. It can be seen that if the value of k is decreased, the band-pass of the filter gets narrow which although implies heavy filtering, but at the cost of slower dynamic response time. Similarly, if k is increased, the bandpass gets wider and the dynamic response gets fast but at the cost of lesser filtering.

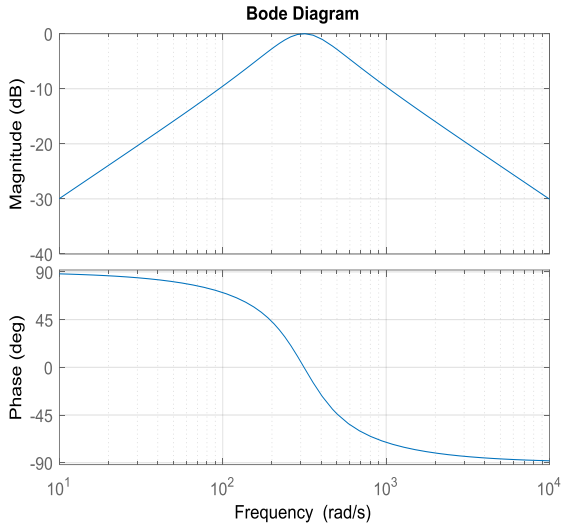

Fig. 9(a) Bode Plot for k=1

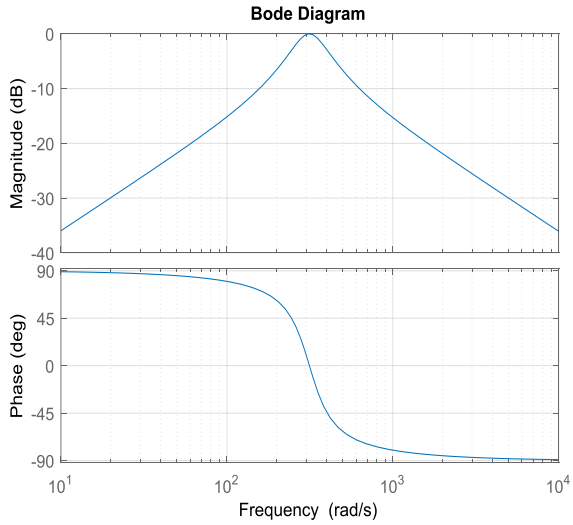

Fig. 9(b) Bode Plot for k=0.5

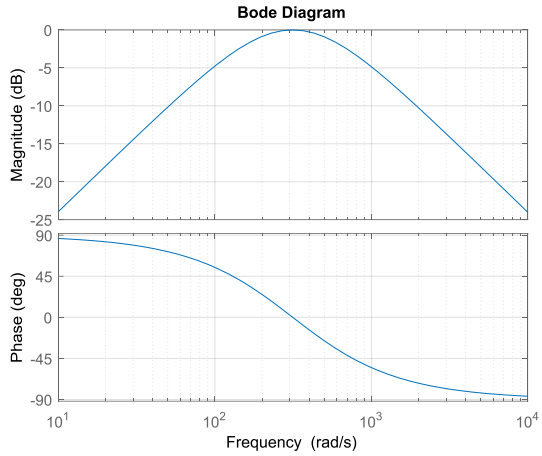

Fig. 9(c) Bode plot for k=2

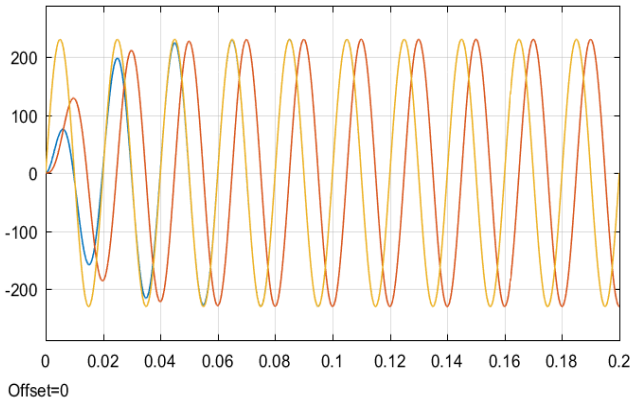

Fig. 10(a) Orthogonal Components of grid voltage for k=0.5

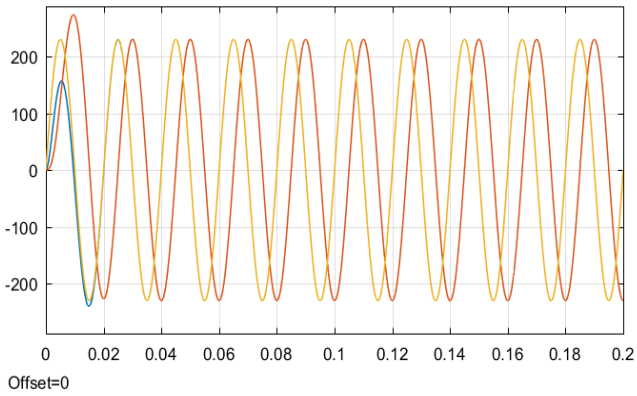

Fig. 10(b) Orthogonal Components of grid voltage for k=2

The d-q quantities are DC quantities in which the d component has the magnitude equal to that of the actual signal and the q component is normally zero. Fig. 11(a) shows the d component of the grid voltage having 230V steady state voltage magnitude and the steady state magnitude of q component is 0V as depicted in fig. 11(b).

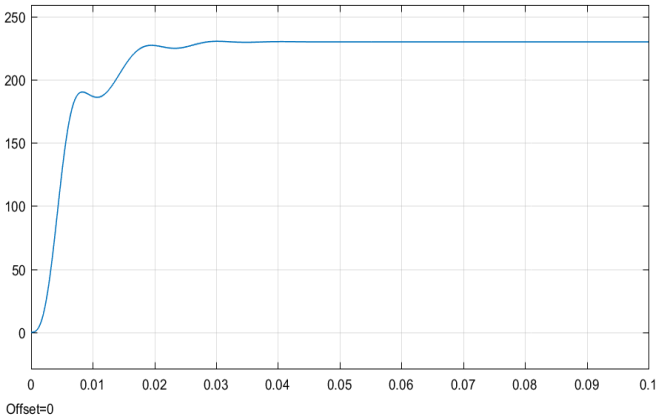

Fig. 11(a) d component of Grid Voltage

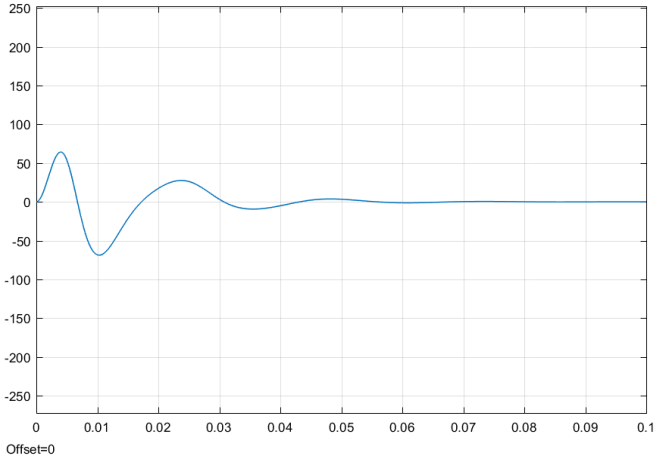

Fig. 11(b) q component of Grid Voltage

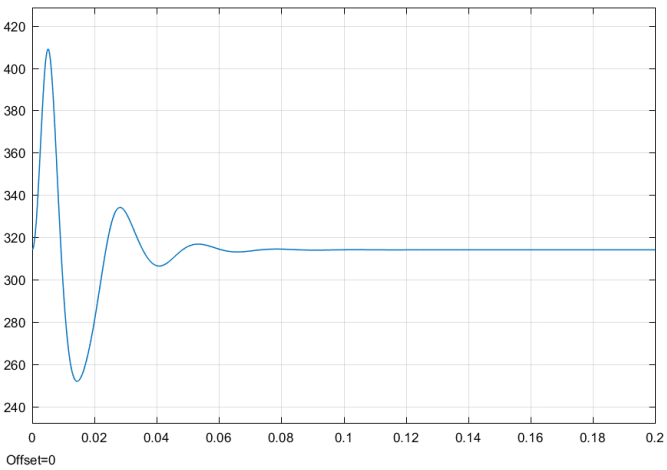

Fig. 12(a) Frequency before voltage dip

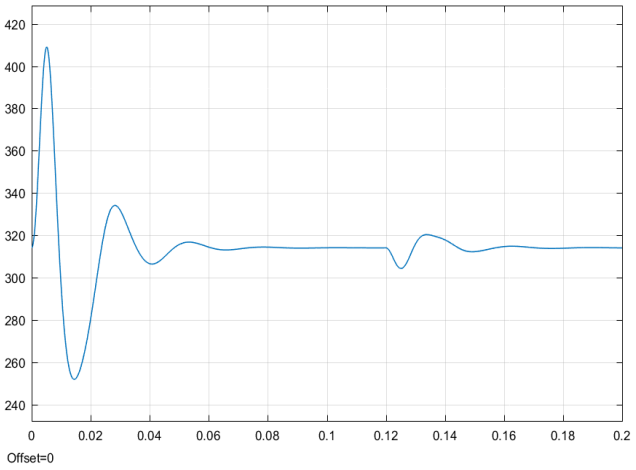

Fig. 12(b) Frequency after Voltage Dip

In the simulation, a voltage dip of 30V amplitude is introduced at 0.12s. The performance of the PI controller on the frequency before and after the fluctuation is shown in Fig. 12(a) and 12(b). The values of K_p and K_i selected are 0.7 and 300 respectively. The frequency gets stable again to 314 rad/s in 0.06s after the disturbance occurs.

4 Conclusion

A second-order generalized integrator based PLL for a single-phase grid connected PV system is modelled in this paper. The impact of the gain k has been presented and analyzed. The steady state response and the dynamic response of PLL have been illustrated. The simulation results show the fast-adaptive nature of SRF-PLL.

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Solar Integration with Grid and Anti-Islanding Protection – A Review

Hassan Zahid Butt[a,*]; Muhammad Awon[a]; Rida Fatima[a]; Hassan Abdullah Khalid[a]

[a]Department of Electrical Energy Engineering, Center for Advanced Studies in Energy, NUST, Islamabad, Pakistan

[*] Hassan Zahid Butt
E-mail: hzbutt120222@gmail.com
Tel: +923218370727

Abstract
With the decreasing fossil fuel reserves and the increase in carbon dioxide emissions from them, the penetration of renewable energy sources has increased enormously in the last two decades. The capturing of renewable sources and their safe integration with the grid is of main importance to all countries. Sun is the biggest renewable energy source and its energy is captured via a photovoltaic cell. However due to its poor efficiency, maximum power point tracking is used to extract the maximum efficiency by matching the load curve with the maxima of the solar array's power-voltage curve. Integration of the PV system to the grid is done via a grid-tied inverter which synchronizes the PV system with the grid using a synchronizing algorithm that matches the phase, frequency and amplitude of the utility's voltage with that of the inverter. Anti-islanding protection is used to cut-off the inverter's supply to the grid when it is down to protect the equipment and the personnel at the utility. The paper presents a review of the maximum power point tracking techniques, synchronizing algorithms and anti-islanding methods.

Keywords: *grid tied inverter; anti-islanding; maximum power point tracking; synchronization; photovoltaics*

1 Introduction

Fossil fuels are the biggest source of the energy utilized around the world. The demand of energy is continuously being increased every year but due to the decreasing fossil fuel reserves, their cost is increasing. These fuels are the biggest cause of all the global environmental pollution. So the world is turning its head towards the capturing of renewable energy sources which are available in abundance and are comparatively pollution free [1]. However, renewable sources face uncertainty and variability problems. To make it sustainable, a storage system thus becomes vital [2]. Reliability, efficiency and security of a system is of keen importance since it should be able to work properly in all working conditions with maximum efficiency and should have fault detection capability and protection circuitry [3][4]. Sun is the biggest renewable energy source and its energy is captured via a photovoltaic cell which is made up of semiconductor materials like silicon, germanium. However, the efficiency of a PV cell is very poor. Advanced solar cells have been made having efficiencies around 35-40% but they are expensive and not suitable for commercial use. The load is always varying. So, to operate the solar system at its maximum efficiency, the I-V curve of the PV cell is changed accordingly to match with the load's I-V curve via a power processing unit which is normally a DC-DC converter [5]. The duty cycle of the converter can be adjusted to give a particular output voltage as shown in fig. 1. To make the system autonomous, fast, and intelligent, the duty cycle is varied via a microcontroller that performs Maximum Power Point Tracking (MPPT). A solar system without an MPPT algorithm is like a person without a brain [6]. The MPPT algorithms can be of different types and each year, new and improved techniques are emerging.

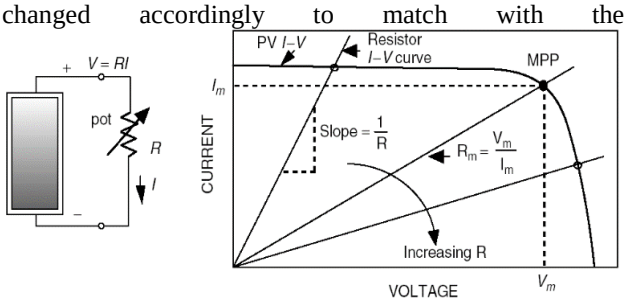

Fig. 1 Solar cell's I-V curve imposed with a varying load curve

1.1 Maximum Power Point Tracking Algorithms

The basic MPPT algorithm is Hill Climb Search which can be applied to any system that involves a bell-shaped power curve. Fig. 2 shows power versus speed curve of a generator indicating that at certain speed, power is maximum. This is analogous to power vs voltage curve in electrical circuits. Among the tracking algorithms, Perturb and Observe (P&O) and Incremental Conductance (INCCOND) methods are very famous.

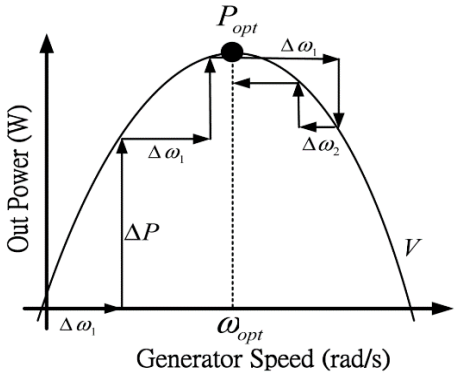

Fig. 2 Perturbation of generator speed to measure change in power

Improvements have been made in these algorithms to increase the tracking speed and accuracy of convergence. A simple P&O technique is discussed in [7] which make use of a DC-DC converter's duty cycle to perturb the voltage and observe the change in output power. Although being a low cost, fast and less complex design, this algorithm faces oscillation around the maximum power point. This problem has been addressed by the incremental conductance method discussed in [8], which is based on the principle that at maximum power point, $\frac{dP}{dV} = 0$, and since $P=VI$,

$$\frac{dV}{dI} = -\frac{I}{V}$$

i.e. when change in voltage with respect to current gets equal to the negative ratio of instantaneous current to voltage, MPP is achieved. However, the system gets more complex and the cost is compromised. The biggest issue of hill climb search methods is that under varying environmental conditions, partial shading phenomenon is observed that gives multiple maxima in the power-voltage curve when bypass diode configuration scheme is applied as shown in fig. 3. [9] and [10] discusses this problem and proposes methods to check for the Global Maximum Power Point (GMPP) instead of Local Maximum Power Point (LMPP).

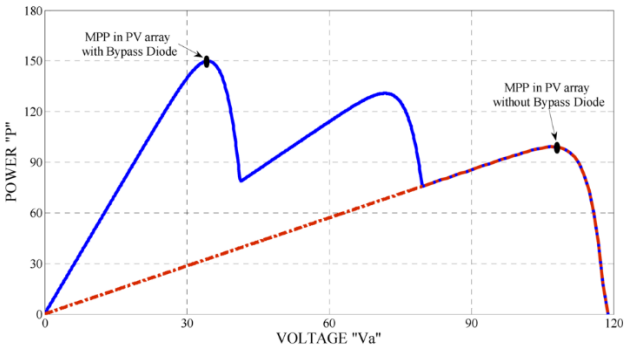

Fig. 3 Multiple maxima occur under partial shading with bypass diode

As stated earlier further improvements are continuously being done in already existing algorithms. [11] makes use of the simplicity of the conventional P&O technique but with an Ant-colony-based search algorithm in the initial stages of tracking followed by P&O. The ability to find the global maximum power point of Ant-Colony Optimization (ACO) and the fast-tracking speed of P&O makes this algorithm work efficiently in all conditions. However, it also faces the issue of oscillations around the maximum power point. [12] [13] describe the use of fuzzy logic controller which is a more robust control technique that gives no oscillations at the maximum power point and works well with non-linearities also. But the implementation is much more complex than the traditional techniques. [14] works on the tracking of global maxima. It states that it is better to scan about the local maxima instead of scanning from the start to end of the *P-V* curve to track the global maxima. The reason for this is that the global maxima has more probability of occurrence about the local maxima than about the start or end of the curve. Therefore, this improved algorithm scans for the global maxima by taking a step on the left and then on the right of the local maxima and continues in the same fashion until the whole D = [0,1) range is covered.

1.2 Grid-Tied Inverter

After the generation of solar energy, comes the step of converting it to AC via an inverter. Grid-integration of this inverter is done to provide excess power to the grid for the maximum utilization of available energy and the ability to sell energy as well [15].

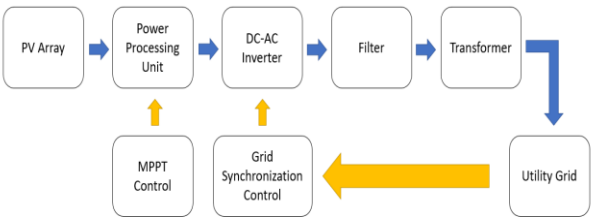

Fig. 4 Block diagram of a grid connected PV system

Filtering of the inverter's output and the extraction of the fundamental sine wave is done using a low pass filter. For the integration to be possible, synchronization of the generation source should be done with the grid i.e. the inverter's output voltage and the grid's voltage should have the exact same frequency, phase and amplitude. There are various methods to implement the grid tied configurations. Typical grid tied inverters use transformers at the output terminals which serve the purpose of filtering harmonics due to its inductive nature, as well as for isolation. The drawback of using transformer is that it is expensive, has less conversion efficiency and a bigger transformer is required for a bigger system which makes the inverter heavy. [16] , [17] and [18] discuss a transformer-less scheme giving low cost, less weight and much better performance than with a transformer. The types of switches used in an inverter also plays a role in determining the efficiency of the system. [17] describes the use of super junction MOSFETs and silicon carbide diodes for the switching purpose as they are fast and more efficient. [19] shows via simulations that the Total Harmonics Distribution (THD) percentage decrease as the output voltage levels increase. So, a seven-level inverter is proposed giving a more harmonic free modified sine wave. However, cost and complexity gets compromised.

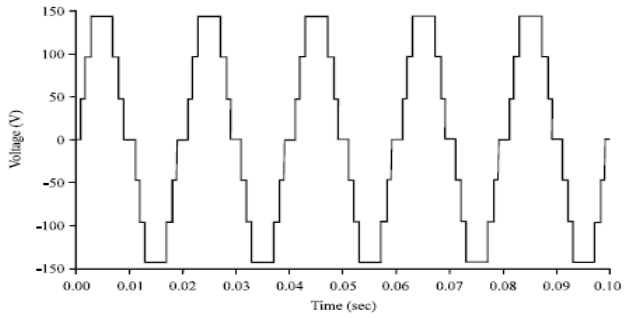

Fig. 5 Multiple level inverter having comparatively less harmonic content

Although the multi-level inverter topology reduces the harmonic content, still a need of a low pass filter is required. [20] discusses the use of line filter among which the most basic is an L Filter. It reduces the harmonic content in current produced by high frequency switching in PWM inverters. An L-C-L filter is more advantageous as the current distortion in it is low as compared to an L filter. A PV inverter system with an L-C-L filter is shown in fig. 6. [21] addresses the problems faced in using a typical L-C-L filter. Simulation has been done to show that harmonic current around the switching frequency is very close to the standard upper limit defined by IEEE1547.2-2008. As the filters are operated at resonance, some stability issues may also arise. [22] and [23] discuss the damping of resonance frequency and using active elements which although removes dissipation but increases complexity. A notch filter is proposed that may provide an efficient solution. However, the tuning of this filter under varying conditions is difficult and the robustness is decreased.

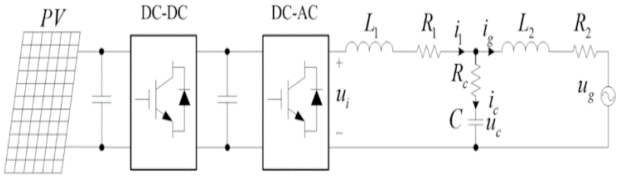

Fig. 6 PV system with an DC-DC and then DC-AC conversion with a passive L-C-L filter

After the filtering there comes the stage of synchronization which is done for power to flow from the inverter to the grid. A grid tied inverter thus should be capable of fast injection of power to the grid [24]. In synchronization, amplitudes, phase angles and frequencies of the two systems should be matched. Feedback control systems are also required for continuous matching of these parameters so that in case of transients, the inverter system should be able to adjust accordingly. [25] discusses zero crossing detection method which is the simplest and basic synchronization technique. The zero-crossing is the instantaneous point at which there is no voltage present. In a sine or cosine wave, this occurs twice during each cycle. Every time when a particular waveform crosses zero, the zero detector which is basically a comparator, gives an output signal. But as harmonics are always present, thus the zero detector fails to track the actual zero crossing since it then tracks the surge impulses also. [26] discusses one such method by controlling frequency via Frequency Locked Loop (FLL) algorithm in which frequency is being observed and varied under distorted grid conditions. The proposed system is able to work efficiently under the influence of voltage fluctuations and harmonics. [27] discusses the enhanced phase lock loop (EPLL). EPLL enhances the standard PLL as it provides an estimate of the input signal magnitude and provides a filtered version of the input signal. In other words, the EPLL not only operates as a PLL, it also functions as a filter. [28] involves a communication method that involves the Communication Area Network (CAN) Bus. In this the algorithm senses the grid voltage, derives the phase angle and transmits the information actively on the CAN network. Although being a fast synchronizing process, the CAN protocol is very complex and does not come with normally available microcontrollers.

1.3 Anti-Islanding Detection and Protection

For a grid tied system, islanding is a critical and unsafe condition in which a distributed generator continues to supply power to the grid even if the electric utility is down. This is dangerous in many ways as it exposes the utility workers to life critical dangers of shocks and burns. Also, the frequency of the distributed system drops heavily and it gets damaged [29]. There are normally 2 ways for anti-islanding detection. Active islanding detection that

involves continuous communication between distributed generator and the grid to ensure the status of electric utility. Passive islanding detection makes use of the transients in voltage, current, frequency etc. for detection. Two basic detection methods of this are over/under frequency protection and over/under voltage protection. The effectiveness of this detection is largely dependent on the thresholds set for the changing parameter [30]. [31] discusses that the islanding can also be detected via measuring the Rate of Change of Frequency (ROCOF). Under normal load variations, the ROCOF is not very high. However, when islanding occurs, ROCOF exceeds the threshold and trips the relay to avoid islanding mode. This technique however can mal-operate as more renewable penetration occurs as the system's inertia gets very low and even in the case of normally varying loads, ROCOF may exceed the threshold and cause false tripping of relays.

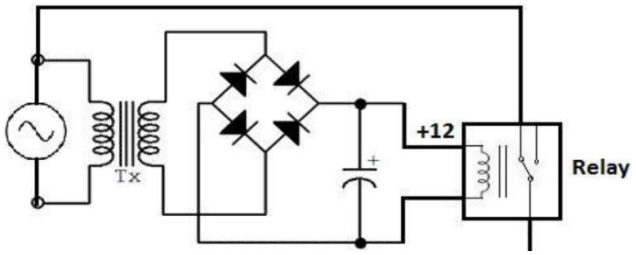

Fig. 7 Simple Anti-Islanding Technique

Fig. 7 shows a simplest anti-islanding protection circuit that when the grid goes down, the relay will trip causing a disconnection between the inverter and the grid.

2 Conclusion

Safe integration of renewable with the grid is of huge importance with the growing energy and environmental crisis. The paper presented an insight of various techniques applied in this field. Continuous improvements are being made to improve the efficiency and minimize the cost of the system. Different schemes have different advantages and disadvantages among which a compromise has to be made and the one which provides a good tradeoff between efficiency, cost and complexity can be used for commercialization.

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Techno-economo-environmental viability assessment of standalone photovoltaic system- A case for Faisalabad Pakistan

Rida Younis [a], Amina Iqbal[a], Umer Farooq[a], Awais Iqbal[a], Habib Ullah Manzoor[a], A. Mehmood[b]

Abstract
With the increased demand of electricity and depletion of conventional energy sources reserves, lately researchers are recommending the use of standalone and grid connected photovoltaic (PV) systems. Pakistan has ~2.9 million MW potential of electricity generation through solar PV applications which is hardly exploited. This work is focused on analyzing the technical, economic, and environmental aspects of a standalone photovoltaic system installed in Faisalabad, where blackouts are very common. In terms of its environmental advantages, renewable energy sources generate electricity with insignificant contribution of carbon emissions. Simulations are carried out on "RETScreen". The weather data used in simulation is reported by the National Aeronautics and Space Administration (NASA). System capacity is 1 kW. Technical analysis is performed in terms of capacity factor and electricity delivered to load. Economic analysis is carried out considering economic parameters: net present value, internal rate of return, payback period, benefit-cost ratio and annual life savings. Outcomes elaborate that the modelled system provides ~34% of total demand to a domestic level residential building with 2.2 years payback period. Further the effect of PV module controlling method was also investigated. GHG emissions possible to get reduced are estimated for pointing out the feasibility of solar PV implementation leading towards green growth of Pakistan.
Keywords: Standalone photovoltaic; RETScreen; Electricity delivered; Economics; Greenhouse gases

1 INTRODUCTION

The growing global demand for electricity, rising fossil fuel prices and increasing apprehensions about global warming have invigorated the idea to rapidly move towards renewable energy resources, especially during last two decades, [1] [2]. As the country population progresses, the energy consumption escalates, [3]. Solar energy is now a main substitute for fossil fuels because of its clean and renewable nature,[4]. Around 67 countries, including the EU countries have set targets to enhance their reliance on renewable energy sources rather than using conventional energy resources. US and EU have set their target to grow the use of these renewables to 20% by 2020, while UK seeks to increase it to 33%, [5]. The paramount advantage of straight transformation of sunlight to electricity is that it takes place without any change of location or environmental releases,[6]. On the contrary other renewable energy sources are location oriented. Sunlight can be harnessed by three types of technologies: photovoltaic (PV), concentrating solar thermal (CST) and solar heating and cooling (SHC), [7].

Solar Energy harnessing is well recognized, as photovoltaic systems have now been used for over fifty years both for stand-alone uses, and grid-connected installations, [8] [9]. That's why solar power is being heavily researched, and solar energy costs have now reached within a few rupees per kW/h of other forms of electricity generation, [10]. The demand-supply gap is soaring day by day in Pakistan and people need to shift towards renewable energy sources like solar energy badly ,[11]. Current literature reveals that energy poverty is a diverse, persistent, and manifold issue,[12]. Adoption of solar PV at household can also relieve Pakistan from chronic electricity shortage, [13]. Household is important for solar PV adoption because it is a major electricity consumption sector in Pakistan and also a major receiver of subsidies, [14] [15]. But sadly solar energy in Pakistan is used without sagacity, [16].

In this article, a standalone PV system installed in Faisalabad city have been analyzed technically, economically and environmentally. Along with using the conventional solar panel setup Maximum Power Point Tracker (MPPT) is also integrated with battery, [17]. Exaughast set of simulations are carried out on RETScreen software. Modeled system viability is evaluated on the basis of economic parameters like inflation rate, debt ratio, IRR cost and

payback periods, [18] [19]. Software calculations also ascertain that how much base case electric power load reduction is possible and how much GHG reduction is possible by the use of solar energy.

2 MODELING METHODOLOGY

A. RETScreen Software

RETScreen is an excel based clean energy management software developed by Natural Resources Canada's CANMET Energy Diversification Research Laboratory (CEDRL) known as Canadian Energy Center, [20]. It is used to evaluate the practicality of any energy project potential for a fast and economical implementation, [21]. Software algorithms calculates the technical, economic and environmental viability of different projects in terms of NPV, capacity, IRR, GHG emission reduction and payback.

TABLE 1. CLIMATE INFORMATION OF STANDALONE PV MODEL IN FAISALABAD

Ambient data/ Location	Climatic information of location(Faisalabad)
Latitude	31.4504° N
Longitude	73.1350° E
Ambient temperature (Annual)	23.8 °C
Daily solar radiations-horizontal(Annual)	5.03 kWh/m²/d
Wind Speed(Annual)	3.3 m/s
Heating Degree-Days	469 °C-d
Cooling Degree-Days	5,042 °C-d

The purpose of current work is to analyze the viability of a RETScreen modeled standalone PV system according to the annual climatic and geographical conditions of Faisalabad.

B. Climatic Conditions of Selected City:

RETScreen software developers have entrenched climatic and geographical conditions of almost all the cities of world map reported by NASA, [22]. Solar irradiance is the basic parameter that determines the complete life cycle of a standalone PV system, [23]. That's why the climatic conditions and geographical location of a city significantly affects the solar system. City of Pakistan selected for current study is Faisalabad. Climatic and geological information of selected city is mentioned in table I.

C. PV Array Technology

In RETScreen, different technologies are available for PV system e.g. Thin Film (TF), Amorphous Silicon (a-Si), Cadmium Telluride (CdTe), Poly crystalline Silicon (poly-Si), mono-Si and spherical-Si, [24]. A vast number of PV models by different manufacturers are also embedded in the software database. PV models represented in RETScreen database are based on Evan's[25] formula. The optimum efficiency can be calculated by using formula;

$$\eta p = \eta r[1-\beta(Tc-Tr)] \quad (1)$$

And by Evan's, [25] formula the relation of module temperature (T_c) and mean monthly ambient temperature (T_a) can be given as;

$$T_c\text{-}T_a=(219+832K)\frac{NOCT-20}{800} \quad (2)$$

For current study, a mono-Si PV model is selected on the basis of parametric characteristics and how easily it's available. The parametric characteristics of selected PV model are given in the table II.

TABLE 2. PARAMETRIC CHARACTERISTICS OF SELECTED PV MODEL

Characteristic	Value
Photovoltaic Technology Type	Mono-Si
Efficiency	19.6%
Nominal Operating Cell Temperature	45º C
Temperature Coefficient	0.40%/ ºC
Solar Collector Area	6.5m^2
Control Method	Maximum Power Point Tracker

D. Standalone PV Model

The grid type of standalone PV model is off-grid system. There are two possibilities for such a system; either utilize output energy directly through charge controller-battery setup or indirectly via battery-inverter setup in AC loads case.

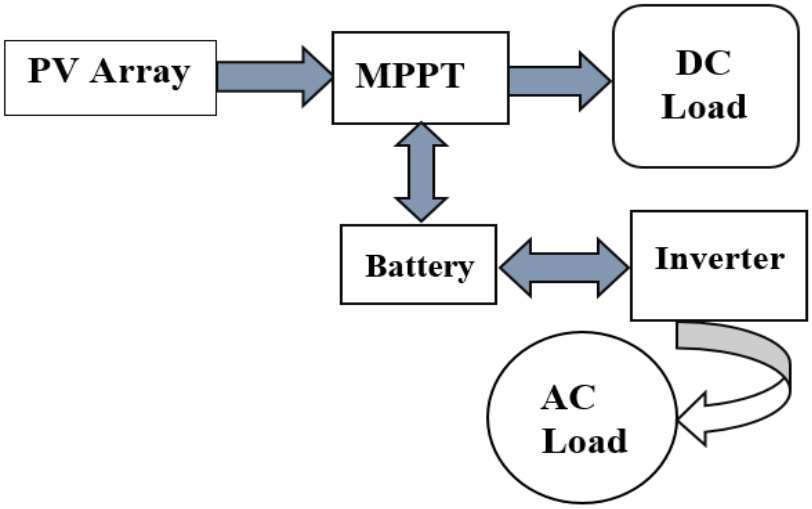

Fig. 1. Standalone PV model Configuration with MPPT

E. RETScreen Simulations

In RETScreen simulation, user specifies the load and its type either DC or AC. Load characteristics of current case study for which standalone PV system modeled is shown in Fig.2.

Description	AC/DC	Intermittent resource-load correlation	Base case load W	Hours of use per day h/d	Days of use per week d/w	Proposed case load reduction %	Proposed case usage time reduction %
3 lights	AC	Zero	150.00	10.00	7		
2 fan	AC	Zero	200.00	13.00	7		
Tv	AC	Zero	150.00	7.00	7		
Motor	AC	Zero	500.00	7.00	7		
			1,000.00				

	Unit	Base case	Proposed case
Electricity - daily - DC	kWh	0.00	0.00
Electricity - daily - AC	kWh	8.65	8.65

Fig.2. Load Characteristics

In proposed case, a battery of 12 V battery bank is used with days of autonomy as one day with 85% maximum suggested depth of discharge. Among other inputs, financial parameters like fuel cost escalation rate, inflation rate and discount rate are the parameters that proves the feasibility of the system. Basic case study input parameters are mentioned in Table III.

TABLE 3. CASE STUDY INPUT PARAMETERS

Parameter	Value
Days of autonomy	1 Day
Battery Voltage	12.0 V
Battery Maximum Depth of Discharge	20%
Temperature Control Method	Ambient
Solar Tracking Mode	Fixed
Cost of PV Panel	50 PKR/W
Fuel Cost Escalation Rate	4.1%
Inflation Rate	7.8%
Discount Rate	9.5%

The two main assumptions while performing this analysis are:

- Base case power source is the grid connected electricity
- Slope of PV model is assumed equal to absolute value of latitude of Faisalabad for maximizing value of solar irradiance.

3 RESULTS AND DISCUSSION

RETScreen software determines the viability of any system in terms of technical terms (i.e. number of PV units required and respective power delivered to load), economic parameters (like IRR, equity, NPV and payback periods) and environmental analysis (like GHG emission reduction). Following three analyses on RETScreen are performed and elaborated:

- Technical Analysis
- Economic Analysis
- Emission Reduction Analysis

A. Technical Analysis

Technical analysis is a key methodology for forecasting future price and volume by perceiving prices in the past, [26]. In engineering, technical analysis encompasses the efficiency and utilization. In this case study, technical analysis gives the insight to the number of PV panel units for ideal power capacity and the power delivered to the load. Results show that by using four PV panels, 100% power capacity is achieved. The total power delivered to load varies because value of solar irradiance is different for various months in Faisalabad.

TABLE 4. ENERGY ANALYSIS PARAMETERS

Parameter	Value
Number of PV units	4
Annual solar radiations-horizontal	1.84MWh/m^2
Power delivered to load	0.98MWh

B. Economic Analysis

Economic analysis is performed to evaluate the economics of a certain project on the basis of determinants like NPV, IRR, equity and payback periods. NPV can be calculated as, [20].

$$-CF_o + \sum_{i=1}^{t} \left[\frac{CF_i}{(1+r)^i}\right] = NPV \qquad (3)$$

IRR is form of return rate that makes NPV of project equal to zero, can be calculated by modifying (3) as[20]:

$$-CF_o + \sum_{i=1}^{t}\left[\frac{CF_i}{(1+r)^i}\right] = NPV = 0 \qquad (4)$$

Where i = 1, 2, 3, ….., t

Figure 3 shows NPV, IRR, P.B. and B.C.R. of standalone PV model. All the economic determinants favor Faisalabad for standalone PV system application. This shows that higher the value of solar irradiance, higher is the value of all economic determinants making the project more feasible.

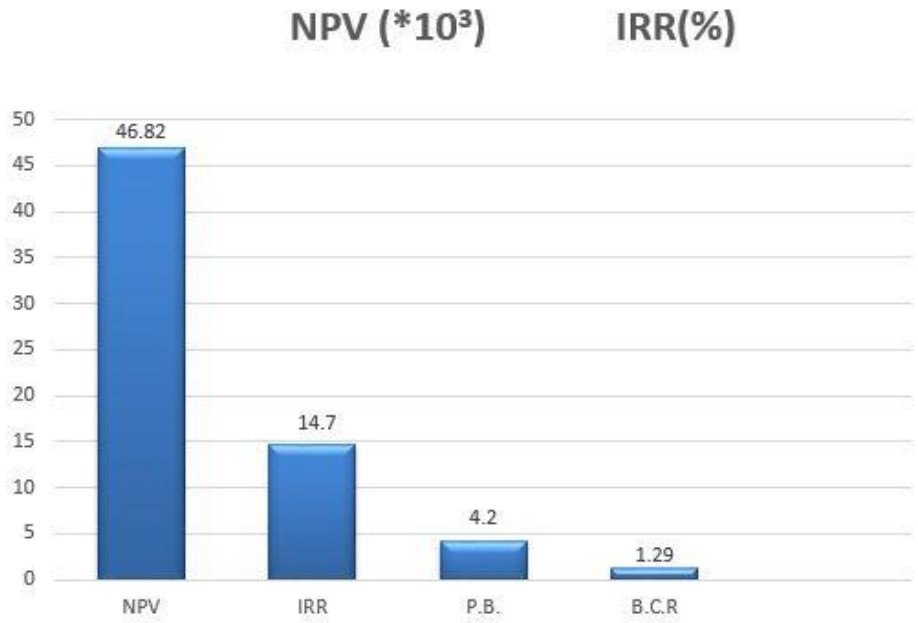

Fig. 3. Detail Economic Analysis

C. Emission Analysis

GHG emissions are the main cause for global warming effect that leads to grave health problems. According to WHO, about 1.6 million people died prematurely due to GHG emissions, [27]. Therefore, it is very important to search for clean and friendly environmental and energy sources. In this way it is important to set diverse techniques to condense GHG emissions.

Table V illustrates net GHG emissions reduction, CO_2 and CH_4/N_2O emission reduction factor that outcomes after the setting up of our proposed case system.

TABLE 5. GHG REDUCTION PARAMETERS

Parameter	Value
Net GHG emission reduction	$0.8tCO_2$
CO_2 emission factor	49.4Kg/GJ
CH_4/ N_2O emission factor	0.0036Kg/GJ

4 CONCLUSION

A stand-alone PV system analysis is performed on RETScreen for the city of Faisalabad, Pakistan. Its technical, economic and environmental analysis is carried out in terms of annual solar radiations, power delivered to the load, net GHG emission reduction, NPV, IRR, equity and simple payback periods. Considered system has the capacity of 1KW. PV technology will lead towards replacement of fossil fuel technology that will result in GHG emission reduction. This GHG reduction is equivalent to bikes and trucks not used for about 25 years. Results show that there is ample potential of PV technology in Pakistan for dealing with the present energy crisis as well as meeting the imminent energy needs.

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Home Energy Management System

Hajra Javed[1, *]; Hamna Rawish[2]; and Akram Rashid[3]

[1,2,3]Department of Electrical and Computer Engineering, Air University Islamabad, Pakistan

[*] Akram Rashid
E-mail: akram@mail.au.edu.pk
Tel: +923455898204

Abstract
Home automation is referred as the efficient control of home appliances and domestic features by local networking or by wireless control. Our aim is to create a Solar powered automation system, that will be self-sustainable and prove effective in electrical energy consumption than using electricity directly from the grid. Home appliances like fans and lights will be controlled using motion and temperature sensors. Current practice of Solar Powered home automation is still not considered energy efficient and cost effective. The energy consumption by electrical appliances can be greatly reduced by automation, thus reducing the cost and increasing efficiency of the designed solar system. Another objective is to use a compact electrical system to minimize the hardware cost. The Solar Panel will provide electricity to charge the battery during day time and use that stored energy during day and at night time as well. In this research work an open source micro controller (Arduino) will be used to display the main power source and control different appliances with sensors making efficient demand resource management of electrical energy with consideration of peak and off-peak hours. The extra energy will be transmitted to the main grid or community grid using smart metering system.

Keywords: *Home automation, System Wireless, system Solar, Energy, Peak hours, off-peak hours*

1 Introduction

Home automation is known as the automation of the home, housework or household activity. It is considered as the control of home appliances and domestic features by local networking or by wireless control. Its main benefits range from increased comfort to a more rational use of energy and other resources, allowing for significant savings. Home automation is one of the major growing industries that can change the way people live. Some of these home automation systems target those seeking luxury and sophisticated home automation platforms; others target those with special needs like the elderly and the disable. It also offers powerful means for helping and supporting the special needs of people with disabilities and, the elderly. This application domain is very important and will steadily increase in the future. Wired homes could be replaced by wireless systems could be the norm soon. It commonly defines a residence that integrates technology and services through home networking to improve the quality of living. Home automation is not a new term for science society and has been around for a significant time. Home automation include mainly centralized control of lighting, temperature, appliances, and other systems, to provide improved comfort, convenience, efficiency and security. Our aim is to create a Solar powered home management system, as automatic systems are being preferred over manual system. Through this project we have tried to show automatic control of a home devices as a result of which power is saved to some extent. The energy consumption by electrical appliances can be greatly reduced by automation, creating an economic and energy efficient system development, thus reducing the cost and increasing efficiency of the designed solar system. Another objective is to use a compact electrical system to minimize the hardware cost.

1. Literature review:

Sriskanthan explained an automated system based on Bluetooth wireless technology which allows the user to monitor and control different appliances that are connected over a Bluetooth network based on a mobile host controller. Maqsood implemented techniques and provided a viable solution to realize home automation system which constitutes Bluetooth control via Android app development for in-house control and GSM (Global

System for Mobile Communication) technology for mobile control using Arduino. Adriansyah, designed a system able to monitor and control lights, room temperature, alarms and other household appliances Vinaysagar K N, Kusuma S M proposed a system which uses Intel Galileo. This system uses wireless communication, internetworking of cloud networks. It operates various lights, fans and simple appliances. The data from the sensors will be collected automatically. This data will be stored in the cloud. The proposed system is built to reduce cost and allows expandability using wide range of devices. This system can be operated from anywhere of the world using internet connection. Basma M. Mohammad El Basioni Sherine M. Abd El-kader, Mahmoud Abdelmonim Fakhreldin proposed a new design which utilizes wireless networks and biometric technology. This paper helps in ensuring the security of home entering process by employing biometric as an authentication tool. This design is capable of building automation system in offices, schools and other places. The paper ends with the idea of employing the technology in larger and comprehensive form. Mohamed Abd El-Latif Mowad, Ahmed Fathy, Ahmed Hafez presents the execution of a multiplatform controlled system that is a combination of both hardware and software technologies. It is an interface to enable remote control with integration of mobile devices. In this paper, the use of a microcontroller, Arduino and few sensors are specified for controlling the home devices like fan, light etc. This paper gives the detailed view of connectivity between a microcontroller and smart phone via Bluetooth.

2. Problem statement

Now a day, energy conservation is major problem in Pakistan. Much of the energy is being wasted during transmission and distribution in our research we are going to manage the home energy keeping in view on and off-peak hours of electrical energy. Our project will be self-sustainable and prove effective than using electricity directly from the grid. Home appliances like fans and lights will be controlled using motion and temperature sensors and the sensors will be controlled with the help of Arduino. Arduino is an open-source prototyping platform that provides easy-to-use hardware and programming environments. It is relatively inexpensive as compared to other microcontroller-based platforms.

3. Hardware platform:

The hardware part mainly consists of a solar panel, charge controller, LCD, battery, inverter, switch, Regulator, Arduino, light, fan, motion sensor and temperature sensor which are being discussed along with their specific functions below the diagram.

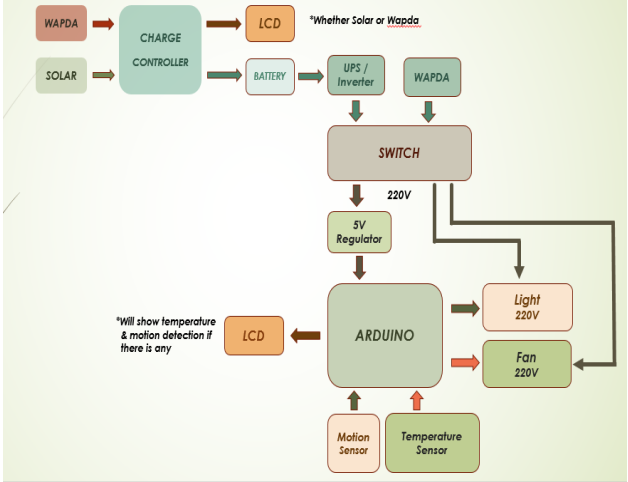

Figure 1: Clock diagram showing sequence of Instructions

Solar panel: Solar panel absorb the sunlight as the source of energy to generate electricity or heat. The price of solar power has continued to fall so that in many countries it is cheaper than ordinary fossil fuels electricity from the grid. Charge controller: Charge controller, charge regulator or battery regulator limits the rate at rich electric current is added to or drawn from the electric batteries. It prevents over charging and may protect against over voltage which can reduce battery performance or life span. It will convert DC TO AC as well as AC to DC Battery: It is used for storage purpose.

Liquid crystal display (LCD): LCD (16*2) will display the data according to the requirement.

Switch: It will allow us to switch to WAPDA in case when battery is not able to provide the required voltage/power to operate our home devices.

Arduino: An Arduino board consists of an Atmel 8,16- or 32-bit AVR microcontroller with complementary components which helps in programming. This board has a 5-volt linear regulator and a 16 MHz crystal oscillator.

Temperature Sensor (LM35): It is an integrated-circuit temperature sensing device with an output voltage linearly proportional to centigrade temperature. LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from output to obtain convenient centigrade scaling. Motion sensor (passive infrared sensor): PIR sensors help in detection of motion. They are generally used to detect human movement within the sensor range. They are also called Passive infrared or IR motion sensors. They consist of pyroelectric sensor which detects the level of infrared radiation. The output is in the form of digital pulse .When motion is detected it shows digital high and when no motion is detected it shows digital low.

Input: Infrared Red, Output: Digital pulse

Light: When the motion will be detected light will turn on and vice versa

Fan: When the temperature is greater than the limit fan will be turned on otherwise it will remain off.

4. Methodology

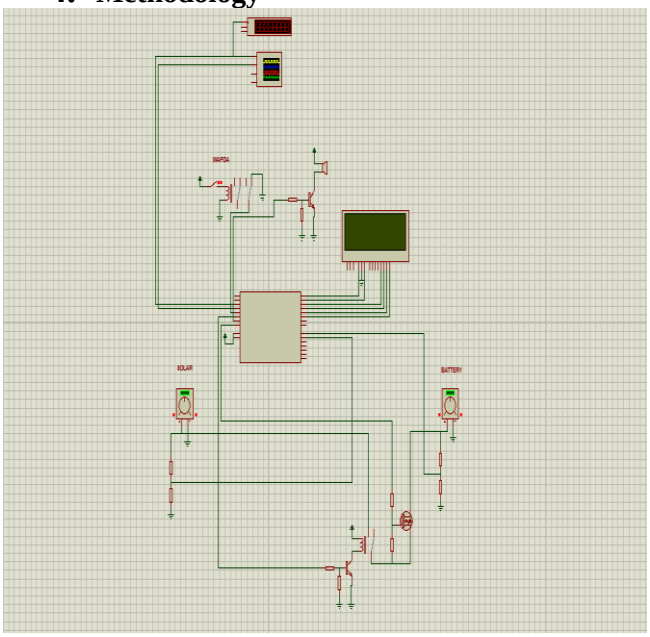

Figure 1-a: Proteus implementation

Figure 2-b: Hardware implementation

Circuit of home automation:

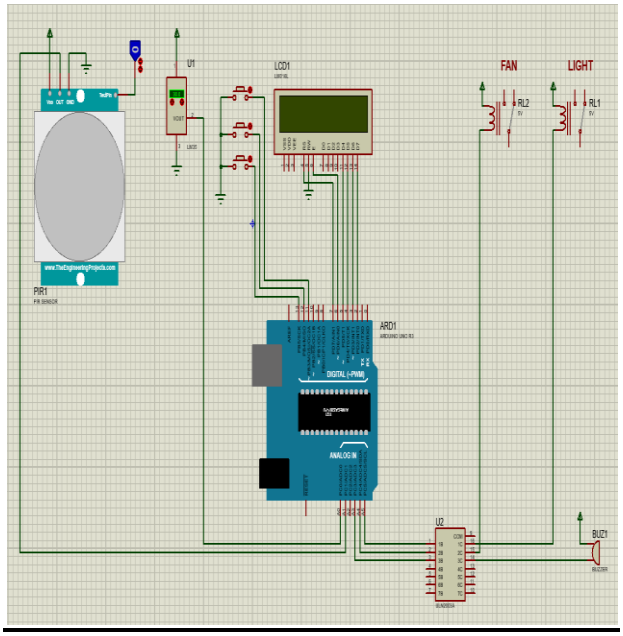

Figure 3-a: Proteus implementation

Figure 2-b: Hardware implementation

5. Results and software implementation:

For motion sensor:

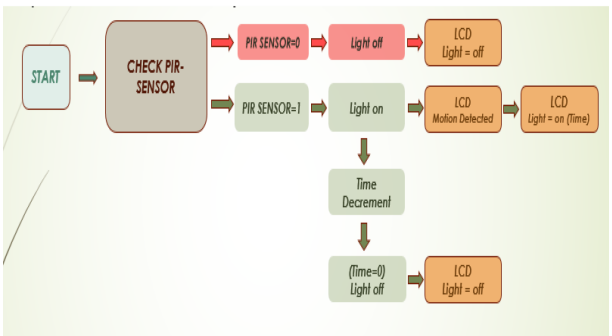

Figure 3

When the program will start PIR sensor is used which will detect the motion. If no motion detected means PIR sensor is equal to zero light will remain off and LCD display 'LIGHT OFF' as shown in figure 4-a. If the motion is detected by PIR sensor light will turn on and LCD will display motion detected (figure 4-b). When the motion is out of range of PIR sensor it will turn off and LCD will display the time interval for which the motion was detected (figure 4-c). Time will start to decrement (figure 4-d) and when the time approaches to zero light will turn off and LCD will display light off (figure 4-e).

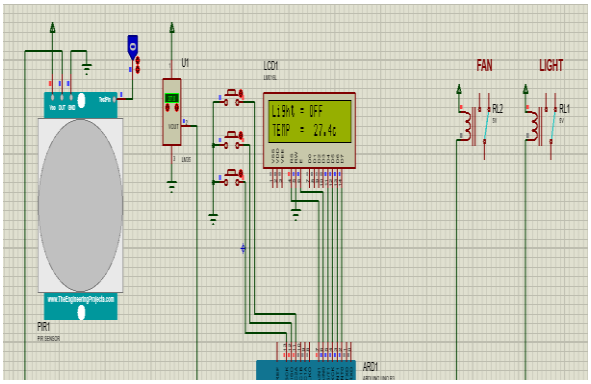

Figure 4-a

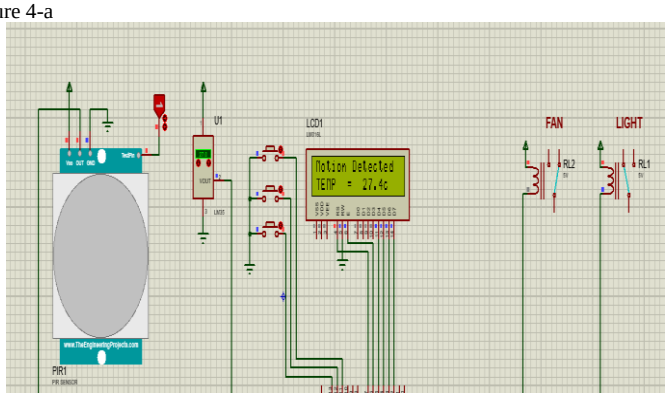

Figure 4-b

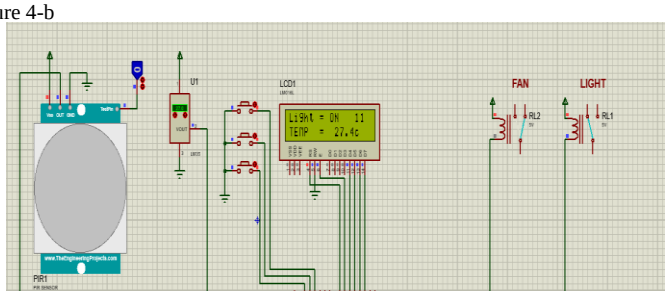

Figure 4-c

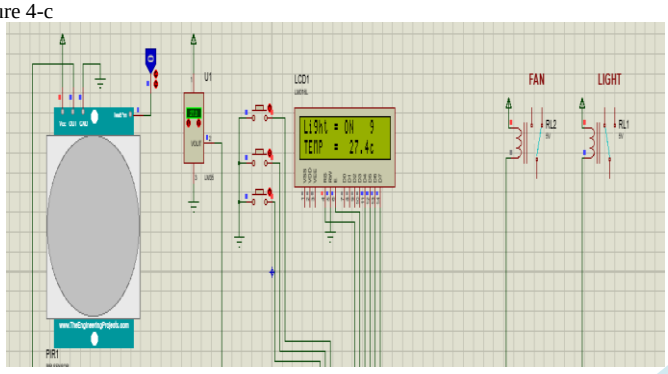

Figure 4-d

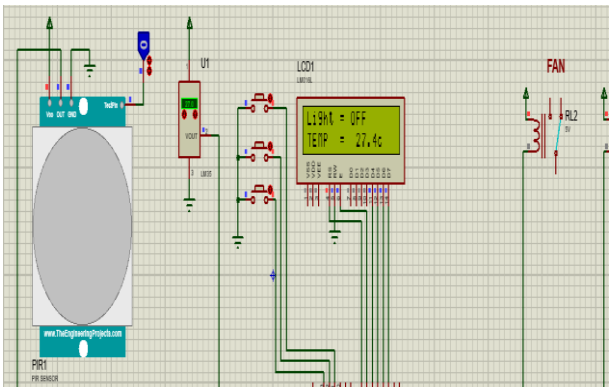

Figure 4-e

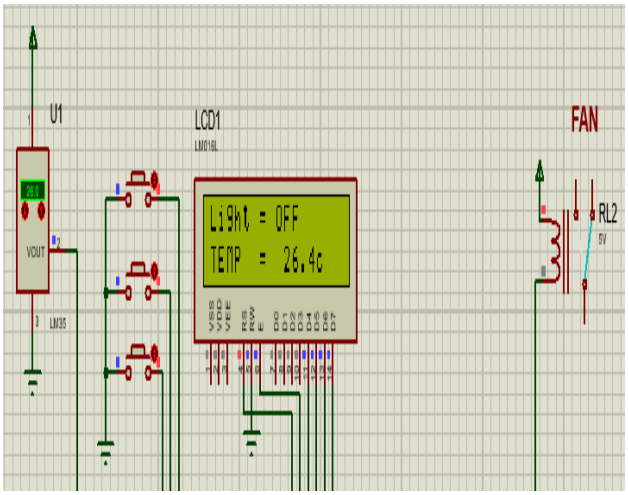

Figure 5-b

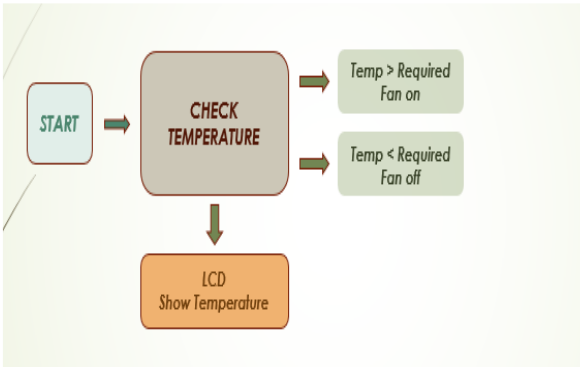

Figure 4

LM-35 is used to check the temperature. Temperature limit is set by using buttons. If the temperature is greater than that set limit fan will turn on and LCD will display the temperature along with the alphabet F as shown in figure 5-a otherwise it will remain off and LCD will only display the temperature. (figure 5-b)

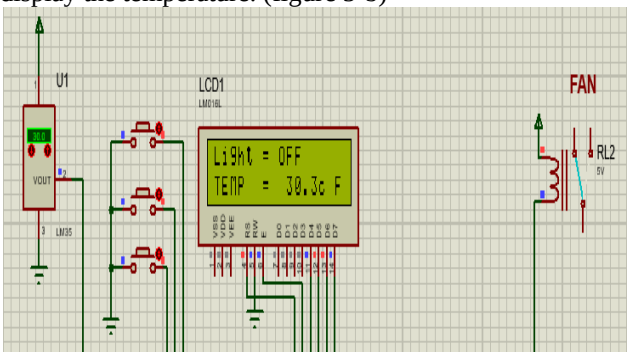

Figure 5-a

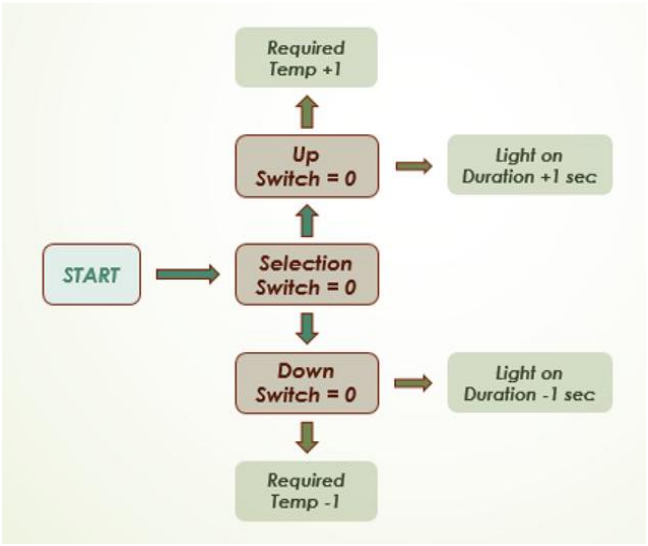

Figure 5

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Variable Frequency Derive for Operating Induction Motor

Hina Nadeem[1,*]; Nabeel K Bangash[2]; Tahir Saleem[3] and Akram Rashid[4]

[1,2,3,4]Department of Electrical and Computer Engineering, Air University Islamabad, Pakistan

[*] Akram Rashid
E-mail: akram@mail.au.edu.pk
Tel: +923455898204

Abstract
Variable frequency drive drives the motor by changing the frequency and voltage supplied to the electric motor. V and F method is used for varying the speed of the induction motor and the starting current (inrush current) required by the motor is reduced. Gate drive circuitries used for inverter stage. The IR2110 and PIC- 18f4520 are used for controlling the Gate drive circuitries. To accelerate an AC motor to full speed using a full voltage connection, a large inrush current may be required. Additionally, the torque of the AC motor is mostly uncontrolled and can shock the connected equipment, potentially causing damage. As a protection measure an idea of Variable Frequency derive is introduced in this research work.
In this research work Variable frequency drives are used in applications where: Complete speed control, Energy savings is required. AC supply: Comes from the facility power network (typically 208V, 230V, 480V, 690V / 50 Hz AC.) Rectifier: Converts (rectifies) network AC power to DC power Chokes and DC bus: Work together to smooth the rectified DC power and provide clean, DC power to the inverter with low ripple content. Inverter: Uses DC power from the DC bus and chokes to invert an output that resembles sine wave AC power using a pulse width modulation (PWM) technique. Pulse width modulation: Switches the inverter semiconductors in varying widths and times that, when averaged, create a sine waveform.

Keywords: *Variable Frequency drive, Induction Motor, Torque, Speed control, Adjustable Frequency, Pulse width modulation*

1 Introduction

Variable frequency drive consists of two stages.
The first stage includes the ac to dc conversion. The second stage consists of the inverter stage. The speed of induction motor is controlled by V and F method. Between the two stages is the dc bus or dc link which produces rectified dc with fewer harmonic.
A 0.5hp, 220v 3-phase motor serves as a load to the inverter. The inverter stage is controlled by microcontroller 18f4520.The inverter stage consists of IGBTS. The first stage i.e. rectifier stage consists of diode bridge. The switches used in power supplies are N type enhancement MOSFETS
Different methods for controlling the speed of motor
The relationship relating synchronous speed or rotor speed with slip of the induction motor is given by:

$$S = \frac{N_S - N_R}{N_S}$$

OR, $$N_R = N_S(1 - S)$$

Rotor speed $$N_R = \frac{120f}{P}(1 - S)$$

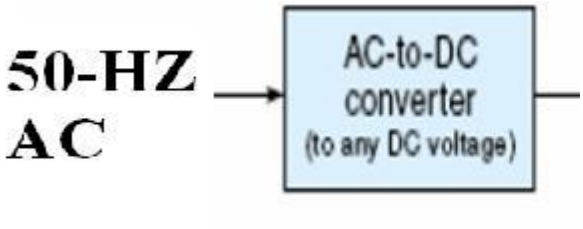
So, speed of the induction motor is controlled by varying any of the three parameters: supply frequency 'f', Slip 's' or by changing the poles. But the most advantageous method is the V/F method for varying the speed of induction motor.

2. Methodology:

V and f method used for controlling and analyzing the induction motor:

In this method firstly the voltage is varied by keeping the frequency constant and then frequency is varied keeping the voltage constant.The torque applied to the induction motor is directly proportional to the magnetic field produced by the stator of induction motor.Hence, the applied voltage at stator is direclty linked with the product of angular velocity and flux of stator.The flux produced by the stator is directly proportional to the ratio of applied voltage and supply frequency.Therefore, varying the voltage and frequency the torque of the induction motor is kept constant throughout the speed range. In the figure below the first stage i.e. Rectifier stage is operated by the supply coming from WAPDA.The second stage consits of the Inverter stage .The inverter is also called as VFD(VARIABLE

FREQUENCY DRIVE) used to control the induction motor.



In the graph below by varying the frequency given to operate the induction motor the torque produced by the induction motor is kept constant.

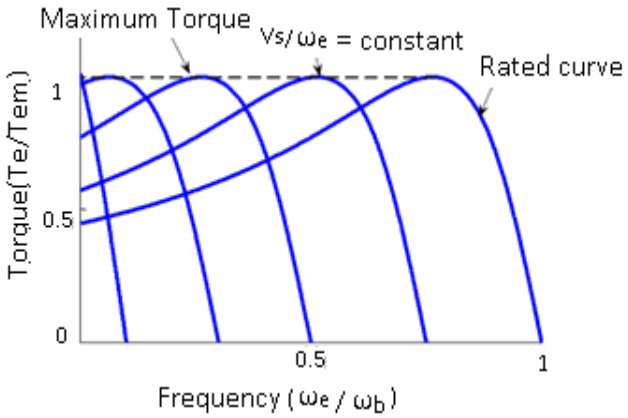


Figure 1 Torque of Induction Motor

3. OBJECTIVES TO USE THE V and F METHOD:

Starting current of the motor will get low. Which will prevent the motor or the driven load to be protected from "instant shocks" and it can be smoothly operated that in turn reduces the wearing out of gears, bearings and belts etc. As a result, the cost of the operation of motor will be minimized.

- As the torque produced by the induction motor is constant over the wide range of variable frequency the **stable operating region of the motor is increased** i.e. instead of running the motor at its base speed or the rated speed the motor now can be operated at 5% of the synchronous speed up to its base speed.

- The **efficiency of the induction motor** is enhanced as motor now can be operated at the wide range of speed and the speed of induction motor can be set according the load requirement by the user.

- . The supply frequency to the motor will be varied from 20-45 hz.

MAIN –BLOCK DIAGRAM:

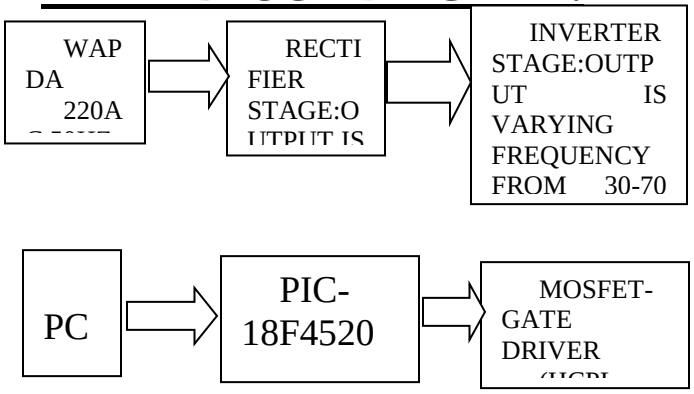


Figure 2. PIC generates the PWM signals required to drive the MOSFET GATE DRIVER.

They are used for high power side and low side applications. This is usually suited to drive power MOSFETS switches. The maximum supply current needed by this Gate driver

2mA that can be provided by the PIC-18F4520 as the current obtained is 25mA per pin by the microcontroller. In full-bridge circuits we have 2 high-side MOSFETs and 2 low-side MOSFETs. In such situations, there is a need to use high-side drive circuitry alongside low-side drive circuitry. The most common way of driving MOSFETs in such cases is to use high-low side MOSFET drivers.

Features

- Floating channel designed for bootstrap operation
  Fully operational to +500V or +600V
  Tolerant to negative transient voltage
  dV/dt immune
- Gate drive supply range from 10 to 20V
- Undervoltage lockout for both channels
- 3.3V logic compatible
  Separate logic supply range from 3.3V to 20V
  Logic and power ground ±5V offset

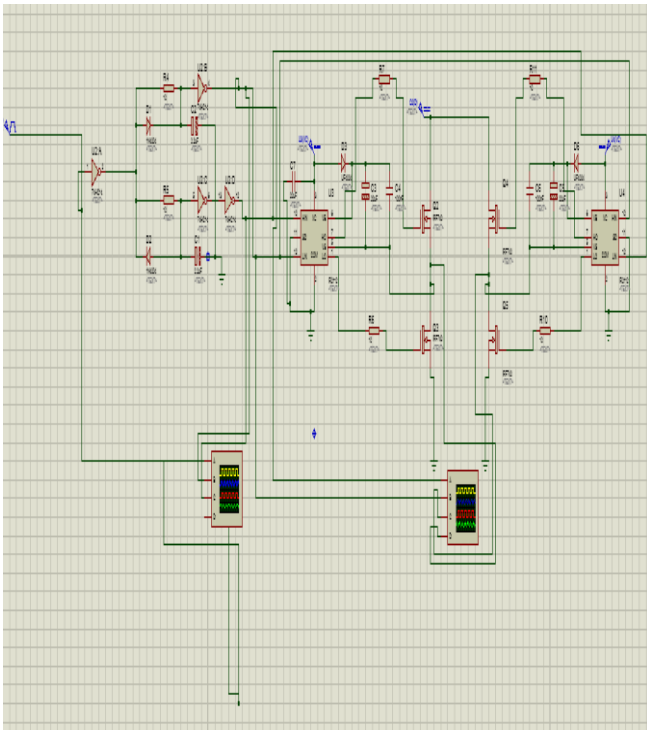


Figure 3 Proteous Simulation for Inverter Stage

ALTIUM CIRCUIT

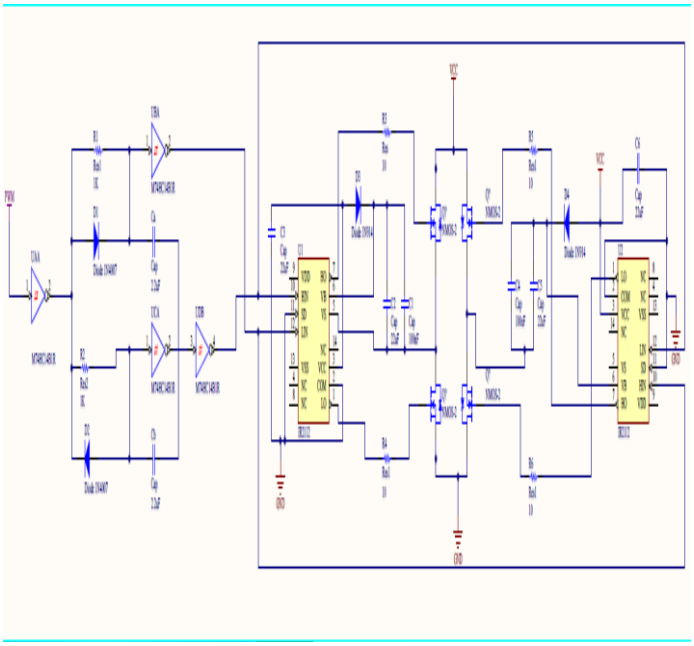


Figure 4 Altium Circuit for Induction Motor

Selection of components for IR2110: (bootstrap circuitry) 1. Capacitor value: Higher the required-on time, higher will be the capacitance. The electrolytic capacitor is used. for frequencies 1kHZ-20KHZ capacitor ranges from 2.2uF-22uF.for this capacitor a ceramic capacitor is installed in parallel with electrolytic capacitor.

2.Resistors and diodes:

Resistors connected to the MOSFETS are gate current limiting resistors. The diodes (1N4007) connected to it discharge the gate capacitance of MOSFETS.

3.diodes(1N4007):

Results

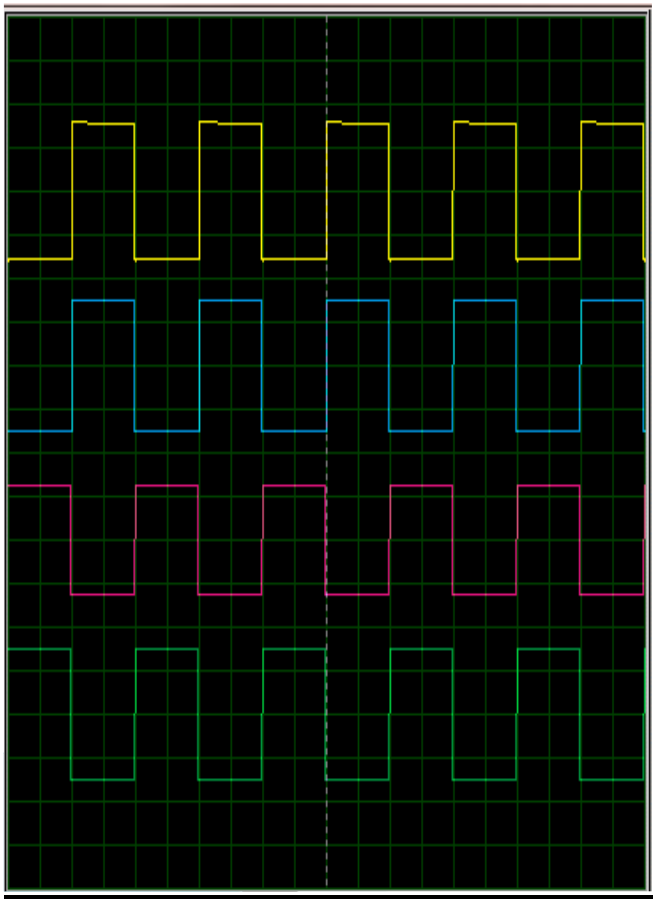


Figure 5 Synchronous output wave forms

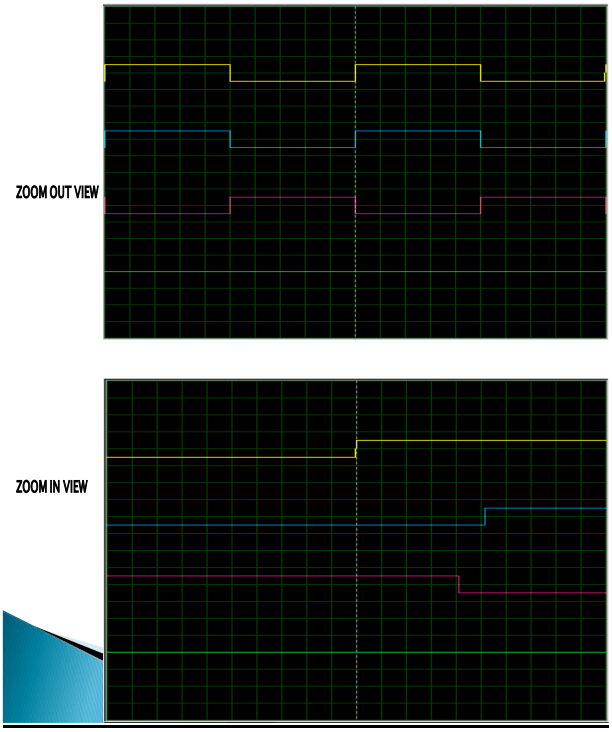


Figure 6 Delay Signals

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Efficient Power Generation using Vertical Wind Generation

Abdul Wasy[1,*]; Irfan Zafara[2];and Akram Rashid[a]

[1,2,3]Department of Electrical and Computer Engineering, Air University Islamabad, Pakistan

[*] Akram Rashid
E-mail: akram@mail.au.edu.pk
Tel: +923455898204

Abstract
Natural resources for electricity generation are reducing with every passing day and this issue has become a global. Cost effective and efficient wind turbines are being installed in the developed countries to meet the growing energy demands. Moreover, a very large part of the rural areas does not have the power supply because they are either too isolated or too expensive to connect to the national grid. The aim of our project is to make a vertical axis wind turbine. To fulfill the Energy deficiency, we have designed and installed affordable and sustainable wind turbine which can fulfill our energy requirements during peak times by connecting the critical loads only in peak hours and non critical loads in off-peak hours.

Keywords: Natural resources, Energy, Generation, cost effective, Demands, National grid Vertical axis wind turbine

1 Introduction

A wind turbine is a device that converts kinetic energy from the wind into the electrical energy. Now-a-days, many types of wind turbine are being manufactured world-over. The smallest turbines are used for such applications such as battery charging for auxiliary power, for boats or caravans, or to power traffic warning signs. Medium sized turbines are generally used for making small contributions in homes, small office buildings etc. Large wind turbines, commonly known as wind farms, are becoming progressively important as a renewable source of energy in many countries.

This literature presents a review of the historical development focusing on wind turbines and its types. Their advantages and disadvantages are discussed and evaluated. Introduction to Vertical Axis Wind Turbine (VAWT) and various parameters considered in VAWTs design are discussed with particular reference to self-starting capability, which is an important consideration for all stand-alone power generating turbines. Literature on research, development issues, and the applications of VAWTs are also mentioned. Furthermore, Braking System for VAWTs, along with its advantages and disadvantages, has also been explained. Different ways of applying brakes on a VAWT are also discussed.

2. History

Wind turbines have proved to be an eminent source of power for hundreds of years. Persians initiated the concept of using wind energy for the generation of power about a thousand years ago. The machine Persians developed had vertical axis and it worked by drag force that pushed the blades of turbine to produce useful work. Obstacles and drawbacks of the machine weren't a big impediment to quench the effectiveness of this newly developed concept.

Europeans, despite their lack of advancement in technology as compared to Muslims, were keen to take up this concept. In the 11th century A.D. Europeans developed horizontal axis machines that used wind energy for pumping of water, grinding mill, sawing wood, and powering tools. In the beginning of the 14th century, Dutch successfully developed comparatively better and more efficient wind machines for the draining the marches and lakes of the Rhine River delta.

Further development and precisions of the systems were performed in the USA during the 19th century, i.e. between the period of 1850 and 1970; over 6 million small machines were used for water pumping. In Cleveland, Ohio, in 1888, the first large wind machine to generate electricity was installed; it was a low speed and high solidity wind turbine with an output power of 12kW.

During the final stages of World War, I, use of 25kW machines throughout Denmark was common. Advance progress of wind generators in the USA was motivated by the design of airplane propellers and monoplane wings, while subsequent efforts in Denmark, France, Germany, and the UK between the periods of 1935 and 1970 showed that large scale Wind Turbines could work. Europeans developments to harness wind energy continued after World War II. Until the early 1960s in Denmark, the Gedser mill, 200kW, three-bladed upwind rotors made its entrance on map. This wind turbine operated successfully. One of the most important milestones of the wind energy history coincides with the USA government involvement in the wind energy research and development (R&D) after the oil crisis of 1973.

Between 1973 and 1986, the commercial wind turbine market evolved from domestic and agricultural to wind farm applications. Between 1981 and 1990, over 16000 wind machines with powers ranging from 20 to 350kW were installed in California because of incentives given by the USA government. In the northern Europe, wind farm installations increased steadily through the 80s and 90s, with the higher cost of electricity and the excellent wind resources leading to the creation of a small but stable market.

Generation of Wind Energy across the Globe

Wind energy is one of the fastest growing energy sources. It has a huge potential to produce electricity with a low cost of initial investment as compared to the other renewable energy sources now-a-days, scientists and engineers are looking for clean and renewable form of energy which helps in reducing the dependence on fossils fuels that result in carbon dioxide emission. Different sources of renewable energy include solar, biomass, geothermal, and wind energy. Among these renewable energy sources, wind energy finds itself a cheaper and viable option among other sources, hence enhancing the interest in the research efforts to improve the electricity generation using wind energy. Inevitably one tends to think of power generated by the wind as free. Wind is undoubtedly an alternative energy source. Alternative energy is the energy which is produced without the undesirable consequences of the burning fossil fuels, such as high carbon dioxide emissions, the major contribution factor of global warming according to the Intergovernmental Panel on Climate Change.

When we talk about energy generated from wind, the USA occupies the top slot, followed by Germany and Spain. Europe ranks high in this regard, although China and India are also major producers. Much of the world, however, generates little, if any, electricity from the wind.

3. Types of Wind Turbines

The Horizontal Axis Wind Turbines (HAWTs)

Horizontal axis wind turbines (HAWTs), as suggested by the name, are the wind turbines that can rotate about horizontal axis. It is the oldest and the most common design of wind turbines. HAWTs have the main rotor shaft and an electrical generator. Both rotor shaft and generator are mounted on the top of a tower. It may be directed into or out of the wind; small HAWTs are pointed into the air by a wind-vane, whereas a servo motor combines with a wind sensor is used in large wind turbines to point it into the wind. Almost all the HAWTs have a gearbox that turns the slow rotation of the blades into a faster rotation, which is adequate to drive an electrical generator to produce electricity.

These wind turbines have maximum theoretical power coefficient (Cp) of approximately 0.45. Nevertheless, these wind turbines can merely achieve an average power coefficient of around 0.3. The key advantage of this machine that makes it common and widely used is its high-power coefficient compared to the other types of turbines. However, every good aspect comes at a cost. High starting wind velocity and dependence on the direction of wind are the two main disadvantages of HAWTs.

Vertical Axis Wind Turbines (VAWTs)

Vertical axis wind turbines (VAWTs) are the wind turbines that rotate perpendicular to the direction of wind. In these turbines, the rotor shaft is arranged vertically and that is why these turbines do not need to be pointed into the wind. Thus, VAWTs prove to be perfect for the sites where wind directions are highly varying. Generators and gearbox can be installed near the ground, which makes it easy for accessibility and maintenance. VAWTs have some advantages over the HAWTs i.e. its simple construction, its ability to be independent of wind direction, and high starting torque (Savonius rotor).

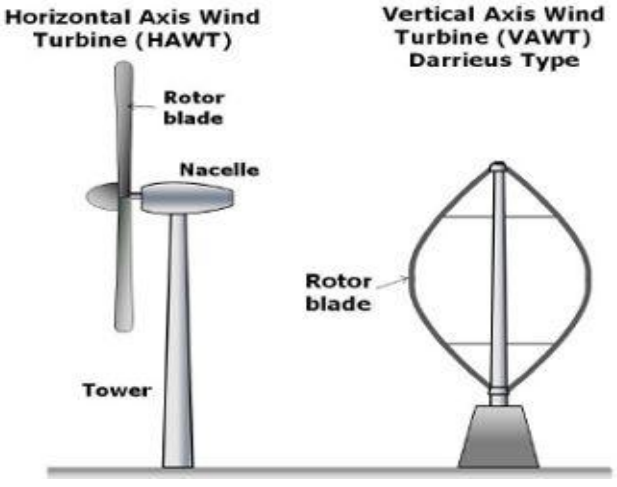

Figure 1. Vertical Axis Wind Turbine

Types of VAWTs

VAWTs can be divided into three main types: -

- Savonius Rotor or S-Rotor
- Darrieus Rotor or D-Rotor
- Combined Rotor between S & D Rotor

Savonius Rotor

These vertical axis wind turbines convert the force of the wind into torque on a rotating shaft. The Savonius Rotor is the simplest form of vertical axis wind turbines. For small scale use, it is economical, and it has high starting torque. However, it has a low power coefficient (Cp) of about 0.25.

Savonius Turbine

The Savonius turbine was invented by a Finnish engineer Sigurd Johannes Savonius in 1922. A simple Savonius Turbine has an S-rotor that consists of two half cylinders placed such that one convex and one concave faces are subjected to the wind. The difference in drag on two sides produces a torque. Therefore, at least two rotors at different angles are needed to guarantee self-starting. Although these vertical axis wind turbines are simple to construct, they are very large and heavy compared to other wind turbines of same power output.

Darrieus Rotor

The Darrieus Rotor is named a French engineer Georges Darrieus who patented the design in 1931. This wind turbine was developed by a US company, Flowed. Darrieus rotor uses aerodynamic lift surface to produce useful torque. The Darrieus machine is characterized by its C-shaped rotor blades that makes it look a bit like an egg beater. It is usually build with two or three blades. This wind machine has been studied and investigated for preliminary designs by Wilson and Lissaman and others. This type of machine can produce the maximum power coefficient about 0.35, which is higher than that obtained from the S-rotor. But whether the blades of this wind machine are curved or straight, typically it develops little or no torque at low speed. It means that it has very low starting torque, making it unsuitable for stand-alone operation.

Combined Rotor

It is merely a modification in Darrieus Rotors to optimize and overcome the problems of low starting torque on Darrieus turbines. Although the S-rotor has a lower power coefficient than the D-rotor, its useful capability is its high starting torque and self-starting at low tip speed ratio. It is equally possible to start the D-rotor with the aid of an S-rotor. It works by producing a large starting torque from the S-rotor, but a higher tip speed ratio operated by D-rotor.

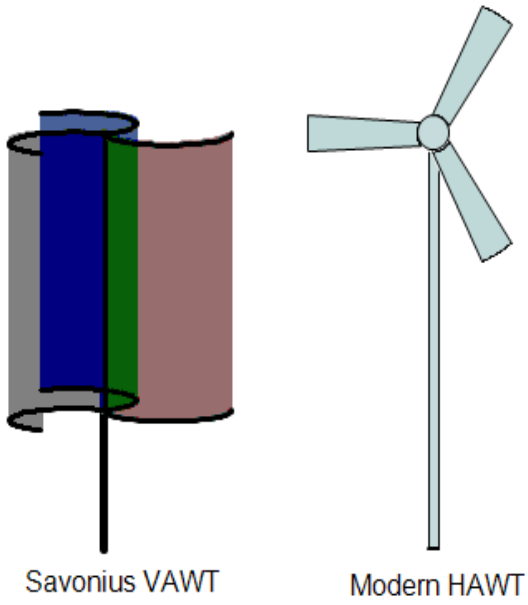

Figure 2. Model prepared as a wind turbine

Specifications of the wind turbine

BLADE DIMENSIONS	SHAFT DIMENSIONS	PULLEY DIMENSIONS
Height - 1000mm	Diameter – 20mm	Turbine pulley – 300mm
Diameter - 1200mm	Length – 1300mm	Generator pulley – 25mm
Thickness - 0.8 mm		Center Distance of Pulley - 300mm
Angle - 45 ° Angle b/w blades - 60°		

Design of Assembly

The components of the full-scale VAWT are Base, Blades, Shaft, Bearings, Pulley and Belt, alternator and battery.

Design of Base

In this project there is a pole base which is made up of mild steel can be with stand, in large force of wind. The base & its height are related to cost and transmission system incorporated. So, the height of our base is 1600mm. & width at bottom is 1400mm & at top is 1400mm.

Design of Blade

Design of blade Wind turbine blades have on aero foil – type cross section and a variable pitch. While designing the size of blade it is must to know the weight and cost of blades in the project three blades with vertical shaft are used, it has a height & width of 1000mm & 370mm

respectively. The angle between two blades is 600. So, if one Blade moves other blades come in the position of first blade, so the speed is increases.

Shaft Designing

Shaft designing the shaft of blades it should be properly fitted to the blade. The shaft should be as possible as less in thickness & light in weight for the blade, the shaft used is very thin in size are all properly fitted. So, no problem of slipping & fraction is created, it is made up is having very light weight. Length of shaft & diameter are 1300mm & 20mm respectively. And at the top and bottom ends mild steel.

Design of Bearing

Design of Bearing For the smooth operation of Shaft, bearing mechanism is used. To have very less friction loss the two ends of shaft are pivoted into the same dimension bearing. The Bearing has diameter of 20mm. Bearing are generally provided for supporting the shaft and smooth operation of shaft. Greece is used for bearing maintenance

Designing of pulley

Designing of Pulley, the speed ratio between two pulleys is 1:12, i.e., in one revolution of larger pulley, the pulley of generator completes 12 revolutions, so the speed can increase considerably. Also, the pulley should have light in weight, so no consumption of power will take place in revolving. For the project, the dimension of larger pulley is 300mm. and for pulley required for generator is 25mm. So, in one revolution of larger pulley, the second pulley completes 12revolution. It is made up of mild steel. It should be properly attached to the shaft of blades. So, no friction will take place. The thickness of pulley is 15mm. For the driving purpose, belt is used, which is placed in these two pulleys.

Brushed DC generator

Brushed DC generators are commonly used for home-built wind turbines. They are backwards from a permanent magnet generator. Ona brushed motor, the electromagnets spin on the rotor with the power coming out of what is known as a commutator. This does cause a rectifying effecting outputting lumpy DC, but this is not an efficient way to "rectify" the power from the windings, it is used because it's the only way to get the power out of the rotor. A good brushed motor can reach a good efficiency but are typically at most 70%. The capacity of the generator is up to 4.6 V. There are many great advantages to using a brushed motor. One of the biggest reasons is because typically you can find one not requiring any gearing and still get a battery charging voltage in light wind.

Energy storage / battery

The output of generator is given to the battery for electric energy storage purpose. The capacity of the battery is up to 12 V. Generally, this battery is lead acid type battery and restorable. The supply of generator is given to the battery through a diode.

Working of vertical axis wind turbine

Vertical axis wind turbine (VAWT) has two or three blades, in which the main rotor shaft runs vertically. These blades are wrapped around the shaft and the generator is mounted at the base of the tower. The output power generated by wind generator is measured by using multi meter. The experimental power output is noted in table

Comparison between Theoretical and Experimental mechanical power

Wind Velocity (m/s)	mechanical power (W) (Theoretical)	mechanical power (W) (Experimental)
4.5m/s	65.8watt	48.8 watt
5.5m/s	120.18watt	102.3 watt
7.5m/s	304.76watt	260.68 watt
10m/s	722.40watt	610.74 watt

From the output, the output of actual and theoretical mechanical power varying the reason is power losses in turbine generator. Main reason for varying power output of wind turbine is natural wind speed, it varies continuously.

4. RESULTS AND DISCUSSION

The average natural wind speed to be 6 m/s. Density of air is 1.204 kg/m3.Turbine 1.2 m in diameter and 1.0m height, the power of the wind is given by,

$Pw = ½ \rho A u3$

Where

Pw - power of the wind (W)

ρ - Air density (kg/m3)

A - Area of a segment of the wind being considered

U - Undisturbed wind speed (m/s)

A= D lb

Where

A-Swept area

D-diameter of the turbine (m)

Lb- length of the turbine Blades (m)

A= (1.2) * (1.0) =1.2 m*m

Pw=1/2 * (1.204) * (1.2) * (6*6*6) = 156.03watt

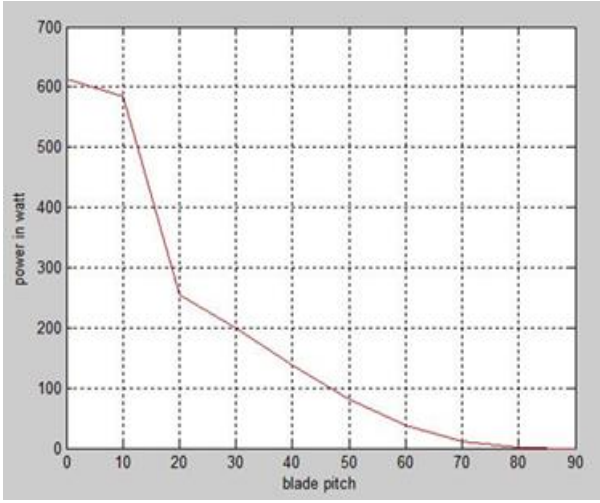

Figure 3. Relation between blade pitch and Power

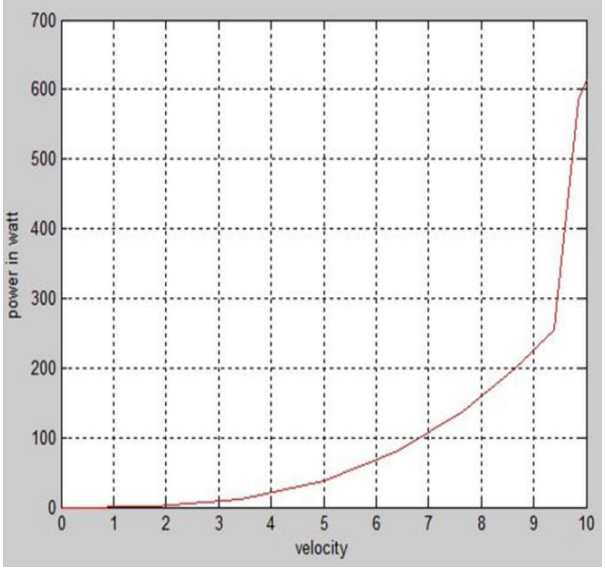

Figure 4. Relation between Blade velocity and power

5. Conclusion

Local authorities in Pakistan, as well as the foreign authorities, will face, lots of problem soon due to lack of non-renewable energy sources. So, they are moving for the renewable energy sources like wind, solar energy, tides, rain, sea waves, geothermal heat…etc. If we can improve the performance of the Vertical Axis Wind Turbines (VAWTs), it's huge advantage for the authorities. They can implement the VAWTs every possible place and generate the electricity while contributing to the reduction of CO2 production and economic growth. Thus, by the researches related to the VAWTs, it is accepted to substantial step forward in this field in the foreseeable future. By introducing there search out comes to the country, it would gain for the national development.

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Simulation of Thermal Performance of Cool Roof options through Building Engineering System Software

Aftab Ahmed[a,*]; Rizwan Ahmed Memon[a]; Khanji Harijan[a]; and Muhammad Ayub Khetran[a]

[a]*Mehran University of Engineering and Technology, Jamshoro, Pakistan*

[*] Corresponding Author
E-mail: aasahito75@gmail.com
Tel: +923053036050

Abstract

This paper investigates the potential of cool roofs in reducing the building energy loads and focuses on how the different cool roof assembly affects the thermal performance of a building in Hyderabad, Sindh, Pakistan. A building envelope is modeled in Energy Plus software and different cool roofs are employed to the building such as Conventional roof, Marble, EPS, SPF, PVC, XPS, Thermocol sheet, Asphalt tile, Gypsum tile, White paint and Jumbolon-board foam were used to find zone air temperature and roof surface inside and outside temperature of the building. Results include daily and monthly reports of zone air temperatures for all types of cool roof materials. The results, obtained for the maximum to average zone air temperature in month of May, shows that Conventional roof reduces temperature from 33.8ºC to 32.1ºC. Thermocol sheet and SPF reduces zone air temperature from 29.7ºC to 28.8ºC. Whereas XPS, Jumbolon-board foam and EPS reduces zone air temperature from 29.6ºC to 28.8ºC, 29.8ºC to 28ºC and 30ºC to 29.1ºC respectively. Whereas Marble, white Paint, Gypsum tile, asphalt tile and PVC found to be less efficient and reduces 33.3ºC to 31.8ºC, 31ºC to 30ºC, 31.8ºC to 30.7ºC, 31.7ºC to 30.6ºC & 31.5ºC to 30.4ºC respectively. From this report the Conventional roof's surface outside and inside temperature difference is 2.9ºC. Thermocol sheet, XPS and Jumbolon-board foam found to be more efficient and reduces inside temperature by 9.2ºC, 9.3ºC and 8.7ºC respectively. In this regard EPS is somewhat better than others by reducing outside and inside temperature by 8ºC. SPF is next to reduces temperature by 7.5ºC. It is concluded that thermocol sheets, XPS and Jumbolon-board foam are optimum cool roof options in order to save energy and costs in future in Hyderabad, Sindh, Pakistan.

Keywords: *Energy Modeling; Cool roof; Simulation; Thermal performance; Parametric comparative study; Hyderabad; Pakistan.*

1. Introduction

Energy crises are the great bottleneck in the economic growth of Pakistan. Energy crises refer to the shortage of energy or other natural resources. These days our country is suffering from different crises of energy and these can be overcome by using non-conventional or alternative energy sources for production and utilization of energy where possible (Energy crisis, 2017). Non-conventional energy sources, including solar, wind, biomass etc. Our major focus is on the solar radiation energy. Solar energy has the greatest impact on buildings indoor environment rather than other energy sources such as electrical appliances etc. A building component that requires more concentration is the roof, especially in residential and non-residential constructions. The non residential buildings having large roof surfaces e.g. flat roofs in contrast to their external wall surfaces. Also keep in eye that roof surfaces are always uncovered to solar radiations between sunrise and sunset. Therefore, the roof is only part that is responsible for internal thermal and cooling load. Filho. J and Santos. T, 2014 [1]. Radiations that are coming directly from sun either reflected back to atmosphere or absorbed to the building's envelope. Roofs are the most predicted and notable area for thermal radiations. The use of special types of building materials has increased significantly in both hot and cold climates. Roofing systems with potential energy savings can help reduce the energy requirements for operating buildings, thereby reducing operating costs. In order to enhance the roof's contribution to energy consumption reduction, different reflective materials are used to decrease the temperature of the desired buildings. This research focuses on thermal performances, energy saving and cost benefits of cool roof systems. The radiative thermal properties of the roof of buildings have a great effect on energy consumption. The heat gain through a roof can be a significant component of the total cooling load from the envelope of a building, especially single-story building. Instead of depending entirely on mechanical means which are electricity dependent and generated mainly from fossil fuels, architects should invest time in researching passive strategies to reach the best combination of low energy and natural climatic control for their buildings. Then mechanical and active systems can become

supplementary aids. Thermal comfort in the summer is always a main concern in hot climate regions like Hyderabad. Natural ventilation and passive cooling have traditionally been two important features in Hyderabad region to achieve thermal indoor comfort. It has been estimated that, in hot climate regions, from 70%to 80% of total energy consumption is used to operate mechanical cooling systems like fans, A/C etc. Most effective options building energy efficiency through passive techniques has become an extremely significant problem for designers, given the maximum energy demand required and the capacity for energy saving. In this opinion, cool roofs shows an interesting passive cooling techniques focusing on reducing building energy needed for cooling (Santanmouris. M et. al., 2013) [2]. In general, the higher the reflectance and the emissivity of a roof coating, the cooler it stays. The emissivity, or thermal emittance, is the ratio of the radiant heat flux emitted by a sample to that emitted by a blackbody radiator at the same temperature. The solar radiation that is not reflected is absorbed, and this absorbed solar energy, now expressed by the roof surface temperature increase, is partially reemitted in the infrared spectrum. The infrared emittance of the surface gives the fraction of the maximum possible infrared radiation that the surface reemits. To maximize cooling energy savings, roof coatings should have high solar reflectance and high infrared emissivity, and maintain these properties for the service life of the coating.

1.1. Energy used in building sector in Pakistan:

The building sector in Pakistan is major consumer of energy resources, with its lighting, heating, cooling and air-conditioning (especially in extreme climatic zones of the country).

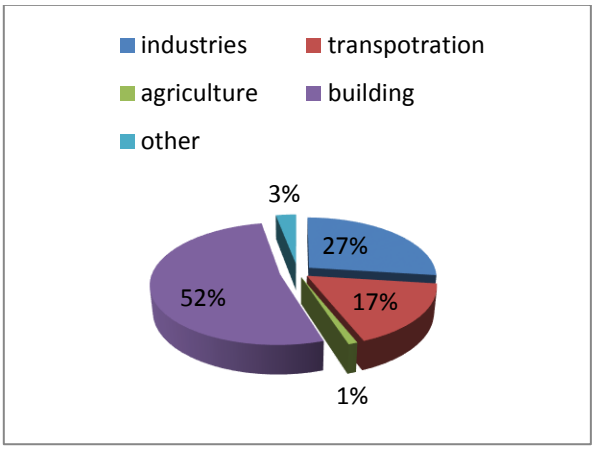

Figure 1.1: Existing energy use in Pakistan

2. Material and methods

2.1. Site selection:

A single zone building has been taken into account for thermal performances of cool roofs. The site location of a building taken in this research work is situated in Hyderabad, Pakistan.

Figure 2.1: Site location of Hyderabad

The following is weather data of Hyderabad:

Longitude= 68.42° Time zone = +05:00 hr
Latitude =25.38° Elevation = 30m

2.2. Data Collection :

In this research the survey is conducted in Hyderabad, Pakistan. A questionnaire design of cool roof materials has been made before survey of location. Survey included the weather and technical data. Weather data includes latitude, longitude, elevation, and time where as technical data include thermal properties of cool roof materials, such as roughness, thickness, thermal conductivity, density, specific heat capacity, solar absorption and thermal absorption etc.

3. Modeling of building:

The building is single zone and is modeled in Energy Plus software. It is naturally ventilated/ non-air conditioned room whose surfaces are made up of different materials like bricks, concrete, wood, glass etc. In fenestration, the door is in the south wall, and is made up of wood. Double pane windows are constructed in the east and west wall and has a surface area of $4m^2$.

The parameters of a single zone building are:

Length = 8m, Width = 6m,
Height = 3m, Floor area = 48 m^2

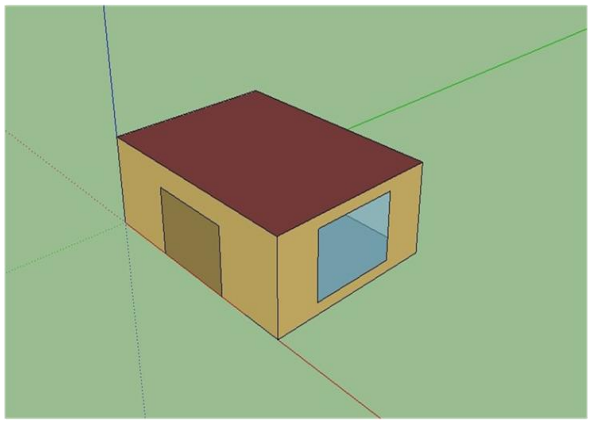

Figure 3: A single zone building

3.1. Cool Roof Materials:

In this research different cool roof materials have been employed to non-air conditioned building to evaluate various parameters / variables of thermal performance. The materials to be used are:

1. Conventional roof
2. Marble Roof
3. Expanded Polyurethane Spray (EPS)
4. Spray Polyurethane Foam (SPF)
5. Poly Vinyl Chloride
6. Extruded Polyurethane Spray (XPS)
7. Thermocol Sheet
8. Asphalt/Asbestos Tile
9. Gypsum Tile
10. White Paint (three Coat)
11. Diamond Jumbolon Foam

3.2. Main out Parameters for a building:

Simulation has been done in a building, operating in non air condition. So that thermal performances of each cool roof option can be evaluated.
The main output parameters are:

1. Zone air temperature (°C)
2. Roof: surface inside and outside temperature difference (°C)

4. Results and Discussions:

Prominence given to this research paper is the thermal performance of different cool roof options. In order to achieve these results, Energy Plus software has been used. This software needs weather and input data file of building location and envelope respectively. Thus, weather data file of Hyderabad and building having latitude and longitude of Hyderabad is employed to simulate in single zone. First conventional roof and then each cool roof material is simulated one at a time to get requisite results.

4.1. **Zone air temperatures:**

4.1.1. Comparative results of various cool roof materials:

A comparison of results of all cool roof options with conventional and with each other have been made on basis of thermal performance. The comparative results of zone air temperature are given below:

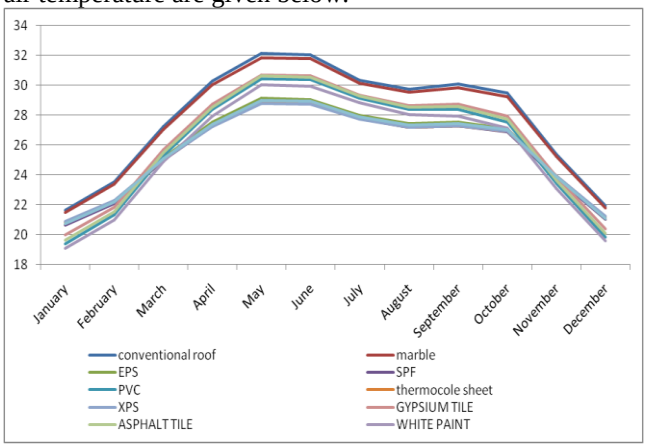

Figure 4.1.1: Comparative result of zone air temperature

Also a complete comparative result of zone air temperature various cool roof options has also been generated annually with help of Energy plus Software, which is also shown in table 4.1.1.

4.1.2. Comparative results to be simulated in month of May 2017:

From results it is clear that May is the hottest month. Therefore maximum zone air temperature obtained is in the month of May is high as compare to other months. So comparative results of zone air temperature in month of May for conventional and other cool roofs have also been generated.

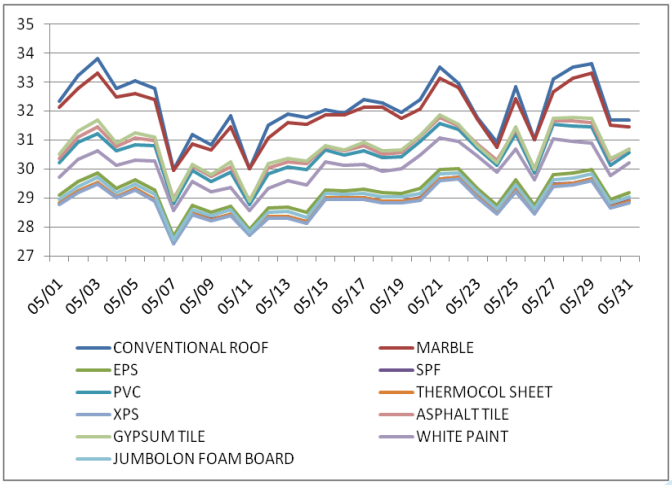

Figure 4.1.2: Comparative Zone air temperature in month of May 2017

4.1.3. Discussion:

Figure 4.1.1, 4.1.2 and table 4.1.1 represents zone air temperatures, daily and monthly basis, when Conventional, marble, EPS, SPF, PVC, XPS, thermocol sheet, white paint, gypsum tile, asphalt tile and jumbolon-board foam roofs are simulated. According to results the maximum zone air temperatures achieved in month of May, when monthly report is generated. From results maximum to average zone air temperature occurs when conventional roof is considered, that is from 33.8ºC to 32.1ºC. Among other cool roofs, thermocol sheets and SPF found to be more effective by reducing zone air temperature from 29.7ºC to 28.8ºC. Whereas other cool roofs such as XPS, Jumbolon-board foam and EPS reduces zone air temperature from 29.6ºC to 28.8ºC, 29.8ºC to 28ºC and 30ºC to 29.1ºC respectively. Whereas Marble, Paint, Gypsum tile and Asphalt tile and PVC found to be less efficient.

Table 4.1.1: Yearly simulation result of zone air temperature

Date	Conventional roof	Marble	EPS	SPF	PVC	Thermocol sheet	XPS	Gypsum tile	White paint	Jumbolon foam
Jan	21.6	21.5	20.7	20.6	19.4	20.8	20.9	20	19.1	20.7
Feb	23.5	23.4	22.2	22.1	21.3	22.2	22.3	21.8	21	22.2
Mar	27.3	27	25.1	25	25.3	25	25	25.7	24.9	25.1
Apr	30.3	30	27.5	27.3	28.4	27.3	27.3	28.7	27.9	27.4
May	32.1	31.9	29.1	28.9	30.5	28.8	28.8	30.7	30	29
June	32.1	31.8	29.1	28.8	30.4	28.8	28.7	30.7	30	28.9
July	30.4	30.2	28	27.8	29.1	27.8	27.7	29.3	28.8	27.9
Aug	29.7	29.5	27.4	27.2	28.4	27.2	27.2	28.6	28.1	27.3
Sept	30.1	29.8	27.5	27.3	28.4	27.3	27.3	28.7	28	27.4
Oct	29.5	29.2	27.1	26.9	27.5	27	26.9	27.9	27.2	27
Nov	25.4	25.2	23.9	23.8	23.4	23.9	23.9	23.9	23.1	23.9
Dec	21.9	21.8	21	21	19.9	21.2	21.2	20.4	19.6	21.1

A comparative simulation result of roof surface outside temperature difference has also been generated in figure 4.2.1 (a) as shown below:

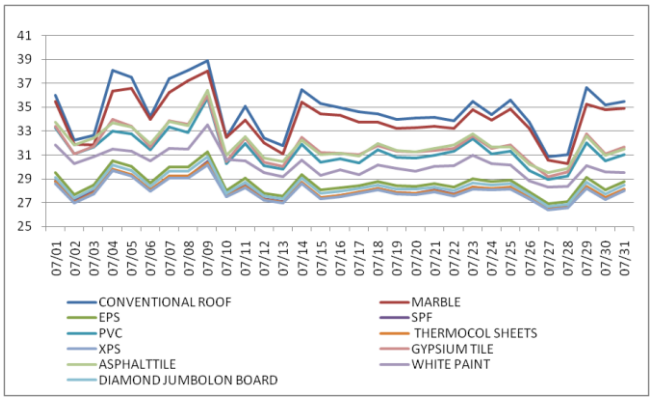

Figure 4.2.1(a): Roof: surface inside temperature difference

4.2. Roof: surface inside and outside temperature difference:

4.2.1. Comparative results of roof's surface inside temperature:

Comparisons of results of all cool roofs have been generated in month of July, 2017. Comparison of cool roof materials with conventional and with each other have been made on basis of thermal performance. The comparative results of roof's surface inside and outside temperature difference are given below:

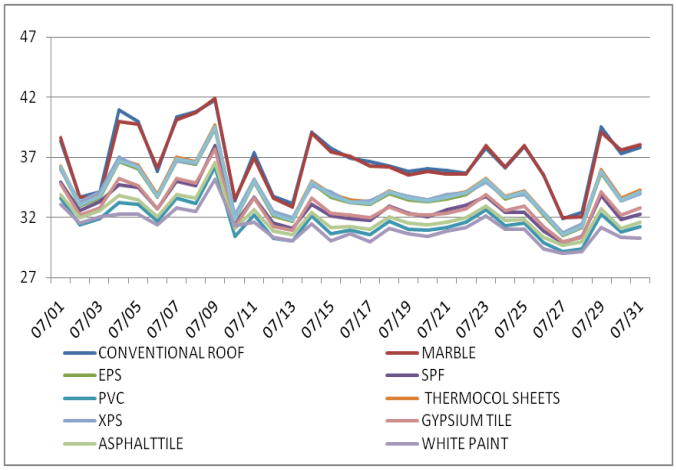

Figure 4.2.1(b): Roof: surface outside temperature difference

The following table shows the result of surface roof inside and outside temperature difference of various cool roof materials.

4.2.2. Discussion:

The figures 4.2.1 (a), (b) & table 4.2 show the surface inside and outside temperature differences of variable cool roofs. This report has been generated in the month of July 2017.From this report the Conventional roof's surface inside and outside temperature difference is 2.9ºC. XPS, Thermocol sheet, Jumbolon-board foam and EPS found to be more efficient and reduces inside temperature by 9.3ºC, 9.2ºC and 8.7ºC and 8.1ºC respectively. In this regard SPF is somewhat better than others by reducing inside temperature by 7.5ºC. Whereas the rest of cool roof materials such as marble, PVC, asphalt tile, gypsum tile and white paint reduce temperature by 3ºC, 0.4ºC, 0.3ºC, 2ºC and 1.7ºC respectively.

Table 4.2: Roof: surface inside and outside temperature difference.

S. No	Cool roof materials	Surface roof: outside temperature diff: (ºC)	Surface roof: inside temperature diff: (ºC)	Temperature Difference (ºC)
1.	Conv. roof	41.8	33.5	2.9
2.	Marble	41.8	33.1	3
3.	EPS	39.3	27.5	8.1
4.	SPF	37.9	26.9	7.5
5.	PVC	36.1	29.7	0.4
6.	XPS	39.4	26.8	9.3
7.	Thermocol sheet	39.6	27	9.2
8.	Asphalt tile	36.6	29.1	0.3
9.	Gypsum tile	37.6	30.1	2
10.	White paint	35.1	28.1	1.7
11.	Jumbolon foam	39.5	27.3	8.7

5. Conclusion

The research investigation is about thermal performance of different cool roof materials locally available in Hyderabad market and their comparison of thermal performance with other cool roof material internationally available. The major focus of this study is to focus on energy saving purpose. Cool roof material having good thermal performance would reduce active loading in order for saving energy. For this study a building envelope is modeled in Energy Plus software and different cool roofs are employed to the building such as Conventional roof, Marble, EPS, SPF, PVC, XPS, Thermocol sheet, Asphalt tile, Gypsum tile, White paint and Jumbolon-board foam were used to find their thermal performances i.e. zone air temperature and roof surface inside and outside temperature of the building. The maximum to average zone air temperature obtained for Conventional roof in month of May is 33.8ºC to 32.1C . Whereas maximum to average zone air temperature obtained for both thermocol sheet and SPF is nearly same 29.7ºC to 28.8ºC. However the maximum zone air temperature obtained for XPS, Jumbolon-board foam and EPS are 29.6ºC to 28.8ºC, 29.8ºC to 28ºC and 30ºC to 29.1ºC respectively. Whereas Marble, white Paint, Gypsum tile, asphalt tile and PVC are less efficient to reduce much amount of temperature. Also from this simulation report the Conventional roof's surface outside and inside temperature difference is 2.9ºC. Thermocol sheet, XPS and Jumbolon-board foam found to be more efficient and reduces inside temperature by 9.2ºC, 9.3ºC and 8.7ºC respectively. It is concluded that Thermocol sheets, XPS and Jumbolon-board foam are optimum cool roof options in order to save energy and costs in future in Hyderabad, Sindh, Pakistan.

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Synthesis and application of Cu based MOF as a CO_2 adsorbent

Junaid Khan[a,*]; and Naseem Iqbal[a]

[a] U.S.-Pakistan Center for Advanced Studies in Energy, National University of Sciences & Technology Islamabad, Pakistan

[*] Corresponding Author
E-mail: 15esejunaid@uspcase.nust.edu.pk
Tel: +923159850839

Abstract
In this paper, the main focus is on the CO_2 adsorption capacity of Copper based Metal-Organic Framework. To investigate the application of Copper based MOF in CO_2 adsorption, the motivating factor was its reversible solvent-exchange property. Copper based MOF was synthesized using solvothermal treatment of terephthalic acid with copper nitrate in DMF. The MOF was characterized by Powder X-ray Diffraction (XRD), Thermal Gravimetric Analysis (TGA) and Scanning Electron Microscopy (SEM). CO_2 adsorption capacity of the MOF was measured by a cyclic adsorption-desorption method with adsorption at 25°C and desorption at 200°C in TGA. The maximum CO_2 adsorption capacity attained was 0.55 $mmolg^{-1}$. This adsorption capacity can further be improved by changing synthesis method and amine modification of prepared MOF. Further adsorption studies will be conducted with sorption analyzer.

Keywords: *metal organic framework; Cu based MOF; CO_2 adsorbent; MOF application; material engineering*

1 Introduction

Today our civilization is facing major environmental concerns among which carbon dioxide (CO_2) emissions is one of the most serious one[1]. Combustion of oil, coal, and natural gas are the main producers of these emissions as they are the driving energy resources of our daily life, industrial development and economic growth[2]. The contribution of CO_2 is approximately 60% to the total global warming effect[3]. During the period between 1970 and 2004, the annual global emissions of CO_2 escalated by about 80%. This ever increasing concentration of CO_2 in the atmosphere has led to urgent calls for strategies to alleviate this problem.

Environmentalists and climate specialists today recognize the need for technologies that remove CO_2 from the atmosphere to mitigate changes to the global climate caused by over a century of expanding anthropogenic CO_2 emissions. The concept of carbon dioxide using sorbents was first introduced in 1999, and in the ensuing decade and a half, a wide array of approaches employing different sorption materials have been described. Currently, the large-scale separation of CO_2 by the liquid phase amine-based absorption process is in commercial operation throughout the world. This "wet-scrubbing" CO_2 capture utilizes alkanolamines, such as MEA (monoethanolamine), as the solvent, which has been used industrially over the past 50 years [4][5]. Liquid and solid sorbents based on alkali and alkaline earth metal oxides and hydroxides, sorbents based on supported amines, and tailored MOFs have been studied.

Metal–organic framework (MOF) is a new class of materials where polyfunctional, organic ligands are bonded with more than one metal atom to form an extended polymeric structure in either one-, two-, or three dimensions. These MOFs are often highly porous, crystalline, and impervious to structural collapse once evacuated[6]. By varying the ligand character, spacer length, functionality, metal atom, and synthesis conditions, it is possible to form of an extensive number of porous compounds each with different properties and applications[7]. This particular and tunable nature of MOFs has increased the investigation of these materials for a wide assortment of potential applications including, however not constrained to, conductivity[8], gas storage and release[9], ion-exchange[10], catalysis[11], sensing[12], energy conversion and light harvesting[13], drug delivery[14] and toxic substances removal from water and air[15].

Porous metal-organic frameworks (MOFs), which are emerging rapidly, are promising as the efficient and cost-effective materials for CO_2 capture and separation[16][17]. The lower regeneration energy cost of these porous MOFs for CO_2 capture by the implementing pressure swing

adsorption (PSA), temperature swing adsorption, and vacuum swing adsorption makes them a better option as compared to the alkanolamine technology mentioned above.

Here, we report the synthesis of a copper based MOF, the organic ligand of which is terephthalic acid, and its application for CO_2 capture. The first metal terephthalate complex, nickel terephthalate, was synthesized back in 1967 by Acheson and Galwey using terephthalic acid and metal salt[18]. After that Sherif synthesized other hydrated metal terephthalates (Fe, Ag, Co, Cr, Cu, La, Mn)[19]. The Cu(tpa) MOF, however like MOF-2, displays a particularly higher surface area, this makes it a good choice for sieving applications, gas adsorption and gas seperation.

2 Experimental

2.1 Synthesis of MOF

In order to synthesize the Cu based MOF, equimolar quantities of terephthalic acid (Aldrich, 0.724 g) and copper nitrate trihydrate (Aldrich, 1.053 g) were dissolved in 87 ml of DMF. The prepared solution was placed in a closed bottle in an oven. The temperature of the oven was set at 110 °C and the solution was heated for 36 h. Upon removal of solution from the oven, blue precipitated crystals could be seen which were recovered through centrifugation at 4500 rpm for 20 mins. Once the crystals were recovered, the crystals were washed using DMF. The obtained crystals were then dried at 180 °C in a vacuum oven.

2.2 Characterization

Powder X-ray diffraction (PXRD) patterns of the sample were collected on a D8 Advanced X-ray diffraction system from Bruker (40 kV, 30 mA). The 2θ operating range of the diffractometer was in the range from 3 to 40° with a step size of 0.02°. The patterns recorded were then compared with the patterns reported from single crystal data in the literature.

Thermal stability of the Cu based MOF was measured in N_2 environment with a heating rate of 10°C min^{-1} from 20 to 700°C on a DTG-60H Thermo Gravimetric Analyzer (TGA). 10mg sample of the MOF was used for thermal stability test and the flow-rate of N_2 gas was 10 ml min^{-1}.

Scanning Electron Microscopy (SEM) images of the sample were also obtained on a TESCAN SEM VEGA3 microscope. The sample was gold-coated before the acquiring of images and the images were taken at SEM HV of 20 kV. The EDS analysis of the sample was also conducted to determine the atomic weights of the elements in the sample.

3 Results and Discussion

"Fig. 1" shows the SEM images of the synthesized Cu(tpa) particles, in which a large number of regular and independent crystal cuboids were observed. This indicates good crystallinity and high yield of the Cu(tpa) MOF. Upon higher magnification of the MOF (inset of "Fig. 1"), the cuboids could be clearly seen each with a diameter of about 3µm.

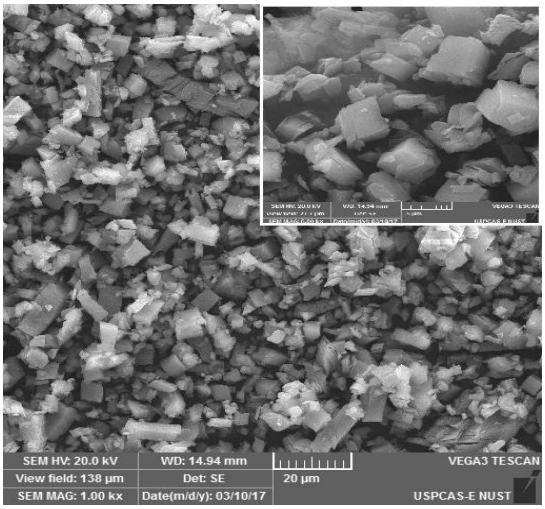

Figure 1 SEM images of Cu(tpa) MOF with low resolution (main image) and high resolution (inset)

The thermogravimetric profile of the MOF is shown in "Fig. 2". The profile clearly shows that a weight-loss step started at 200 °C and ended at 260 °C. This initial weight loss, which is about 10%, corresponds to the loss of solvent that might be trapped in the pores of the MOF. No significant change in weight of the MOF above 260 °C indicates the stability of the MOF until pyrolysis starts at 340 °C, breaking the structure of MOF and leaving behind just carbon.

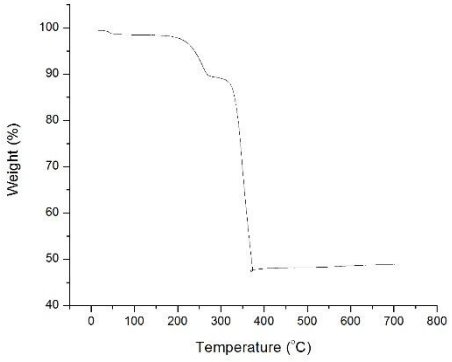

Figure 2 TGA curve of Cu(tpa) MOF

X-ray powder diffraction experiments were carried out to verify the crystals formed during the synthesis of Cu based MOF. "Fig. 3" depicts the peaks attained by XRD which exactly matches the peaks from the literature[20]. During the search match it was further verified that the peak at

Θ=10.10° is of Cu(BDC) | Copper 1,4-Benzenedicarboxylate, which is the required MOF.

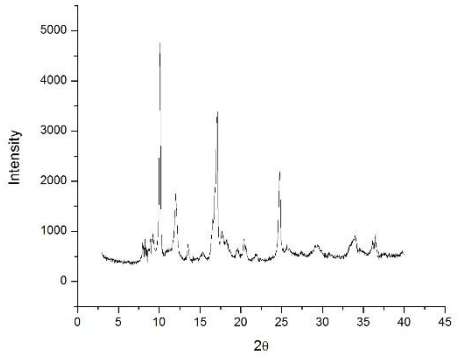

Figure 3 The X-ray diffraction patterns of Cu(tpa) MOF

"Fig. 4" depicts the elemental peaks obtained during the EDS analysis of the MOF sample. A portion of sample was selected for elemental analysis and its spectrum was obtained indicating the elements present. The representative peaks of each element (inset of "Fig. 4") can be seen, confirming the presence of the structural elements of the MOF. "Table 1" shows the weight and atomic percentages of each element which are in accordance with the structure of the MOF and its chemical formula i.e. $C_8H_4CuO_4$.

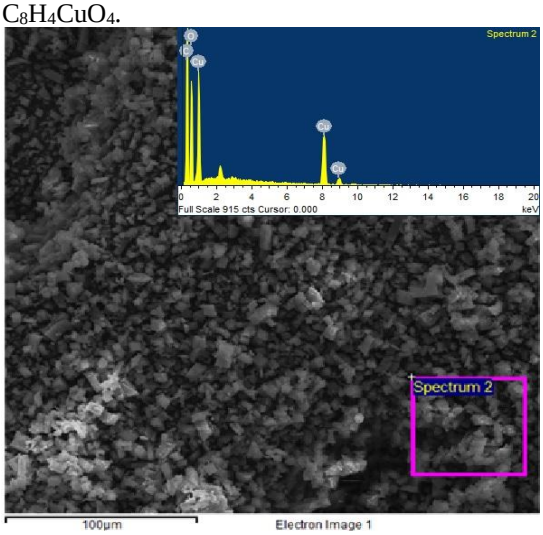

Figure 4 EDS of the MOF

Table 1 Percentages of elements in MOF determined through EDS

Element	Percentage	
	Weight %	***Atomic %***
Carbon	51.93	64.26
Oxygen	35.25	32.74
Copper	12.82	3.00

The CO_2 adsorption capacity of the MOF was also conducted on a DTG-60H Thermo Gravimetric Analyzer (TGA). A 10 mg sample of the MOF was tested to determine its CO_2 adsorption capacity. Initially the sample was heated to 200°C in N_2 environment at a heating rate of 10°C min^{-1} and this temperature was held for 10 mins. This removed any solvent trapped in the pores of the MOF so that the pores can be available for CO_2 adsorption. In "Fig. 5" the initial drop in the weight of MOF from 10.30 mg to 9.95 mg shows that there was some solvent in the MOF which was removed by heating it. The sample was then cooled to 16°C at a cooling rate of 50°C min^{-1} and CO_2 was passed through it at a flow rate of 10ml min^{-1} at room pressure. CO_2 was passed through the sample overnight so that the maximum capacity of the MOF could be determined. With the passage of time, the weight of the MOF started to increase indicating that CO_2 is being adsorbed. A total of 0.24 mg of CO_2 was adsorbed by the sample overnight and the total adsorption capacity of the MOF was calculated to be 0.55 mmol g^{-1}. Keeping in view other MOFs, this is an acceptable value for CO_2 adsorption as the values for different MOFs range from 0.1 mmol g^{-1} to 4.00 mmol g^{-1}[17].

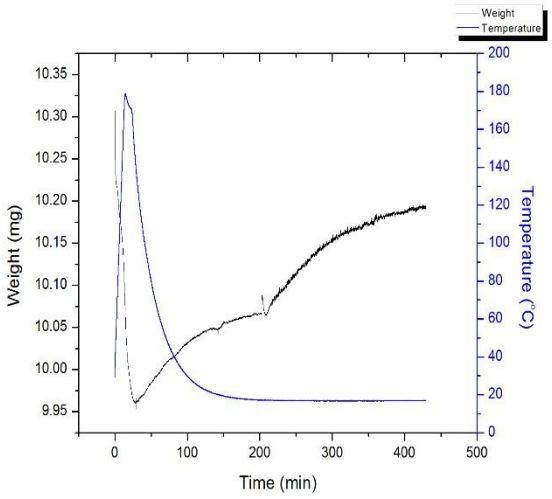

Figure 5 CO_2 adsorption analysis of Cu(tpa) using Thermogravimetric Analyzer (TGA)

4 Conclusions

The results presented here clearly shows that the Cu based MOF, Cu(tpa), has a good potential for being used as a CO_2 adsorbent. The porous nature and reversible solvent-exchange property of this MOF also adds up in making it a good choice. Although the adsorption capacity is relatively less as compared to other MOFs reported, but the nature of Cu(tpa) provides a platform to improve its adsorption capacity. This improvement can achieved by modifying the structure of the MOF through varying conditions during the synthesis. Another approach can be by modifying the MOF through incorporating amines into the MOF structure

which can provide additional sites for CO_2 adsorption hence enhancing the overall CO_2 adsorption capacity.

Currently the adsorption analysis was conducted using TGA but to know the CO_2 adsorption at different conditions, a sorption analyzer will be used in further studies. This will allow us know how the MOF behaves during CO_2 adsorption at different conditions of pressure and temperature.

ACKNOWLEDGMENT

We thank the U.S.-Pakistan Center for Advanced Studies in Energy, NUST Islamabad for their assistance in helping us carry out different test and analyses during our work. Thanks to the staff at Advanced Energy Materials & Systems laboratory at USPCAS-E, NUST for use of Powder X-ray diffraction system (PXRD), Thermogravimetric Analyzer (TGA) and Scanning Electron Microscopy (SEM).

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Design Of Multivariable PID Controller: A Comparative Study

Engr.Anum Khowaja[a,*]; Engr.Dinar Khowaja[a*]; and Prof.Dr.Mukhtiar Ali Unar
[a]Department of Chemical Engineering, COMSATS Institute of Information Technology, Lahore, Pakistan

[*] Engr.Anum Khowaja
E-mail: an_alwani@hotmail.com
Tel: +92-3362608556

Abstract
PID controller is widely used control system in industry. More than 100 methods of PID tuning are given in the literature. But, most of methods are only suitable for Single input Single output (SISO) systems. Very little work has been done on Multiple input Multiple output (MIMO) systems. A few MIMO PID control techniques are available but it is not clear which method is suitable in which condition. There is a need to compare the performance of MIMO PID design method for a particular application .Broadly speaking there are two types of MIMO systems which are Decoupled systems and Coupled systems
In this project we shall investigate both coupled and decoupled systems. This work will select four methods for MIMO PID controller. Two of these methods will be based on decoupled approaches and the other two will use coupled methods. In order to test the performance of the chosen methods, we shall apply the designed PID controller for a Distillation column control system. The aim of this project is to study the main methods for multivariable PID controller design and compare their performance through simulations studies. Study of latest methods of MIMO PID controller available in literature. Selection of four methods of multivariable PID controller these controllers will be tuned for a distillation control system. Comparison based on transient and steady state analysis. We create programming code and block diagrams to simulate the control system using MATLAB.

.**Keywords:** PID controller; Zeigler Nichols method ;biggest log modulus tuning method; MIMO systems

1 Introduction

In multivariable PID system, not only computations of P,I and D parameters is important but also process interactions between various loops are important.
Consider Figure 1 given below:

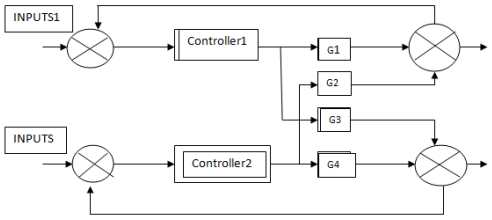

Figure 1 multi input and multi output system

In this figure controller I may improve the output I but it may degrade output 2, Similarly controller 2 may be good for output 2 but not for output 1. This example clearly indicates that the design of multivariable PID controllers is much more challenging than SISO PID controllers This project therefore is related to the design of multivariable PID controllers. The aim of this project is to study the main methods for multivariable PID controller design and compare their performance through simulations studies.

Following are the objectives of the project :

- Study of latest methods of multivariable PID controller available in the literature.
- Selection of four methods of multivariable PID controller, these controllers will be tuned for a given application
- Comparative analysis of the tuned controllers

Initially one method of multivariable PID controller will be chosen . It will be properly tuned for an application transient and steady state analysis will be carried out. The procedure will be repeated for three other controllers for the same application. Based on the transient and steady state performance, it will be found which controller is the most suitable for the application.
K.J.Astrom in 1993 worked on Adaptive techniques such as gain scheduling, automatic tuning and continuous and adaptive has been used in industrial single loop controllers for about ten years. This paper gives survey of the different adaptive techniques, the underlying process models and control designs.[1].
Unar M.A in 1996 worked on Design and Tuning Of Fixed Structure PID Controller.[2]
This paper provides a deep survey of methods for design of fixed structure Proportional Integral Derivative (PID) controllers. The design of single input single output (SISO), Cascade and multiple input multiple output (MIMO) PID Controllers is coated. Both linear and non linear approaches are viewed.
Modern days have seen immense developments in the field of controller. There are many controllers

developed these days with different specifications. But the only drawback is that, there is no fixed method for the tuning of these controllers, which is important for controlling of the system based on the variation of the input or for the variations in the system. In order to overpower this drawback, in this paper they have compared different tuning methods of PID controller for non-linear system. As a non-linear system we have taken the dc motor as a system. For the particular DC motor controller transfer function has been found and control parameters such as Proportional Gain, Integral Time and Derivative time are identified. There are many methods of developing a Proportional Integral and Derivative (PID) Controller, from them some methods are adopted in this paper and Comparisons of Time Domain specifications of those controllers has been carried out.(Sahu D.S., Sharma S.,March 2017).[3]

A vast majority of control algorithms are given however most designers use old Ziegler-Nichols tuned PID control which was proposed in 1942. Although some of recent methods have been used in other areas of engineering yet hardly any of them have been utilized for a ship steering. This paper compares the performance of four more recent controllers for ship steering and performance of controllers calculated for both open loop stable as well as open loop unstable ships. The controllers are judged through simulation studies.(Unar M.A, Scotland 1995).[4]

1.1 Selected Methods Of PID Control Design

1.1.1 BLT Tuning Method

1. Consider the Ziegler Nichols tuning parameter of the diagonal elements of the system transfer function matrix $g_{ii}(s)$ as through the diagonal elements represented SISO systems.
2. Choose a detuning factor F
3. Compute K_{ci} for each loop by

$$Kci = \frac{Kzn}{F} \tag{1}$$

4. Calculate the function W

$$W = -1 + \det[1 + G(j\omega)Gc(j\omega)] \tag{2}$$

5. Calculate the function $L_c = j\omega$ where

$$Lc(j\omega) = 20\log\left|\frac{W}{1+W}\right| \tag{3}$$

6. Fix F till L_c log modulus curve L_{cm} is equal to 2N i.e. $L_c^{\max}$ =2N

1.1.2 SIMC Tuning Method

In this section a simple effective decentralized PID controller design methodology will be presented based on dynamic interaction survey and skogestad internal model control principle. On the basis of structure decomposition, the dynamic relative interaction is defined and represented by the process model and controller explicitly.

1.1.3 ERGA Tuning Method

The properties of RGA can be extended to ERGA:

1. The value of $\emptyset ij$ is part of the effective interaction expected in the i[ith] loop if its output yi is paired with uj.
2. The elements of ERGA beyond any row or down any column

$$\sum_{i=1} \phi_{ij} = \sum_{j=1} \phi_{ij} = 1 \tag{4}$$

3. Let e_{ij} is negative with other loops closed

$$e_{ij} = \frac{1}{\phi_{ij}} e_{ij} \tag{5}$$

Thus analyzing RGA method with RGA and DRGA we may assume that in moreover steady state gain only time constant and time delay are mandatory in ERGA method, it is bit simple to find DRGA methods. ERGA only uses information of open loop process transfer functions it is controller type individually.

1.2 Results And Discussion

Firstly of all we start with 2 × 2 system whose transfer function matrix is:

$$G(s) = \begin{bmatrix} \frac{-2.2e^{-s}}{7s+1} & \frac{1.3e^{-0.3s}}{7s+1} \\ \frac{-2.8e^{-1.8s}}{9.5s+1} & \frac{4.3e^{-0.335s}}{9.2s+1} \end{bmatrix}$$

The dimension of the plant is 2by2 so we have pairing choice is 2, which is equal to 2. The DC gain and NI values for all available pairings for mentioned process are

$$k_1 = \begin{bmatrix} 1.3 & -2.2 \\ 4.3 & -2.8 \end{bmatrix} \qquad k_2 = \begin{bmatrix} -2.2 & 1.3 \\ -2.8 & 4.3 \end{bmatrix}$$

Table 1 Control Parameters by all methods

method	**Loop 1,2**		
	Kc	τ_i	τ_d
BLT	-1.0502 1.9354	7.233 2.6318	0 0
SIMC	-0.7048 1.9449	7.000 4.2000	0 0
ERGA	3.2007 1.6660	9.2000 7.000	0 0

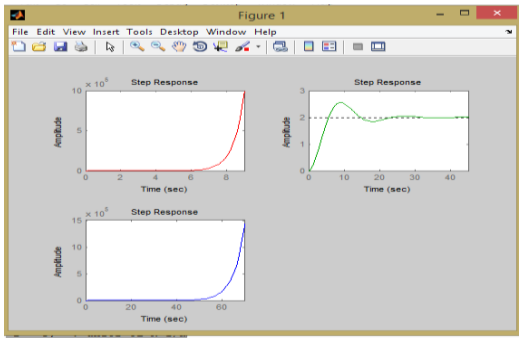

Figure 3: Step response w.r.t Y1

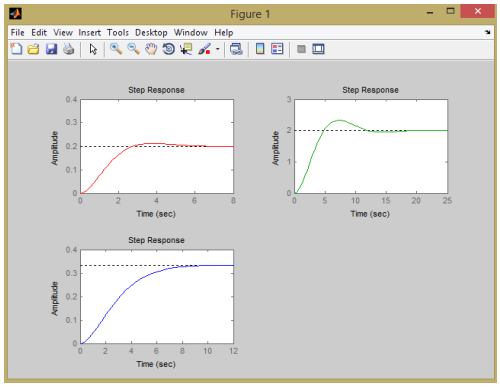

Figure 4: Step response w.r.t Y2

now let's repeat the same procedure with 3 by 3 system whose transfer matrix is given as:

$$\begin{bmatrix} \dfrac{0.66e^{-2.6s}}{6.7s+1} & \dfrac{-0.61e^{-3.5s}}{8.64s+1} & \dfrac{-0.0049e^{-s}}{9.06s+1} \\ \dfrac{1.11e^{-6.5s}}{3.25s+1} & \dfrac{-2.36e^{-3s}}{5s+1} & \dfrac{-0.01e^{-1.2s}}{7.09s+1} \\ \dfrac{-34.268e^{-9.2s}}{8.15s+1} & \dfrac{46.2e^{-9.4s}}{10.9s+1} & \dfrac{0.87(11.61s+1)e^{-s}}{(3.89s+1)(18..8s+1)} \end{bmatrix}$$

The dimension of the plant is 3 by 3 and the only pairing choice is 3, which is equal to 6. The DC gain and NI values for entire possible pairings for this process are

$$K_1=\begin{bmatrix} -0.0049 & -0.6100 & 0.6600 \\ -0.0100 & -2.3600 & 1.1100 \\ 0.8700 & 46.2000 & -34.6800 \end{bmatrix}$$

$$K_2=\begin{bmatrix} 0.0049 & 0.6600 & -0.6100 \\ -0.0100 & 1.1100 & -2.3600 \\ 0.8700 & -34.6800 & 46.2000 \end{bmatrix}$$

$$K_3=\begin{bmatrix} -0.6100 & -0.0049 & 0.6600 \\ -2.3600 & -0.0100 & 1.1100 \\ 46.2000 & 0.8700 & -34.6800 \end{bmatrix}$$

$$K_4=\begin{bmatrix} -0.6100 & 0.6600 & -0.0049 \\ -2.3600 & 1.1100 & -0.0100 \\ 46.2000 & -34.6800 & 0.8700 \end{bmatrix}$$

$$K_5=\begin{bmatrix} 0.6600 & -06100 & -0.0049 \\ 1.1100 & -2.3600 & -0.0100 \\ -34.6800 & 46.2000 & 0.8700 \end{bmatrix}$$

$$K_6=\begin{bmatrix} 0.6600 & -0.0049 & -0.6100 \\ 1.1100 & -0.0100 & -2.3600 \\ -34.6800 & 0.8700 & 46.2000 \end{bmatrix}$$

Table 2: parameter calculation of all methods by loop system

Method	**Loop**	Kp	τ_i	τ_d
BLT	1	1.4802	16.703	1.1441
	2	-0.2892	18.3007	1.2535
	3	2.5838	6.7937	0.4616
SIMC	1	0.1334	6.7000	0
	2	-0.0938	5.0000	0
	3	6.9234	6.0000	0
ERGA	1	0.8763	6.7000	0
	2	-0.1585	5.0000	0
	3	2.5793	10.000	0

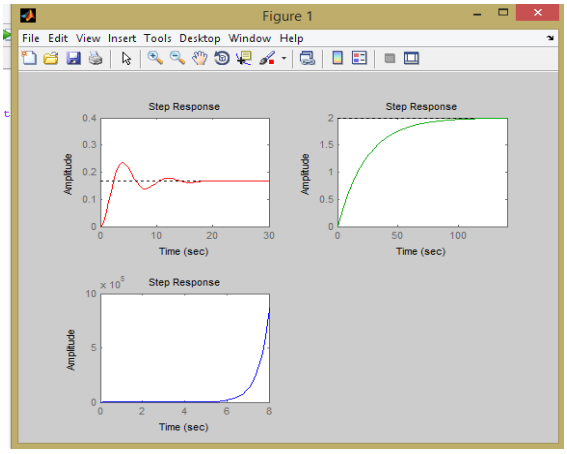

Figure 5 : step response of Y1

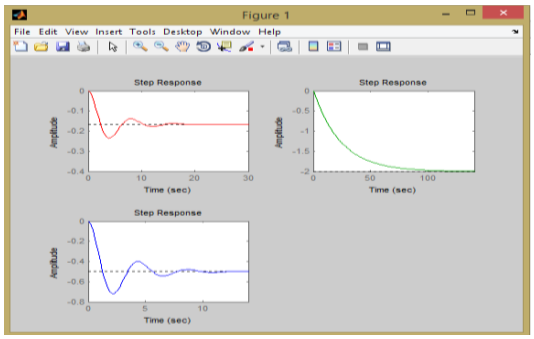

Figure 6: Step response of Y2

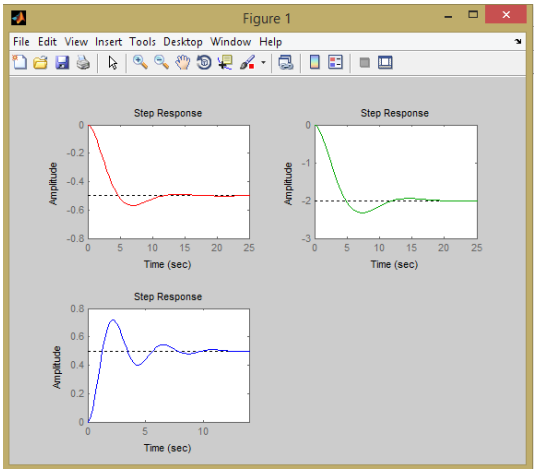

Figure 7 : step response of Y3

1.2.1 Conclusion and Suggestion For Future Work

The results shows that BLT settings give stable and reasonable responses. Whereas pairing in other methods may have negative pairing which give not smooth result therefore BLT method gives more accurate and stable response.

According to the simulation results we conclude that the three methods presented in this project can be easily applied to high dimensional processes with complicated interaction modes such as distillation column

The SISO design Tool is graphical user interface (GUI) that allows you to analyze and tune SISO feedback control systems. Using the SISO Design Tool you can graphically tune the gains and dynamic compensator and pre filter (F) using a mix of root locus and loop shapping techniques.

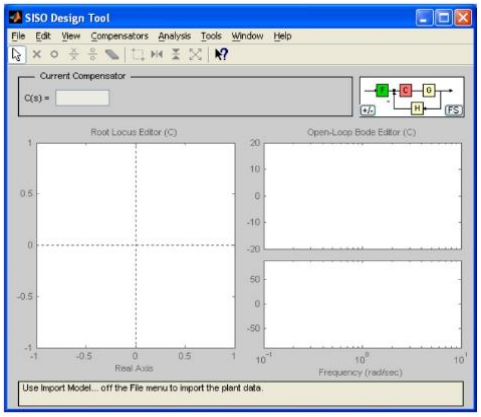

Figure 7

ACKNOWLEDGMENT

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Synthesis of alumina polysulfone nano composite membrane for copper ions removal from wastewater

Muhammad Ayaz*[a], Syed Fawad Ali Shah[b], Qazi Sohaib[a], Amir Muhammad[a], Asim Laeeq Khan[c], Muhammad Younas[a]

[a]Department of Chemical Engineering, University of Engineering and Technology, Peshawar, P.O. Box 814, University Campus, Peshawar 25120, Pakistan
[b]Department of Civil, Chemical, Environmental and Materials Engineering, University of Bologna, Via Terracini 28, 40131 Bologna, Italy
[c]Department of Chemical Engineering, COMSATS Institute of Information Technology, Lahore, Pakistan

* Corresponding Author
E-mail: engr_ayaz07@yahoo.com
Tel: +923149600070

Abstract
Copper is a heavy metal and pose a serious threat to environmental pollution due to its toxic effects on environment including human beings as well as plants. Several methods are used for copper ions expulsion; however, due to its conspicuous characteristics, membranes have dominated its use in this field. In this research polymeric nano composite (alumina/polysulfone) membranes have been fabricated to enhance copper ions rejection efficiency and durability of the polysulfone membrane.
A novel polymeric nanocomposite membrane was synthesized using polysulfone and alumina nanoparticles. Different membranes with different concentrations of nano alumina were prepared by phase inversion method. Nano alumina was verified by scanning electron microscope. The performance of the synthesized membranes was analyzed in terms of copper ions rejection, static adsorption and reusability test. All the composite membranes showed higher copper ions rejection in contrast to nascent polysulfone membrane. The highest Cu (II) ions uptake (69%) was shown by membrane with 1 wt. % nano alumina and the lowest rejection (29%) was observed for pristine polysulfone membrane. The reusability test of the composite membrane confirmed its durability after several cycles using EDTA as regenerator.

Keywords: *Nano-composite membrane; Polysulfone; Alumina nano-particles; Water treatment; Copper ions removal*

1 INTRODUCTION

Copper belongs to heavy metals family and has been recognized as a serious threat to environmental pollution due to its toxic effects on living organisms [1]. Copper easily build up in human body as it does not decay. Although copper is essential for animal metabolism, however, it causes several diseases when taken in excess (>2 mg/l) [2]. Problems like gastric, intestinal, and muscular are associated with copper [2-4]. Besides, copper is also dangerous to plants as its excess affects growth of roots [5]. Therefore, wastewater containing copper ions must be treated before disposing it to the surroundings.
Several techniques like ion exchange, chemical precipitation, electro-dialysis, reverse osmosis, coagulation and flocculation, cementation [4, 6], adsorption and membrane filtration are the methods that have been used for the expulsion of copper ions from wastewater [3, 7-16]. However, membrane technology due to its outstanding characteristics has dominated this field [17, 18]. Currently; polymeric membranes have attracted the focus of the researchers due to its better properties like inexpensiveness and low space requirement for erection [19].
Polysulfone (PS) membrane has been commonly used in industrial fields because of its excellent chemical stability and mechanical strength [20]. However; it has low adsorption capacity for copper ions expulsion and is hydrophobic in nature which results in membrane's fouling [21]. Therefore to overcome these problems, alternate methods have been developed which involves introducing second phases in the membrane matrix [22].

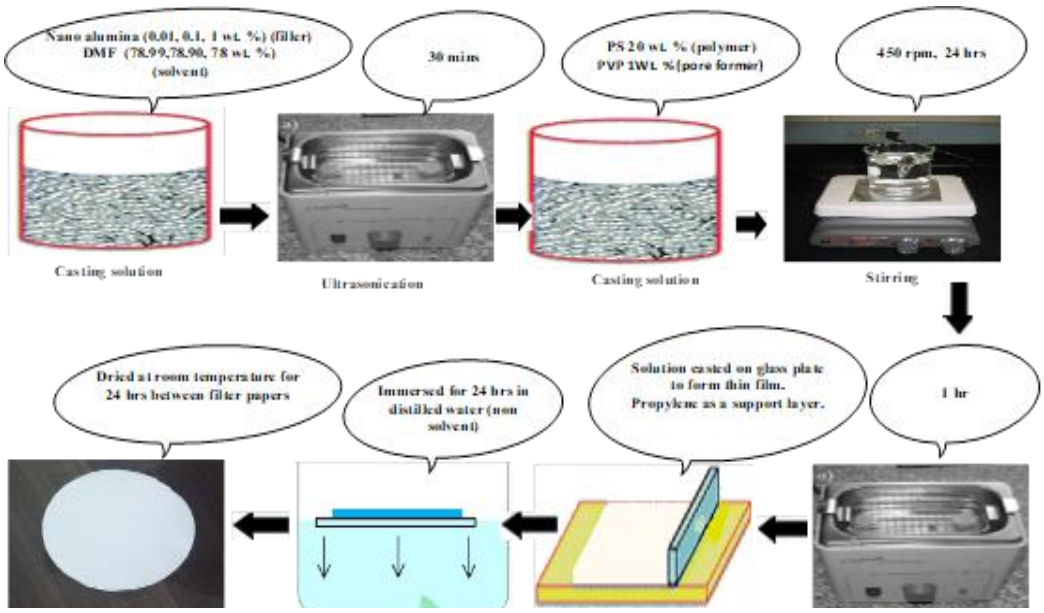

Figure 1 Synthesis of alumina/polysulfone nano composite membrane

Nano fillers have been utilized to ameliorate the adsorption and antifouling characteristics of the polysulfone membrane [23]. TiO_2, ZnO, Fe_3O_4, SiO_2 and ZrO_2 are some of the commonly used nano fillers in membrane technology [24]. However; the excellent hydrophilic and adsorption capacity of nano alumina has attracted the focus of the researchers to use it as nanofillers in membrane [25] [26].

However; a little research work has been done in this field [27-30] and most of these researches were aimed to raise antifouling and permeability characteristics of membranes [31-36]. Since, no significant research work regarding the utilization of nano alumina in membrane for copper expulsion has done [37], therefore; this research has the novelty to enhance copper rejection using nano alumina in polysulfone membrane.

The objective of current study was to synthesized polymeric (PS) nano composite membranes with different concentrations of nano alumina which has high copper removal efficiency and antifouling characteristics. The size of nano filler was analyzed using image J. software. Copper ions rejection, static adsorption and regeneration were used for analyzing the performance of the membranes. Durability of the fabricated membranes was investigated through reusability test using Etylene-di-amine-tetra-acetic acid (EDTA) as a regenerator agent.

2 EXPERIMENTAL

2.1 Materials

Polysulfone (PS) was purchased from Scientific Polymer Products, Inc., USA, while N, N Di-methyl-formamide (DMF) was acquired from Sigma Aldrich, USA. Polyvinylpyrrolidone (PVP), copper nitrate ($Cu(NO_3)_2$), and alumina (Al_2O_3) were bought from Dae-Jung Chemical and Metals Co., Ltd., Korea.. Nano alumina was synthesized by centrifugal ball mill (Retsch, S100).

2.2 Synthesis of Al_2O_3/PS nano composite membrane

For synthesis of nascent PS membrane, a casting solution containing 20 wt. % PS and 1 wt. % PVP were dissolved in 79 wt. % DMF followed by stirring at 450 rpm for 24 hrs and Ultra-sonication for 1 hr, respectively. The solution was, thereafter, casted on a glass using an automatic film applicator (Elcometer 4340) and then immersed in distilled water for 24 hrs at room temperature. Finally two filter papers were used for drying of membrane by placing it for 24 hrs.

Figure 1 illustrate the synthesis procedure of composite membranes. Firstly; alumina with different concentrations was dissolved in the solvent and sonicated for 30 minutes. Composition of synthesized nanocomposite membranes is shown in **Error! Reference source not found.**. Then 20 wt. % PS and 1 wt. % PVP were added to the prepared solution followed by stirring at 450 rpm for 24 hrs and sonication for 1 hr respectively. Finally the casting and immersion process were carried out in the same manner as done for the nascent PS membrane.

Table I Composition of membranes solution

Membrane	PS (wt. %)	PVP (wt. %)	DMF (wt. %)	Al_2O_3 (wt. %)
PS	20	1	79.00	----
PAl0.01	20	1	78.99	0.01
PAl0.1	20	1	78.90	0.10
PAl0.5	20	1	78.50	0.50
PAl1	20	1	78.00	1.00

3 CHARACTERIZATION OF MEMBRANE

3.1 Copper rejection efficiency of membranes

Copper nitrate solution with 20 mg/l concentration was used as a feed. Copper ions concentration in permeate was noted after every 10 minutes till a constant concentration was achieved, using atomic absorption spectrophotometer (AAS), and copper rejection efficiency was determined using equation 1 [24]:

$$R\ (\%) = (1- C_P/C_F) * 100 \quad (1)$$

Where, R% is the copper rejection, C_P (mg/l) is the copper ion concentration in permeate and C_F (mg/l) is the copper ion concentration in the feed, respectively.

3.2 Static adsorption of membranes

For finding the static adsorption of the membranes, these were cut into distinct fragments and measured. These membranes were then dipped in 50 ml of Cu (II) solutions with concentration of 20 mg/l under continuous stirring. Copper ions concentration was noted after every one hour, using flame atomic absorption spectrophotometer (AAS), till a constant concentration was obtained. The static copper ions adsorption was calculated using equation 2 [2, 38].

$$S_{Ads.} = V\ (C_i - C_t)/\ m \quad (2)$$

S_{Ads} is the static adsorbed amount of copper ions on the membrane (mg/g), V is the volume of the solution (ml), C_i is the initial concentration (mg/l) of copper ions in the solution, C_t is the copper ions concentration at time t and m is the mass of the membrane (g).

3.3 Regeneration of membrane

The regeneration and durability of the composite membrane was tested using Etylene-di-amine-tetra-acetic acid (EDTA) as a regenerator agent. The membrane was dipped in 25 ml of 10 mM EDTA solution and stirred for 1 hr. then; the membrane was cleansed with sufficient de-ionized water and reused for copper ions rejection using dead end stirred cell.

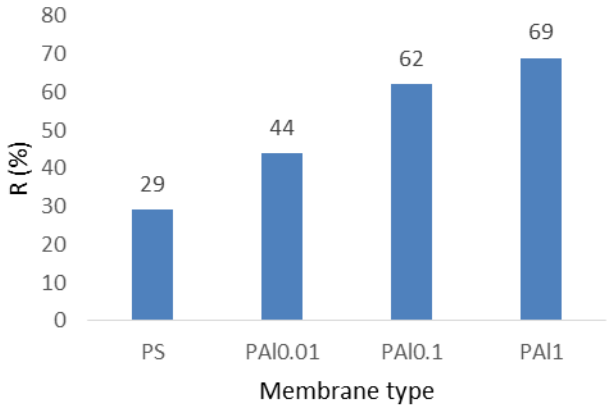

Figure 2 *Copper ions rejection (%) of synthesized*

4 RESULTS AND DISCUSSION

4.1 Copper removal efficiency of membranes

The results showed that copper rejection was greater by composite membranes in contrast to nascent membrane as shown in Figure 2. Highest (69%) and lowest (29%) copper ions uptake were shown by PAl1 and nascent PS membrane, respectively. This increment in copper ions rejection was due to the efficient dispersion of nano alumina which provides large active sites for copper adsorption [39-42] and results in restriction of copper ions to cross membrane surface.

4.2 Static adsorption of membranes

Static adsorption efficiency of the membranes was observed as presented in Figure 3. The results revealed that all composite membranes offer higher copper ions adsorption in contrast to nascent polysulfone membrane. The highest adsorption was shown by membrane with 1 wt. % nano alumina (PAl1) while the lowest adsorption was observed for nascent polysulfone.

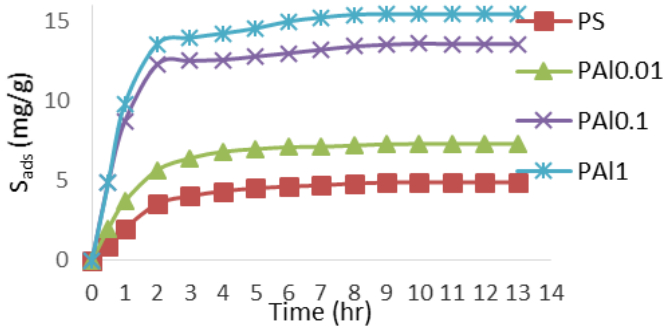

Figure 3 Static adsorption Vs time of the synthesized membranes

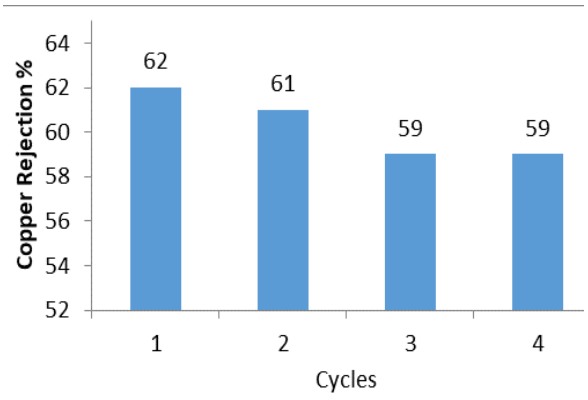

Figure 4 Reusability of PAl0.1 membrane

4.3 Reusability and durability of membrane

The PAl0.1 membrane was selected for the reusability test. The results revealed no significant reduction in copper rejection efficiency even after four cycles of regeneration as shown in Figure 4. Hence, nano composite membranes can be employed for heavy metals' rejection due to its excellent durability.

5 Conclusion

In this research, nano alumina was employed to enhance the copper ions rejection efficiency of polysulfone membrane. Membranes with different concentrations of nano alumina were synthesized and were compared in terms of copper rejection. The results revealed that the copper ions rejection of the membranes increased with increasing concentration of nano alumina. The highest and lowest copper rejection was observed by membrane with 1 wt. % nano alumina and pristine polysulfone membrane, respectively. The regeneration test of the composite membrane showed only a small reduction of 3% in copper rejection after four cycles of regeneration. Hence, the reusability and copper ions rejection results confirmed the significance of composite membranes to be employed in heavy metals rejection from wastewater in contrast to pristine polysulfone membrane due to the better adsorption characteristics of nano alumina.

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Recycling of wastes in to composites

Muhammad Altaf[a*]; Murtaza Khan[a]

[a] Department of Chemical Engineering, University of science and Technology, Peshawar, Pakistan
E-mail: rayanhameed@yahoo.com

Abstract

The aim of this study was to investigate the expediency of composite formation from tonnage of wastes produce not only environmental problems but also required huge budget on its disposal. The aim of this review is to undergo through comparative analysis of composite of biodegradable materials (PLA)/Waste Tyres, rHDPE/PCB and fibre/matrix (resin) with the most general composites of ceramics.one of the main purpose of this review is to show how theoretical and experimental data that is already available can be used to design new composites from new materials with match properties and to select most suitable waste materials for formation of composites.

Keywords

Biodegradable, ceramics, environment, feasibility

1 Introduction

Industrial revolution has been taken place from the century which facilitate human by production of huge amount of wastes which have no use. Beside uselessness it also gives severe threats to human and environment in the form of diseases. So, it is our need to find some alternative way to get relieve of this wastes by converting it in to some important things. Currently recycling is one of the most acceptable way to deal with these wastes [1].

Many useful materials such as paper, glass, plastic, and metals can be recovered from trash and can be recycled in production of different useful products such as composites, reducing the most expensive virgin raw components needed for production of that. Products. Approximately nine billion ton of wastes generate from the globe in which eighty percent of the waste is capable to be recycled however there is no much attention for their recycling. To fully realize the benefits of recycling, three elements must be in balance: collection, manufacturing and buying recycled [2].

Progresses in the field of materials science and technology have given birth to these gripping and wonderful composite materials. A Composite Material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. A composite material can provide superior and unique mechanical and physical properties because it combines the most desirable properties of its constituents while suppressing their least desirable properties [3].

The first modern composite material was fibreglass. It is still widely used today for boat hulls, sports equipment, building panels and many car bodies. The matrix is a plastic and the reinforcement is glass that has been made into fine threads and often woven into a sort of cloth. On its own glass is strong but one property is brittleness that make it to break if bent. By combining it with plastics it is prevented from breaking by supporting the force with glass. [4]

Some advanced composites are now produced using carbon fibres instead of glass. These materials are lighter and stronger is advantageous but more expensive. They are used in aircraft structures and expensive sports equipment such as golf clubs [5].

Another example of using non-metallic printed circuit board (PCB) waste as filler in recycled HDPE (rHDPE) in production of rHDPE/PCB composites. Maleic anhydride modified linear low-density polyethylene (MAPE) was used as compatibilizer. The effects of non-metallic PCB and MAPE on mechanical properties of the composites were assessed through tensile, flexural and impact trials having matches with ceramic and wood products. [6-7]

Scraped tires have a solid elastomeric part is mixed with filler biodegradable PLC in a bra blender 60cc mixer and manually pressed in a mould for composites. The composite is mechanical characterized and give acceptable properties [8].

1.1 Composites

The term composite is derived of composed term mean that it contains two or more components combined along with the binder to form useful product which is different in properties from the parental components. But in modern materials engineering, the term usually refers to a "matrix" material that is reinforced with fibres. For instance, the term "FRP" (Fibre Reinforced Plastic) usually indicates a thermosetting polyester matrix containing glass fibres, and this composite has the lion's share of today's commercial market Many composites got much attention in term of their properties in field of material engineering [9-10].

1.1.1 rHDPE/PCB composites

In recent era world is suffering from the growing volume of end of life electronics. There has been increasing concern about the growing volume and is consigned for landfilling with no recycling of materials done. Tonnage of non-metallic materials being disposed by means of most conventional thermal methods such as incineration. But it may cause secondary pollution and resource wasting. A lot of polymeric substances been wasted in different products which can be reused by changing in to composites reducing the risks to environment. It is noted that composites formed of this have decent and adequate properties. Table. 1explore the properties of composite of recycled high-density polymer and print circuit board [11].

Table 1 Mechanical properties of the composites of rHDPE with various PCB Content (wt. %)

Property	**0**	**10**	**20**	**30**
Tensile testing				
Young's modulus (GPa)	0.64	0.85	1.32	2.32
Tensile strength (MPa)	7.95	6.67	6.71	6.78
Elongation at break (%)	3.5	2.8	2	1.6
Flexural testing				
Flexural modulus (GPa)	1.62	7.32	13.8	16.41
Flexural strength (MPa)	10.4	10.71	11	12.44
Impact strength (J/m)	59.6	48.3	44.2	42.5

1.1.2 Biodegradable materials (PLA)/Waste Tires composites

Elastic part of waste tires were used as a filler in the biodegradable PLA matrix mixed in different proportion in bra bend mixer to get different strength composites. Research shows that from las decade the main usage of PLA is limited to biological and medical applications such as implant devices, tissue scaffolds, and internal sutures because of its high cost and low availability however recent study explained to us that it can be used as an ingredient in formation of composites. Table.2 shows the physical properties of PLA and waste tires composite [12].

Table 2 Mechanical properties of the composites of PLA with various scraped tire solids (wt. %)

PLA (%)	Strength(MPa)	Strain (%)	E(Mpa)	Elongation (%)
90	2	0.6	1249.8	1.89
80	0.9	0.46	1241.4	1.28
70	1.7	1.08	1237.1	1.2
60	1	1.7	272.6	1.01
50	0.9	2.2	218.9	.89
40	0.8	2.3	245.1	0.46

1.1.3 Fibre/matrix (resin) composite

Fibres such as fibre glass, carbon fibre and polyester can be used as a main component in making composites along with resins such as vinyl ester and phenolic as a filler. Normally the higher fibre content give strength and stiffness to composites. Composites materials are replacing metals and plastics in many industries and composites are the material of choice for many new applications. Fibreglass have both the sides of advantages and disadvantages however fibre glass is very most suitable choice in corrosive environment, large parts, where strength needed. Fiberglass is a designer's ideal material, because the parts can be tailored to have strength and/or stiffness in the directions and locations that are necessary by strategically placing materials and orienting fibre direction. The mechanical characterisation is distributed in table. 3 [13].

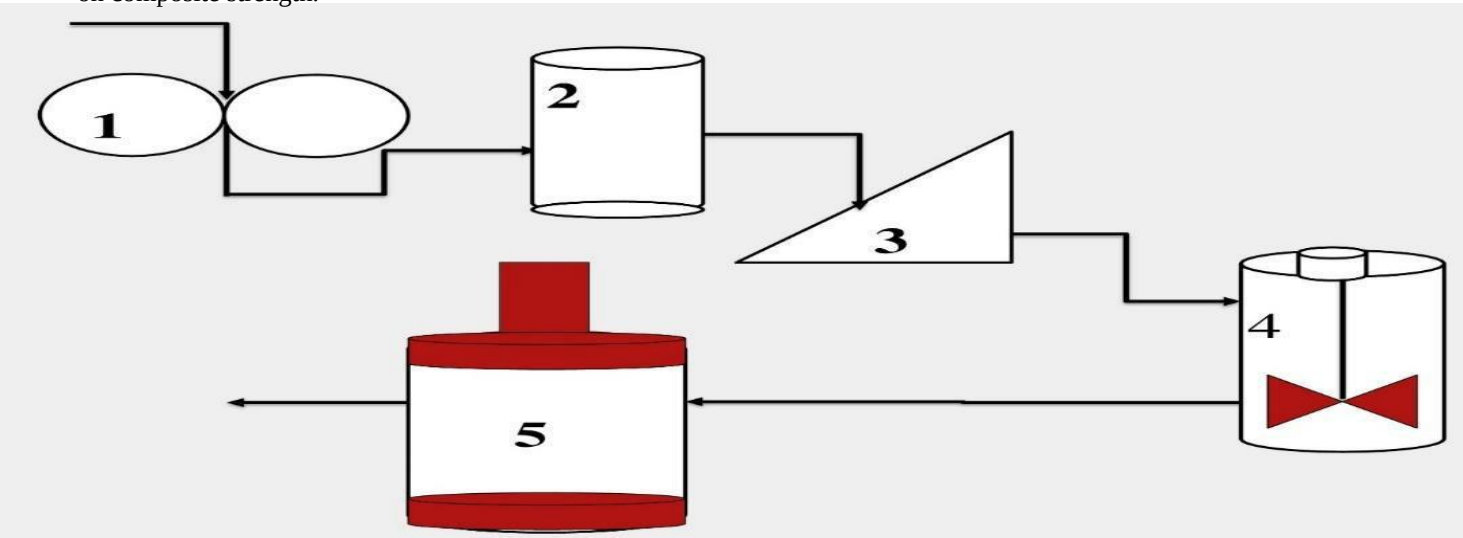
Table 3 Mechanical properties of the composites of resin matrix with various Fibre (wt. %)

Fibre (%)	Strength(MPa)	Strain (%)	E(Mpa)	Elongation (%)
70	10.9	3.08	8287.1	0.896
60	1	3.7	4272.6	0.742
50	0.9	4.2	2318.9	.7123
40	0.8	4.88	1245.1	0.51

2 Process

The process of composite formation consist of simple physical processes. The review shows that

- First mechanically dismantling of the waste is done if needed.
- Many of separation techniques is been utilized for separation of metals and non-metals from the waste by keeping eyes on optimized technique.
- The size distribution Aloysius is carried out to decide the processing of various streams.
- Non-metals will be mixed with a bonding and filler material in different percentages to look for their effect on composite strength.
- A pre-set mould containing composite mixture placed in a manual press machine is pressed under high pressure to get composite of greater strength.
- Composite strength is judged by varying particle size and filler ratio to get the most suitable proportion.
- Results of wastes composites will be compared with virgin wood and with composites of other materials.
- The generalized process of waste composite formation is explained by flow chart in fig.1.



S.NO	Equipment
1	CRUSHER
2	SEPERATOR
3	SCREEN
4	MIXER
5	PRESS MACHINE

Figure 1 Flow chart for the process of formation of composites from waste

3 Comparative analysis

Table shows the Comparative analysis of different composites that is made of Different wastes and most generalized. The three physical properties Tensile strength, Young's modulus and %elongation are taken for five different types of composites. The composite taken of most descent filler ratio which have best physical properties. These mechanical properties which is chosen as a standard are compared with each other shown on Table 4.

Table 4 Comparison of physical properties of different composites

S. No	Composites	Tensile Strength(MPa)	Young's Modules (GPa)	Elongation (%)
1	rHDPE/PCB	6.78	2.32	1.6
2	PLA/Waste Tyres	1.7	1.25	1.28
3	Fibre/matrix (resin)	10.9	8.29	0.896
4	Ceramics composites	16	11	4
5	Wood product (Red owk)	9.5	8.2	2.3

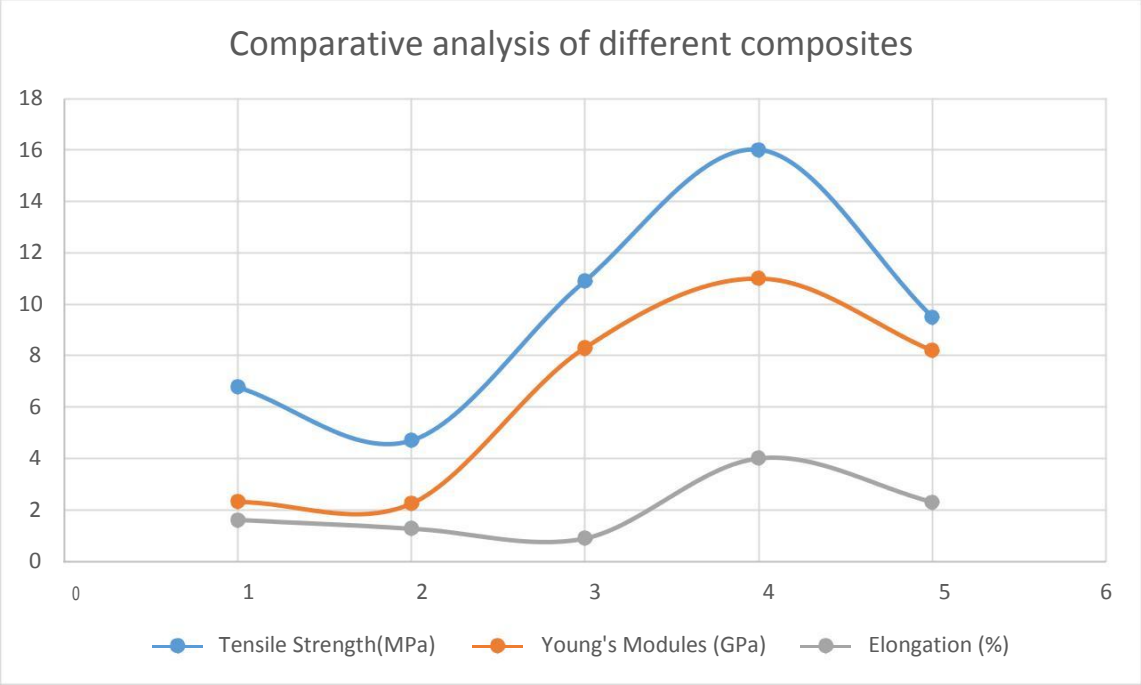


Figure 2 Comparison of different waste composites

4 Conclusions

The recycling of waste in to composite lay the foundation that it offers better replacement as a composite for most general ceramic composites and most expensive verging wood products. From fig it shows that the properties of composite composed of waste is nearly matched with the most expensive wood products. It is from fig.2 that these waste composites can be better replacement for most virgin wood products.

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Study of Wind Resource Potential in Bahawalpur (District of Southern Punjab), Pakistan using Artificial Neural Network and RETScreen

Anam Zahra[a*]; Rashid Wazir[a]; Samreen Siddique[a]; Hassan Abdullah Khalid[a]; Mazhar Ali[a]

[a]U.S.-Pakistan Center for Advanced Studies in Energy, NUST, Islamabad, Pakistan

[*]E-mail: 15eseanam@uspcase.nust.edu.pk
Tel: +923334891054

Abstract
Pakistan is currently facing an electricity shortfall of about 5000MW. To overcome this shortfall, adaptation of renewable technologies is increasing day by day in Pakistan. Mainly, solar and wind are being integrated with central grid system. This study aims at exploration of wind power potential in Bahawalpur district of southern Punjab, Pakistan. The data used for this study has been collected from meteorological high precision(MHP) station installed at Bahawalpur. Initially, wind speed data is organized and then forecasted using Artificial Neural Network model with the help of MATLAB. To check the technical and economic viability of a 50 MW wind farm, RETScreen software is used. In order to get optimized wind farm, 317 turbines with different rating of various manufacturers at multiple hub heights were observed. The results illustrate that 100 wind turbines of 500KW manufactured by EWT installed at 75m hub height produce 103.544 GWh energy annually, which make the project viable technically.

Keywords: Wind energy; wind farm; Forecasting; Artificial Neural Network; MATLAB; MHP; RETScreen

1 Introduction

An index to measure prosperity of a society or country is its energy consumption per capita. Energy in the form of electricity helps development of industry and economy [1]. With population exceeding 207 million, Pakistan is undergoing acute energy crisis. The demand-generation gap has increased up to 7000MW. And this shortfall has resulted in 4% decrease in Gross Domestic Product(GDP) over past few years [2][3][4]. To overcome the prevailing energy conditions, new power generation resources are needed to be added in the current energy mix of the country. According to state of the industry report 2016, issued by National Electric Power Regulatory Authority (NEPRA), share of renewable energy in total energy production was only 1.38% in the year 2015-2016 [5]. Following figure shows the fuel-wise energy generation mix of the country for last five years:

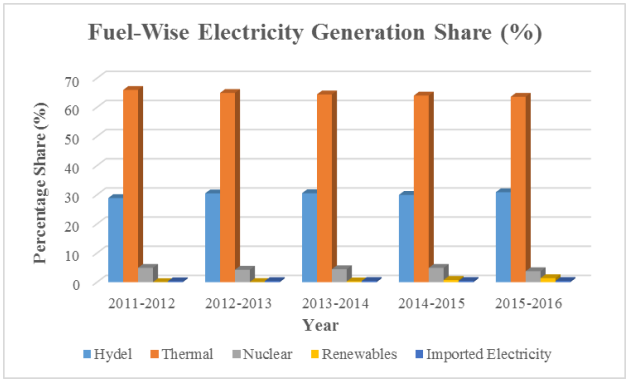

Figure 1 Yearly Electricity Generation Share of Different Technologies

Out of total renewable energy share, a very little fragment is covered by wind energy. Wind energy development is still in early stages in Pakistan despite of having a very good wind potential in Pakistan. Alternative energy development board of the country along with the help of USAID and National renewable energy laboratory (NREL) developed a wind resource map for Pakistan in 2007 [6]. The map shows a very good wind potential in all over the country as can be seen below:

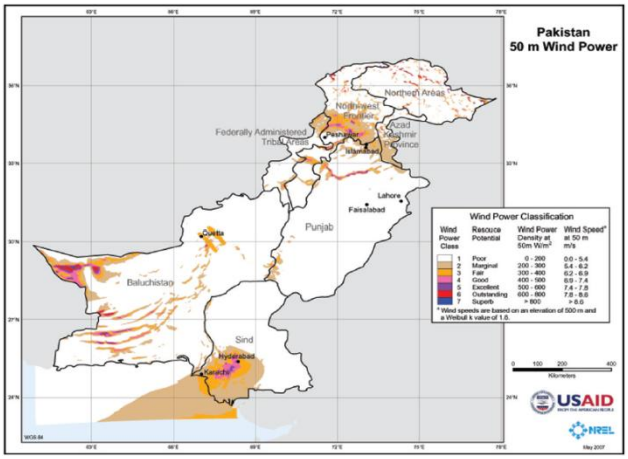

Figure 2 Wind Resource Map of Pakistan

Wind power is directly dependent on cube of wind speed. As wind speed is intermittent in nature, it is necessary to accurately predict wind speed to ensure favorable design of wind farm at any site under observation [7][8]. Different physical, statistical and artificial intelligence methods have been used to forecast the wind speed [9]. This study uses Artificial Neural Network (ANN) technique for wind speed forecasting. Back Propagation Levenberg-Maquardt (BPLM) algorithm is used in this method to predict the wind speed. Artificial neural network basically consists of three layers; input, hidden and output. The hidden layer assigns weights to inputs to generate outputs with minimum error [10].

2 Materials and Methods

2.1 Data Collection and Testing

Wind speed data was collected from Meteorological High Precision (MHP) station installed at Quaid-e-Azam Solar Park (QASP) Bahawalpur at a height of 10m[11]. The MHP station provided wind speed values for every 10-minutes from October 2014 to March 2017 i.e. a total of two and half years. These 10-minute values were converted to monthly average wind speed and this monthly time series data was plotted as shown below in Fig. 4:

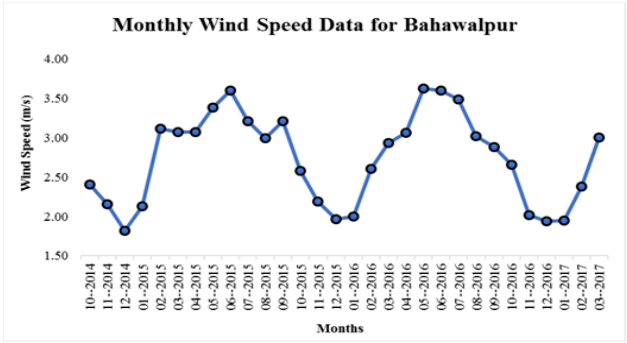

Figure 3 Monthly Wind Speed Data for Bahawalpur from October 2014 to March 2017

A maximum wind speed of 3.63 m/s was recorded in May 2016 and a minimum wind speed equal to 1.82 m/s was recorded in the month of December in 2015, during the time span of two and a half years. To check the seasonality and stationarity of the data, Autocorrelation and Partial autocorrelation functions of the data were plotted. The figures below show the significant value only at lag 1 while followed by all other values within 95% confidence limits. The significant value at lag 1 indicates that wind speed is dependent on only its previous value.

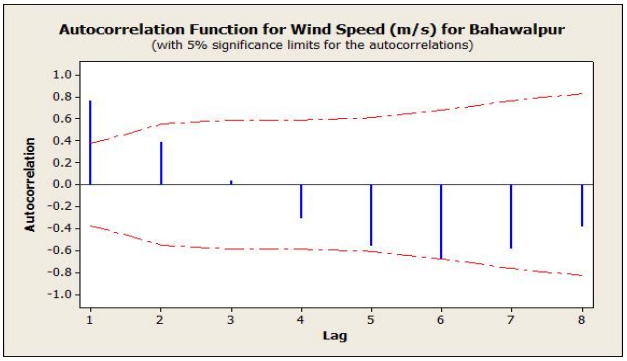

Figure 4 Autocorrelation Function for Bahawalpur Wind Speed Data

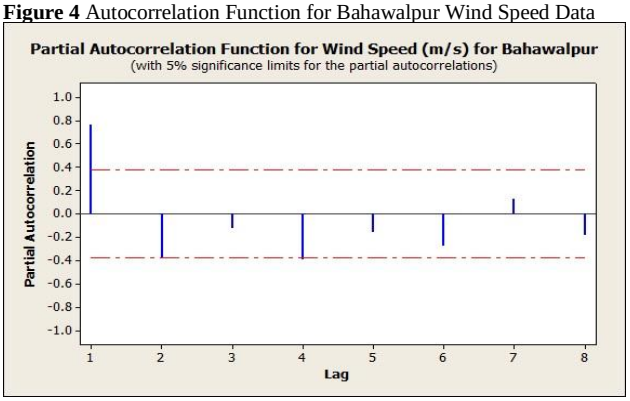

Figure 5 Partial Autocorrelation Function for Bahawalpur Wind Speed Data

Minitab software was used to perform normality test of the data by means of probability plot. A "p" value greater than 0.05 indicates that data is well-modeled and follows a normal distribution resulting in forecast with a good fit [12].

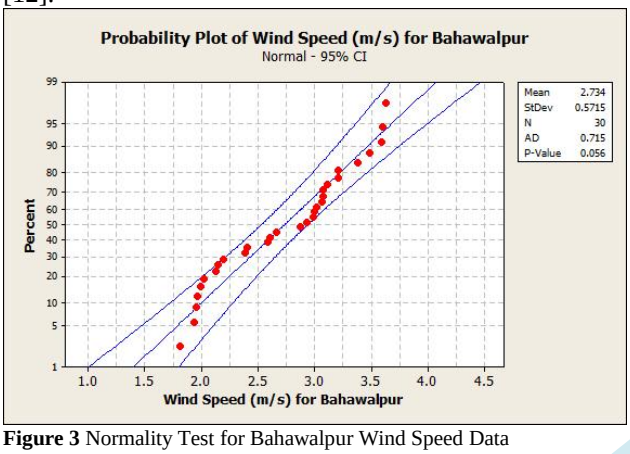

Figure 3 Normality Test for Bahawalpur Wind Speed Data

2.2 Forecasting using Artificial Neural Network (ANN)

Once normality of the data was verified, the time series was forecasted using ntstool of MATLAB software for the upcoming two and half years i.e. from April 2017 to September 2019. 70% of the total data was reserved for training of the algorithm while 15% was used to validate the data and the remaining 15% was used to test the algorithm. Number of delay was selected as one owing to the results of ACF and PACF plot i.e. significant values at lag 1. Hit and trial method was used to select the number of hidden neurons. The results showed that mean square error was minimized and regression (R) values were maximized when number of neurons was selected equal to 18.

Following table shows the comparison of MSE and R values for different number of neurons during all the three phases i.e. training, validation and testing of the process.

Phase	12 Neurons		14 Neurons		16 Neurons		18 Neurons	
	R	*MSE*	*R*	*MSE*	*R*	*MSE*	*R*	*MSE*
Training	0.66	0.09	0.85	0.08	0.89	0.02	0.97	0.10
Validation	0.73	0.16	0.88	0.23	0.36	0.32	0.42	0.09
Testing	0.74	0.15	0.62	0.24	0.47	0.59	0.53	0.26

TABLE 1 MSE and Regression Values for different Number of Neurons

The figure below shows that the overall regression value for the data is 0.80. which means data has been forecasted with a good accuracy.

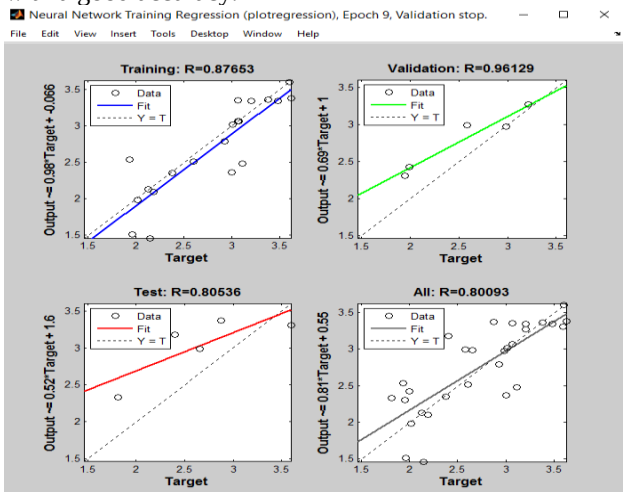

Figure 4 Regression Values during Different Phases of Artificial Neural Network

Following figure shows the forecasted values and their variation from the original values:

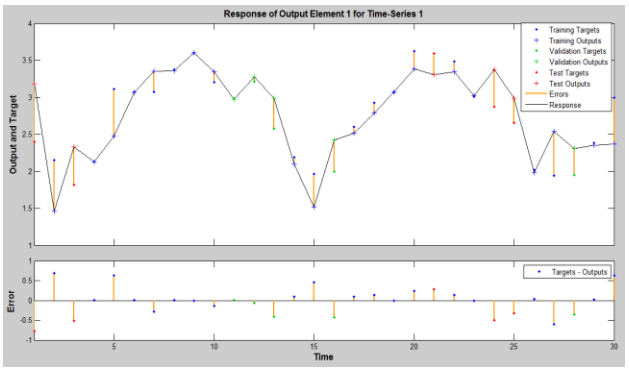

Figure 8 Forecasted Values of Wind Speed using ANN

2.3Technical and Financial Feasibility Analysis of Wind Farm using RETScreen

RETScreen is a clean energy management software which help assess and optimize different clean energy projects [13]. Wind speed data of two and half years was averaged for one year and the values were entered in RETScreen software. Wind shear exponent was selected as 0.37 due to urban location of Bahawalpur. Availability of wind speed was selected as 95%. 317 different wind turbines of various manufacturers and varying hub heights were tested against the given wind speed.

DW 54 wind turbine with hub height 75m, manufactured by EWT was selected. RETScreen software incorporates the changes in wind speed w.r.t hub height of the wind turbine i.e. for case of this study, available data of wind speed at 10m is projected at 75m which hub height of the above-mentioned wind turbine is. The projected speed is then used to calculate the wind power. Total 100 turbines were selected to produce 50MW power. Following figure show the power curve of wind turbine mentioned above:

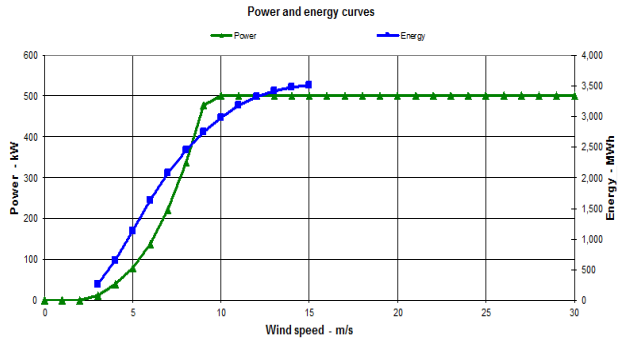

Figure 5: Power curve of DW54 Wind Turbine

For financial analysis, following parameters were considered as per directive of National Electric Power Regulatory Authority (NEPRA) for determination of tariff for wind power generation [14].

- Project cost (EPC and non-EPC costs): 1930 USD/KW
- Operation and Maintenance cost: Rs. 1.0670/KWh
- Insurance during operation: 0.5592/KWh
- Project life: 20 years
- Discount rate: 3.8%

- Discount rate: 10%
- Debt to equity ratio: 75%
-

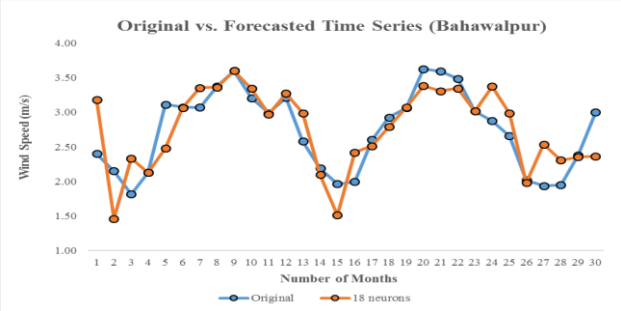

Figure 6 Comparison of Original and Forecasted Wind Speed Series

3 Results and Discussions

Forecasted wind speed was compared with original wind speed data and the comparison showed that the trend of the original time series was followed with great accuracy. The figure below is comparison of both the time series:

If we observe the wind speed trend of five years by combining original and forecasted data i.e. from October 2014 to September 2019, it shows a promising wind potential in Bahawalpur. Which if utilized effectively, can help to cater the energy needs of the area. Average forecasted annual wind speed is 2.8 m/s which is comparable to original value of 2.9 m/s.

The RETScreen results showed that a 50MW wind farm in Bahawalpur can produce 103.544GWh of energy with capacity factor of 23.6%. Electricity tariff was set as Rs. 7.7342 per KWh. Equity Payback period of the project is 18.4 years for a total lifetime of 20 years while simple payback period is 13.1 years. B:C ratio of the project is 0.11 which indicates that although technically feasible, the project is financially not viable. Cumulative cash flow graph for the project is shown below in figure:

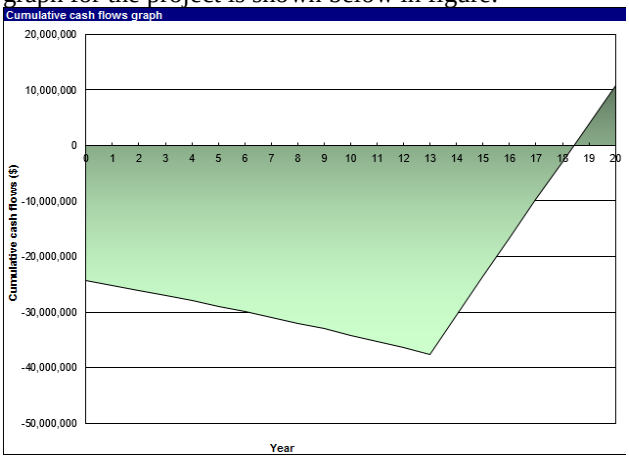

Figure 7 Payback Period Plot for a 50MW Wind Farm in Bahawalpur

The results discussed above show that a 50MW wind farm can generate an adequate amount of energy. However, with 100% local financing considering 75:25 debt to equity ratio, the project becomes financially unfeasible.

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