

# ENERGY RETROFITTING IN BUILT ENVIRONMENT: FINANCING AND POLICY EVALUATION

**Submitted by:** Ravi Shah

**Date:** August 18, 2016

**Supervisor:** Dr. Gail Krantzberg

**Master of Engineering and Public Policy**

**W BOOTH**  
SCHOOL OF ENGINEERING PRACTICE

---

W Booth School of Engineering Practice  
[msepmcmaster.ca](http://msepmcmaster.ca)

---

**Abstract:**

Given the current situation in which energy efficiency is considered as an important issue and the potential rise of greenhouse gas emissions, this paper analyzes and finds possible ways to improve energy efficiencies in buildings through an evaluation of existing business models and relevant policies.

The first phase of analysis includes the selection of the best business model from the existing retrofitting business models, comparing their performance to stakeholder interest and market challenges, based on the policy framework and its elements and therefore addressing the most suitable business model for the retrofitting process.

The second phase of analysis involves evaluation, based on the set Objectives/Goals, of the both private sector and government existing policy options for Financing the Energy Retrofitting of the buildings, thereby addressing the Financing challenges of the Retrofitting process.

Additionally, Policy Recommendations are made to improve the Energy Efficiency of the Building Envelopes as a whole and the Building Stocks that involve the Heating and Cooling Technology through Stakeholder engagement and Innovative Technological development.

## **Table of Contents:**

|   |    |
|---|----|
| 1.0 Introduction .....  | 1  |
| 1.1 Problem Introduction and Motivation .....   | 1  |
| 1.2 Background .....  | 1  |
| 1.3 Stakeholders .....  | 2  |
| 2.0 Energy Efficiency Policy Framework .....  | 3  |
| 2.1 Policy Framework Categories .....   | 3  |
| 2.2 Policy Implementation- Supportive Elements .....                                  | 3  |
| 2.3 Policy Implementation- Barrier Elements .....                                     | 5  |
| 2.4 Existing Business Models for Energy Retrofitting .....                            | 6  |
| 3.0 Analysis and Challenges .....   | 9  |
| 3.1 Stakeholders Primary Interest .....   | 9  |
| 3.2 Market Challenges .....   | 11 |
| 4.0 Evaluation of Retrofitting Business Models .....                                  | 15 |
| 4.1-Business Models performance against Stakeholder .....                             | 15 |
| 4.2-Business Models Performance against Markets .....                                 | 18 |
| 5.0 Evaluations of Policy Options .....   | 21 |
| 5.1 Private Sector Financing Options .....  | 21 |
| 5.2 Government/Public Sector Financing Options .....                                  | 26 |
| 6.0 Policy Recommendations .....  | 32 |
| 6.1-Policy Recommendations for Building Envelopes .....                               | 32 |
| 6.2-Policy Recommendation for Building's stock (Heating and Cooling Technology) ..... | 38 |
| 7.0 Conclusion .....  | 44 |
| References  |    |
| Appendix A: Energy Modelling instrument for Policy Evaluation                         |    |
| Appendix B: Feed-In Tariff Program: Economic and Environmental Benefit Analysis       |    |

Appendix C: Long Term Strategy for achieving Net-Zero Energy Homes

Appendix D: Stakeholders Action: An overview based on policy recommendations and long term strategy

List of Tables:

Table 1: Comparison of existing retrofitting business model

Table 2: Performance Evaluation of retrofitting Business models against Stakeholder Interests

Table 3: Performance Evaluation of retrofitting Business models against Market Challenges

Table 4: Evaluation of CMHC and Green House Program

Table 5: Evaluation of 2<sup>nd</sup> and/or 3<sup>rd</sup> Mortgages financing Program

Table 6: Evaluation of Home Equity Loan Program

Table 7: Evaluation of Chattel Mortgages Financing Program

Table 8: Evaluation of eco-ENERGY Program

Table 9: Evaluation of Ontario Affordable Housing Program

Table 10: Evaluation of Municipal Community Improvement Plan (CIP) Program

Table 11: Evaluation of Property Assessed Payments for Energy Retrofits (PAPER) Program

List of Figures:

Figure 1: Ideal Energy Model dimensions for Policy Evaluation

# **1 Introduction**

## **1.1 Problem Introduction and Motivation**

The problem was posed by a community member of Hamilton who is on the board of corporation of a 30 years old building located in Hamilton itself, when approached with the words saying “The Building is Leaking”. On further consultation it was found that the ‘City of Hamilton’ is facing the same problems as many buildings from the city has reported the same to the Office of Energy Initiatives.

The idea of retrofitting and refurbishing the old buildings for purpose of minimizing energy consumption is not a new idea. However, developing public policy agenda which can be an applicable tool in regards to international context can serve as a motivation not only for the concerned stakeholders but for the public as a whole due to the fact that Energy retrofitting generally involves technological aspects and developments that look at the technological side only, neglecting the public policy perimeter.

## **1.2 Background**

There exists a global opportunity for effective energy utilization thereby leading to greenhouse gas emission reduction and savings of money, both benefits knot together. However, large up-front capital is required to refurbish the built stock as the only way of paying back is savings derived from the same building energy consumptions. So, certain period of ROI (Return on Investment) is involved which has the possibility to go for ascertain period if not planned properly. Therefore, proper engagement of financing with the policies involved along with properly educating can handle the problems associated to address this global problem having barriers but opportunities involved.

Several studies have indicated that up to 20-50%, energy usage of a particular building can be reduced in a cost-effective way. (WBSCD, 2009) (EPA, 2006) (McKinsey, 2009) (Roadmap, 2010). Now, on global level, with energy targets to be achieved by emission reduction by 2050, it

is amongst one of the important consideration for significant number of countries that needs to be addressed (WBSCD, 2009).

Until 1970's oil crisis, no proper attention was given, and energy efficiency policy dates back to this history of oil crisis, when government start paying attention as the crises forced on taking measures for cost efficiency that were designed in particular to reduce emissions and guide consumer (it was oil but in this case the model can be applied to energy, refer Appendix-A). (Birgit, July 2012)

### **1.3 Stakeholders**

Energy retrofiting involves multiple stakeholders. It is necessary to consider the requirements of relevant stakeholder to develop a successful business model. As there is unique importance of each and every stakeholder for consultation and satisfying needs, there also lies different actions that needs to be taken by each stakeholder to meet the goals. So business acts by collaboration of all actors involved. The stakeholders involved in business model includes: building's occupant/residents and owner/residents, government, manufacturer/ trade associations, financial institutes, academia and research supporters, utilities (both service providers and regulators), retrofiting service providers (inclusive of all consultant and professional both commercial and non-commercial, directly or indirectly involved with the business).

## **2 Energy Efficiency Policy Framework**

There is regulatory framework established and under these regulatory elements there lies sub-elements which can be supportive or may serve as barrier in the implementation.

### **2.1 Policy Framework Categories**

Policies can be divided into the four main categories (Council C. G., Jan 2016) (Tsenkova, 2013) (Comission, Jan 2014):

#### **1-Standards/ Regulated Mandates**

This refers to strong building code which may be applicable to buildings, retrofit providers, cities/regions, utilities companies. These can be regarded as minimum prescribed standards that needs to be attained, thereby following set by-laws and legal compliances.

#### **2-Direct Cost Provisions**

This refers to any sort of government led direct assistance to cover the expenditure and other financial expenses that has a direct impact on energy retrofitting or related energy efficiencies investments. It can be in any policy-led form such as incentives, insurance, tax benefits or credit.

#### **3-Maket Mechanism**

This refers to creating single standardized energy certifications globally. Also, adaption of standardized fiscal codes for buildings. These can serve as a benchmarking tool for all energy efficiency programs.

#### **4-Eradicating Hurdles**

This refers to eradication of all the hurdles that affects market penetration of retrofitting. It may include everything from education to awareness and other assistances such as building labelling and certifications, energy usage information.

### **2.2 Policy Implementation- Supportive Elements**

#### **1-Standards/ Regulated Mandates**

Under this category the sub-elements include: strong building codes, requirements at building resale/rent time, service accreditations, opting-out, requirements of minimum spending, appliances standards. *Strong building codes* means adherence to the standards which would automatically ensure that the building stock is running in an energy efficient manner. This codes needs to be applicable both for newly developed building or existing building getting regenerated (Vaughan, 2012). *Requirements at building resale/rent time* means that it should be a compulsory requirement for any building that is being rent or resold to have energy labelling/ energy performance certificate. This would require the current owner or resident to adhere to retrofitting compliances (Association P. c., 2016). *Service accreditations* means retrofit service providers should be accredited in terms of technical warranties of the equipment installed. This ensures risk reduction on both the sides i.e. the customer and the lender (Council, 2015). *Opting-out* means that if government has made policy to make particular region or city regenerated than there is a possibility of any individual or particular small group to opt-out as during formulating policy, the whole of region/city is automatically considered. *Requirements of minimum spending* means that utilities provide little financial support from their profits. *Appliances standards* means that new appliances should meet energy efficiency standards and requirements (Energy, 2015).

## 2-Direct Costs Provisions

Under this category the sub-elements include: direct government incentives, government insurance/ risks, tax/ property financing. *Direct Government incentives* means any sort of incentives directly from the government in the form of loans or low interest rates (Canada, 2015). *Government insurance/ Risks* means government taking loan guarantees and loans below market rates (Toronto, 2016). *Tax/ Property Financing* means loans offered by municipalities for retrofitting purpose and repaid through additional surcharge on properties taxes being paid annually (Performance, 2011).

## 3-Market Mechanism

Under this category the sub-elements include: certificate programs, fiscal Incentives. *Certificate Programs* means to improve the efficiency based on setting targets and achieving this targets through energy trading system information (ETSI) by setting up a single database for gathering an information accessible by all. *Fiscal Incentives* means tax credits/ tax incentives for improvements in building energy efficiency or/and inefficiency penalties (Energy O. M., 2015).

#### 4-Eradicating Hurdles

Under this category the sub-elements include: education, requirement of energy labelling, government assistance. *Education* means developmental programs aimed at improving energy efficiency through retrofitting and also readiness to implement those learning outcomes for energy efficiency. *Requirement of Energy labelling* means performance ratings to be provided in clear and transparent manner if its need to be rented or sold out. *Government Assistance* means support from government in regards to publishing data and analysis in easily accessible format in forms of both electronic and a handbook and also update it on regular bases (Canada, Implementing an Energy Efficiency Awareness Program, 2012).

### **2.3 Policy Implementation- Barrier Elements**

#### 1-Standards/ Regulated Mandates

Under this category the sub-elements include: rates inversely proportional to uses. *Rates inversely proportional to Uses* means that Electricity rates declines as the use rises as when large providers gets cheap electricity to the consumer, incentives used for more efficient energy utilization declines. (Callander, 2016) (Board, 2015) (Smith, 2015)

#### 2-Direct Costs Provisions

Under this category the sub-elements include: limitations of Government led direct subsidy. *limitations of Government led direct subsidy* means that several projects are completed by government subsidy. However, this doesn't mean that those projects which are profitable and under implementation stage can be totally completed as they are also dependent on the government funding. Therefore, based on needs and requirements of market and its proper analysis subsidy should be designed in a careful manner. (Riggs, August 1991)

#### 3-Market Mechanism

Under this category the sub-elements include: Tax exemptions perception. *Tax exemptions perception* means if government emphasizes more on energy efficiency and conservation by providing tax exemptions or write-offs, it appears to be a wrong indication for utility service provider as their volume of use will be decreased and also negative beliefs amongst people thinking

that why government is focused on energy efficiency programs only when there are ‘N’ number of other way to address the different problems in different sectors to reduce emissions and reach national targets.

#### 4-Eradicating Hurdles

Under this category the sub-elements include: Profit-driven based on volume sold. *Profit-driven based on volume sold* means Utility industries are more profit-driven through sales, that means that their profit margin is low (like in cents per kilowatt-hour), so they are dependent on the ‘volume’ of electricity sold to determine their profits (Smith, Utilities’ Profit Recipe: Spend More, 2015). So if emphasizes are more laid on the energy efficiency it would led to disincentive of the customers. (Association, 2010)

## **2.4 Existing Business Models for Energy Retrofitting**

For Financing of any retrofitting projects, there are three basic models and each model involves a principle stakeholder (Owner, Utility company and Retrofit Service Providers) who generates the capital cost for the project. At a time of execution of the project, only one of the following three model can be factored in due to the fact that for business model to work efficiently it is necessary to ensure the interest of the particular stakeholder who develops funding initiatives. These models are quite common in all developed countries especially those with specific policies that focuses on Energy Efficiency by retrofitting. However, different size of energy retrofitting projects has been addressed by each of these below models (MEEFS, 2011)

### 1-Owner Financed Model

In Owner Financed Business Model, contracting with service providers, selecting retrofitting components and equipment and hence deciding the price under which project is to be carried out, is all under the control of the building owners. He/ She makes the economic decision and is therefore, fully liable for projects themselves. Overall Energy Performance ratings has nothing to do with his/ her payback. It is his/ her responsibility to pay for the full project cost. Therefore, he/ she pays by the savings or through loans. Under this model everything is under control of the owner. This model works perfect for single-property communities who are market oriented and

economically rational. However, one of the positive aspect is that if the outcome of the project is economical, the owner can clearly take all benefits himself/ herself in a long run without sharing with anyone. The whole cycle of designing, implementation and financing lies in responsibilities of the owner and contracts it to the service-provider. It is not necessary to pay the whole amount up-front for retrofitting cost as owner can pay as the project progresses or it depends on the agreement made by the owner with the contractor as they directly deal with each other. The owner has to not only take into consideration his/ her return in terms of ROI, but also post-retrofitting living conditions as criteria in decision-making. (Retrofitting, June 2013) (MEEFS, 2011)

## 2-Utility Fixed Repayment Model

In Utility Fixed Repayment Business Model, the Utility company is responsible for funding of retrofitting through subsidizing the up-front investment. These utilities company can be a part of government. Therefore, it needs a supporting policy framework in-case if the utility is a government-owned to get subsidy and effective support to function properly. Here the level of funding varies by program and funding of 100% cost involved is not guaranteed. The risk liability lies to both the utility companies and the financial institution. The cost is obtained from consumer's monthly payments and not at all performance related in terms of energy efficiency they are achieving after retrofitting or not or/and are being in profit or not. The building occupants are incurred fixed costs decided in agreement to repay after retrofitting is completed as a part of their repayment irrespective of their success or failure of retrofitting and so the building occupants are also liable to risk with respect to financing aspects. The advantage involved is that savings in terms of dollar amount and extra payment the residents pays to the utility company is displayed on the same bill which makes them to compare and realize their actual savings. (Kats, Updated: March, 2012) (MEEFS, 2011)

## 3-Energy Performance Model

In energy performance retrofitting business model, the financing of the project is done by the retrofitting service providers and repayment is done through savings achieved by being energy efficient after Retrofitting is carried out. So the cycle is simple, specialized Energy Service Retrofitting Provider finances the investment and from the generated Energy savings by retrofitting, the service provider directly recovers their capital investment. Here, the upfront capital costs are 100% funded at the start of the projects itself. One of the benefit of this performance

model is that it can be combined to another incentive scheme easily and therefore increasing the probability on the greater project returns. However, the agreement process involves quite a bit of documentation and negotiations. Moreover, development of this model in small business market is limited as it is difficult to track the accurate energy savings derived post-retrofitting and also to measure them to incorporate into bills to determine the savings achieved due to the fact that it involves many transaction costs that are not feasible for smaller projects. (Kats, Updated: March, 2012) (Commission, 2016)

The Table 1 below is the overview of all above mentioned retrofitting business models and compares all the three retrofitting model in aspects such as investment (who makes an investment), investment liability, Limitations with respect to financing, funding level and timing and growth potential with respects to markets the model can reach out.

Table1: Comparison of existing retrofitting business model

| <b>Retrofitting Business Model</b>   | <b>Investment</b>                  | <b>Investment Liability</b>        | <b>Limitations</b>                              | <b>Funding Level</b>                 | <b>Funding Timing</b>       | <b>Growth Potential</b> |
|--------------------------------------|------------------------------------|------------------------------------|---|--------------------------------------|-----------------------------|-------------------------|
| <b>Owner Financed Model</b>          | Building Owner                     | Building Owner                     | Owner's funding capacity                        | Depends on mutual agreement / Varies | Depends on Mutual Agreement | Medium                  |
| <b>Utility Fixed Repayment Model</b> | Utility/ Government                | No one/ Everyone                   | Regulations / supporting Policy framework       | Varies by Program                    | Upfront                     | Large                   |
| <b>Energy Performance Model</b>      | Energy/ Retrofit service Providers | Energy/ Retrofit service Providers | Financing Balance holdings of service providers | 100%                                 | Upfront                     | Limited                 |

### **3 Analysis and Challenges**

#### **3.1 Stakeholders Primary Interest**

Energy retrofiting involves stakeholders and they also have large role to play. Each stakeholder involves some primary interest associated with retrofiting and can be evaluated in the context of possible policy gaps to address successful implementation of the retrofiting program (Lawrence, 2010). Stakeholders analysis are classified into the following categories with their primary economic interests:

--Client

1-Owner (building owner/ boards/ corporations)

The primary interest of the owner is to maximize building value. So that when resold or rented, gets the desire price on the building.

2-Building residents/ occupant

The primary interest of the residents/occupants is to reduce the energy usage cost with comfortable living by minimum 'hassle' to them. Building occupant/ residents are the most important stakeholders involved as energy usage level is determined through them. (McKinsey, Pathways to a low carbon Economy, 2009)

--Finance

3-Equity funding agency/ institution

The primary objective is to maximize the returns on equity by knowing the risk involved with an opportunity to repay or exit within a horizon determined in particular fixed number of years (Network, 2015) based on the records and analysis being carried out by them as equity investments always involves third party risks and are subjected to market conditions.

4-Loan providing bank/ institution

The primary objective is similar to equity funding agency as they are interested to see steady cash-flows records and make predictable estimates which realizes them that are on a proper track. This makes the Banks more comfortable in lending and serving their clients for retrofitting projects as they aren't experts in making assumptions but cash-flow analysis makes them more comfortable.

--Gas and Electricity utilities

5-Power generators

The primary interest of power generators is to generate more power at lower cost and to increase their volume of sales.

6-Power distributors

The primary objective of power distributors is to maximize and generate more profits from their power distributions revenues.

7-Electricity suppliers and/or retailers

The primary interest of electricity suppliers is to maximize profit from their electricity retail business by more energy sales.

8-Gas providers

The primary interest is similar to that of electricity supplier, but here to maximize their profits from gas provisions. Today gas powered appliances are less used especially in residential buildings but maybe in future it is possible that buildings use more combined heat and power/ co-generation facilities and during that time, gas providers will have crucial role to play (commission, 2016) (Solutions, 2015).

--Other/ Miscellaneous

9-Energy service retrofit providers

The primary objective of the service providers is to develop their business more and earn more profits from their business and every future projects. Moreover, they also build long-term

relationships with buildings they managed in the past for retrofitting and also do servicing and maintenance stuffs for the buildings they worked on for retrofitting purpose, for long period of time (maybe life-long also).

#### 10-Government

Governments have several primary interests but all are inter-related such as reducing GHG emissions, developing region as overall and increasing employment opportunities and improving energy security, thereby creating values to the national economy as a whole.

### **3.2 Market Challenges**

Apart from stakeholder analysis and gaps, there are more loops in the successful implementation of the program that are referred as market challenges. The term described here as ‘Market Challenges’ are categorized into market structural, financial and behavioral aspects which offers challenges for retrofit markets penetration, with each categories having sub-elements under it.

#### --Structural Aspects

##### 1-Market aggregation

This barrier means that there are large number of retrofitting service providers and all fragmented at different scales. Moreover, retrofitting involves changes in the different equipment which are purchased from different manufacturers and also with some retrofitting service providers there are sub-contractors involves in which say for example installation work is done by the different set of peoples and maintenance is done by the different group of people. Also, this type of purchases involves a cost known as ‘Transaction Cost’. However, in some cases ownership varies when there is not the problem involved with transaction cost say the owner can be a government or large property owner or owned by a corporation. So, it is necessary to provide a ‘one-stop’ shop solution and achieve economy of scale to tailor the requirements according to the project. (Nock, 2010)

##### 2-Tenants or ownership changes

This refers to the irregularities or changes over period of time. As nothing is constant, there is always a possibility that the owner-ship of the building changes or patterns of occupants/ resident energy usage changes. So, instead of getting tied-up to owner or occupants in the deal, energy retrofitting should be concerned with the building itself only irrespective of the owner or residents. Therefore, payment should be from account of building or directly to the property taxes, a separate building account payable independent of the ownership or tenants as overall benefits of retrofitting will ultimately go to them only. (Torbert, 2012)

### 3-Internal conflict

Generally, the occupants are the beneficiary group of people from any sort of retrofitting that is carried out in the building. They enjoy new technologies and energy savings. However, all the initial arrangements (which may involve some spending also) need to be made by the owner himself/ herself. However, post retrofitting there is conflict between the same group of people with the owner/ board with respects to incentives splitting and monetary sharing aspects. Also, any inconvenience caused post-retrofitting, the occupants have to suffer. So there is conflict of interest between the owner who is considered as the building value beneficiary in the market and residents who play an important role in ultimate energy usage. (Belliveau, Spring 2011)

### 4-Discouraging regulatory policies

There are certain examples in which countries maintain their policies that discourages the energy efficiencies. In US, the regulator, under utility regulation set up a fixed price per kWh for a period of time by calculating expected utility costs divided by their expected sales of kWh and then the system is developed such that incentives are developed to increase the electricity sales and decrease their cost, thereby ensuring profitability increase (Duke, 2008). Say in US, there is legal restriction on companies for charging them for energy efficiency improvements in building (David Hoppock, November, 2008). However, only 15 provinces have achieved success to restructure it (Energy U. d., 2010).

### --Financial Aspects

### 5-Cherry plucking

This refers to lack of ‘whole building approach’ which means that there are certain strategies used in retrofitting out of which one involves refurbishing less costly equipment to start with and then track the savings, if effective then not all equipment or components of buildings are refurbished. ROI is also taken into consideration. This is known as cherry plucking. But later it sometimes becomes difficult to find less attractive components easily. Moreover, whole approach gives definite paying back period time and economics of ROI are also properly known. (Baker, March 2012)

#### 6-Energy requirements changes

This refers to consumer preferences that changes over period of time. Now, if in the nearby future there are major changes in the energy usage patterns and if the pay-back period was based on the usage estimates and forecast, then it is troublesome. (CMHC, 2002)

#### 3-Return Rate Expectations

This refers to the perceived retrofitting risk, as Energy prices are volatile and if forecasts are based on energy savings then there are possibilities of variations and return rates. Moreover, even though retrofitting appears to be an attractive and beneficiary for the energy efficiency, many residents are reluctant as they might already be in debt for house or any other. So they fear to take little more debt by retrofitting investment. This is because retrofitting is an investment whose value is realized over period of time. Therefore, it can be said that both consumer and investor have unrealistic expected returns from investment for energy efficiency. (Fuller, 2008) (Tversky, 1979) (NRDC, 2008)

#### --Behavioral Aspects

#### 7-Awareness

This refers to the lack of awareness and understanding today’s users and service professional lacks with regards to the building energy usage and at the same time maintaining the quality of life leads to improper energy efficiency improvements decision making. Therefore, proper information and awareness is necessity for the success. (Karen Palmer, October 2011)

#### 8-Non-economic decisions

Generally, decisions are based on non-economic factors as consumers don't do detail analysis like cost estimating and projecting or cost/ project optimality etc. Their ultimate decisions are never made on base of economic rationale only. Their decision making approach is affected by the hierarchy of needs and requirements and their desired goals. (CIEE, 2009) (Witta Ebel, 2016)

#### 9-Rebound Effect

This refers to the general human behavioral aspects say for example if you are saving from the energy efficiency, you will increase the use. Like if your old fridge wasn't efficient in terms of energy savings, you will replace it with the new one which has better energy ratings and performance, but possibilities are high you may keep the old fridge somewhere in storage place or garage for any small general purpose. Say another example a fan or a heater. Keeping it in backyard for leisure time. (WBSCD, 2009) (Labandeira, 2010) (Erdal Aydin, October 24, 2015)

#### 4 Evaluation of retrofitting business models

Evaluation of business models is carried out by comparing the retrofitting business model against stakeholders and market challenges to determine the best suited retrofitting model not only meeting stakeholder interest but also be able to address the market challenges.

As far as addressing stakeholder primary interest is concerned, the business models are measured and their performance are categorized into 5 aspects, out of which 0 representing no interests are met and 10 representing all interests met (but these are likely to be the case to happen). Therefore, the further divisions are based on condition in which almost interests are not met so 2.5 or mostly met so 7.5. And, 5 points for stakeholder interests that are partially met.

Similarly, for measuring performance against addressing market challenges, for 0 and 10, it indicates that business models are not addressing at all or are completely addressing, however, this is also very less in terms of possibilities to successfully address all challenges. Therefore, for mostly not addressed it is 2.5 and for mostly addressed it is 7.5. And, in between 5 for partially being able to address the challenges.

##### 4.1-Business Models performance against Stakeholder

The following decision matrix table evaluates how each of the business models will perform against the stakeholder’s primary interests.

For Points out of 10,

0=No Interest met, 2.5=Most Interests not met, 5=Interest partially met (depending upon the circumstances), 7.5=Interest Mostly met, 10=Interests all met

Table 2: Performance Evaluation of retrofitting Business models against Stakeholder Interests

| <b>Stakeholder</b> | <b>Owner Financed Model</b> | <b>Utility-Fixed Repayment Model</b> | <b>Energy Performance Model</b> |
|--------------------|-----------------------------|--------------------------------------|---------------------------------|
| <b>Client</b>      |                             |                                      |                                 |

|  |     |      |      |
|--|-----|------|------|
| Owner (Building Owner/Boards/Corporations) | 2.5 | 5    | 7.5  |
| Building Residents/<br>Occupant            | 2.5 | 2.5  | 5    |
| <b>Finance</b>                             |     |      |      |
| Equity Funding Agency/<br>Institution      | 0   | 0    | 2.5  |
| Loan providing Bank/<br>Institution        | 2.5 | 2.5  | 2.5  |
| <b>Gas and Electricity Utilities</b>       |     |      |      |
| Power Generators                           | 0   | 0    | 0    |
| Power Distributors                         | 0   | 2.5  | 0    |
| Electricity Suppliers and/or<br>Retailers  | 0   | 5    | 5    |
| Gas Providers                              | 0   | 2.5  | 0    |
| <b>Other/Miscellaneous</b>                 |     |      |      |
| Energy Service Retrofit<br>Providers       | 2.5 | 7.5  | 7.5  |
| Government                                 | 0   | 5    | 2.5  |
| <b>Total Success Points:</b>               | 10  | 32.5 | 32.5 |

#### Owner Financing Retrofitting Model:

Owner financing model has no scores in relations to electricity and gas utilities companies as none of their interests are related to each other as the utility companies are concerned with stuffs that the owner is concerned to reduced (owner on electricity usage reduction and utility on to increase their volume of sales to earn more profits) and therefore there is no point in assuring to see whether the interests has been met or not and moreover there are more provisions for utility to grow under different business model. Building owner is likely to approach equity provider and equity funding institute is likely to provide support to them due to the third party involvement and unknown success or risks guarantee. Therefore, the option available is loan providing banks/ institutions.

The building owner deals directly with the service provider and everything of the project is done on the basis of set agreements. It is likely that their interests meet initially as both involves their own opinions and ideas. This model works well only for those residents who are conscious about the environment and access to finance, with all resources to manage retrofitting process.

#### Utility Fixed Repayment Model:

This model has an overall moderate performance in meeting stakeholder's interest. With financing risk liability to everyone, equity funding agency does not get involved in providing any sort of financial support. The generator's interest is not met of achieving high sales in terms of volume of electricity. However, with some shared responsibilities of finance, customer needs are fairly met well. The shortcoming of this model is that the risks is fully not assured by the utility companies and irrespective of retrofitting performance consumers pays the fixed amount annually or monthly as agreed upon. However, electricity retailer interests are met to some extent as they are maximizing their profit on investment, as the ultimate return goes to them. The government interests are mostly met as their policy are decided more based on the utility focused then consumer focused (because it is hard to determine the consumer behavior and trends), as they are key in terms of nation's economy aspects.

#### Energy Performance Model:

This model is best suited to the consumer interests. As the returns are linked to Retrofitting performance, under this model there are some strict actions taken to ensure the performance of retrofitting such as penalizing usage deviations etc., and this all are done to ensure the post-retrofitting success as everyone are benefited if it is achieved. The constraint of balance sheet issue makes it score low on financial aspects. This model has a capacity to create a win-win situation and minimize the debt and other risks involved as compared to other model due to the fact that here shared responsibility is involved not in compulsion such as payments (as compared to utility fixed model) or high-risks for particular segment (such as owner financed model) but everything are in terms of betterment, therefore would ensure positive efforts from everyone perceiving better future prospect and positive environment.

To summarize, the basic and the most common weakness appearing in all the three business models is to attract the proper retrofitting financing. Utility fixed repayment model takes care of financing

but the risks involvement is too high for all people in finance aspect and is unclear how the pay-back will be for medium to long run as compared to Energy performance model where there are problems initially only such as proper sets of agreements and documentation.

#### 4.2-Business Models Performance against Markets

The following decision matrix table evaluates how each of the business models will perform against the various Market Aspects.

For Points out of 10,

0=Not Addressed, 2.5=Mostly Not Addressed, 5=Partially Addressed, 7.5=Mostly Addressed, 10=Completely Addressed

Table 3: Performance Evaluation of retrofitting Business models against Market Challenges

| <b>Market Aspects</b>               | <b>Owner<br/>Model</b> | <b>Financed<br/>Repayment Model</b> | <b>Utility-Fixed<br/>Performance Model</b> |
|-------------------------------------|------------------------|-------------------------------------|--|
| <b>Structural</b>                   |                        |                                     |  |
| Market Aggregation                  | 0                      | 5                                   | 2.5  |
| Tenants or Ownership<br>Changes     | 2.5                    | 7.5                                 | 2.5  |
| Internal Conflict                   | 0                      | 2.5                                 | 5  |
| Discouraging<br>Regulatory Policies | 0                      | 0                                   | 0  |
| <b>Financial</b>                    |                        |                                     |  |
| Cherry Plucking                     | 5                      | 0                                   | 2.5  |
| Energy Requirements<br>Changes      | 0                      | 0                                   | 7.5  |
| Return<br>Rate<br>Expectations      | 2.5                    | 7.5                                 | 5  |
| <b>Behavioral</b>                   |                        |                                     |  |
| Awareness                           | 2.5                    | 5                                   | 5  |

|                              |      |      |      |
|------------------------------|------|------|------|
| Non-Economic Decisions       | 0    | 5    | 2.5  |
| Rebound Effect               | 0    | 0    | 5    |
| <b>Total Success Points:</b> | 12.5 | 32.5 | 37.5 |

**Owner Financing Retrofitting Model:**

The owner financing model has very limited ability to address the market challenges except for the cherry plucking as all the decision lies to the owner, otherwise it fails for addressing almost all other market challenges. Also, it addresses the challenge of return-rate expectations as the residents might be reluctant to add any extra debt. It is necessary for this model to leverage to reach the scale. The model however does not address the challenge of change in energy requirement which should be a key consideration for the owner in post-retrofitting situation, especially when owner has financed the investment. And, non-economic decisions too as the decision is made by the owner solely on his ability and little considerations of resident ability, therefore lack of proper estimation and costing by not considering everything in making decisions.

**Utility Fixed Repayment Model:**

Utility companies has a ready data of energy usage pattern and consumer tend in the energy uses and therefore they can help overcome any type of agent problems (the sole person who is responsible for taking any decision) as retrofitting involves many decision maker and opinion generators. Therefore, this model can help achieve non-economic decisions along with spreading awareness and information. It does not address the issue of the cherry plucking or changing energy requirements as they aren't concerned about the post-retrofit conditions.

**Energy performance Model:**

Energy performance model addresses the challenges aggregately, however not having access to direct consumer bills and usage patterns increases difficulty for this model but unlike utility fixed repayment, their concerns lies post-retrofitting conditions too and therefore paths forward to achieve the retrofitting success. Also the rebound effect could be handled by detailed and proper contracts. However, there is lack of support from the government for this model (as service

providers are responsible for upfront capital investment, this service provider are business enterprises and they don't get money from the government) and also faces behavioral issues (opinions generated for retrofitting as per the individual needs and interests).

None of the model addressing or countering the discouraging regulatory policies (but most of them is prevalent in US only (Duke, 2008)) and all models are low on financing segment.

## **5 Evaluations of Policy Options**

There are two financing mechanisms that applies to energy retrofitting model i.e. Private Sector (Banking Institutions and other financial institutes such as credit unions) and Public Sector (Government support). In addition, the Feed in Tariff is analyzed in terms of economic feasibility, as it is one of the most well-known program in Ontario (refer Appendix-B).

The analysis includes four objectives: Deep reductions, Retrofit larger homes in terms of percentage, Affordable capital access and Benefits to the society. *Deep Reductions* includes elements like low interest rates, net energy cost savings, optimizing energy savings and Minimizing debt of owner, municipality, and per house costing to program facilitator who carries out process. *Retrofit larger Homes in terms of percentage* includes elements like Upfront capital costs and Attachments with assets financially say for example if owner empties his house to move to other house but if retrofitting is going on than he has to pay for finance but does not enjoy the benefits of retrofitting. *Affordable Capital Access* includes element like Keeping risks low of lender/ investors. *Benefits to the Society* includes element such as feasibility to all income level along with health, environmental benefits with off-course economic benefits.

The final evaluation output is formulated in the table in the format of ‘Yes’, ‘No, or ‘Blended’ which means if ‘Yes’ than it fits for the financing option and is beneficiary. ‘No’ represents that the desired objective is not been able to be identified from the evaluation option. Whereas, ‘Blended’ refers to the conditional situation in which in certain manner the option has been able to meet the objective and in some ways not.

### **5.1 Private Sector Financing Options**

Canada Mortgage and Housing Corporation (CMHC) and Green House program are two of the options are available and under this sub-category includes taking retrofitting loan as 2<sup>nd</sup> or 3<sup>rd</sup> Mortgage and Home Equity loan.

#### **1-CMHC Mortgage Loan**

CMHC Loan insurance works with Green House program for energy improvement costs (CMHC, Canadian Mortgage and Housing Corporation, 2014). From Table 4 which shows evaluation of CMHC and Green House Program it is clear that in spite of low interest rate with ownership equity

less than 20 percent, the debt isn't reduced on the ownership's totals (LaScelles, June 17, 2010 ). For the facilitator if he is the financing entity (say like owner model) reduce the costs to him due to lower rates but not to the retrofitting program as a whole because the debt remains. It reduces debt to the municipality is in the aspect that the municipality are not involved in this type of financing and therefore do not provide any sort of financing from their funds. The second goal is also blended as in terms of providing upfront capital costs it provides the finance. But it is attached to the assets so in case if owner moves owner repaid a part of it but now no longer could enjoy the benefits. There are no cash flow benefits from retrofits since the repayment is designed such that the savings doesn't exceeds the payment they have to do back the financing mechanisms. So no such cash flow benefits are visible. In terms of availability, it depends on the credits for lower housing income (LaScelles, June 17, 2010 ) but the green house program is also available to those who have acquired less than 20 percent of house equity (LaScelles, June 17, 2010 ) and green jobs are also limited thereby making the objective blended.

Table 4: Evaluation of CMHC and Green House Program

| <b>Objective</b>                                      | <b>Evaluation Output</b> |
|---|--------------------------|
| <b>Deep Reductions</b>                                | <b>Blended</b>           |
| Low Interest Rates                                    | Yes                      |
| Minimizes Debt of Owner                               | No                       |
| Minimizes Debt of Municipality                        | Yes                      |
| Lowers the cost per house to Program facilitator      | Blended                  |
| <b>Retrofits larger homes in terms of percentages</b> | <b>Blended</b>           |
| Provides upfront Capital Cost                         | Yes                      |
| Assets attachments to Finances                        | Blended                  |
| <b>Affordable Capital Access</b>                      | <b>Blended</b>           |
| Lowers Investor/ Lenders risks                        | Blended                  |
| <b>Benefits to the Society</b>                        | <b>Blended</b>           |
| Availability for levels of income                     | Blended                  |
| Economic Benefits                                     | Blended                  |

## 2-2<sup>nd</sup> or/and 3<sup>rd</sup> Mortgages

The Table 5 as shown below indicates the summary of 2<sup>nd</sup> or/and 3<sup>rd</sup> Mortgages financing program and from the table it is clear that eligibility depends on the credit history and loan-to-value ratio (Lohmueller, June 2010). As it is paid after the 1<sup>st</sup> Mortgage the interest rates tend to be higher as compared to 1<sup>st</sup> Mortgage. Municipalities has no role to play in this type of financing. Whatsoever, there are no financing upfront for low-to-middle income so it can be considered as blended and assets attachments considerations are similar. But in case of risks involved it is a clear No as more risks is involved as both the lender and the investor are behind the first mortgage on money liquidation. And, as not accessible to low income due to the fact that higher interest rates imposed for second or third mortgage but would create some green jobs as this is an extra opportunity by giving a loan for retrofitting, those who already are under some sort of mortgage (Jens, september, 2010) (Corps, June 2010), therefore can be defined blended in terms of being beneficiary to the society. Again, here also being a private sector financing, it reduces debt to the municipality is in the aspect that the municipality are not involved in this type of financing and therefore do not provide any sort of financing from their funds.

Table 5: Evaluation of 2<sup>nd</sup> and/or 3<sup>rd</sup> Mortgages financing Program

| <b>Objective</b>                                      | <b>Evaluation Output</b> |
|---|--------------------------|
| <b>Deep Reductions</b>                                | <b>No</b>                |
| Low Interest Rates                                    | No                       |
| Minimizes Debt of Owner                               | No                       |
| Minimizes Debt of Municipality                        | Yes                      |
| Lowers the cost per house to Program facilitator      | Blended                  |
| <b>Retrofits larger homes in terms of percentages</b> | <b>Blended</b>           |
| Provides upfront Capital Cost                         | Blended                  |
| Assets attachments to Finances                        | Blended                  |
| <b>Affordable Capital Access</b>                      | <b>No</b>                |

|                                   |                |
|-----------------------------------|----------------|
| Lowers Investor/ Lenders risks    | No             |
| <b>Benefits to the Society</b>    | <b>Blended</b> |
| Availability for levels of income | Blended        |
| Economic Benefits                 | Blended        |

3-Home Equity Loans

The Table 6 shown below indicates Home Equity Loans program evaluation which is taken for energy improvements and is in relations to first mortgage i.e. it is paid in par with mortgage. It simply means that the owner has acquired the sufficient equity over the house when it is under the first mortgage of the house through line of credit and shows good line of credit. Interest rates are low but accessible only for good line of credit household. Debt stays on the owner’s total and municipalities has no role to play and therefore it reduces debt to the municipality in the aspect that the municipality are not involved in this type of financing and therefore do not provide any sort of financing from their funds. Upfront capital costs available only to those middle to upper income houses showing the potential to pay-off in extra to 1<sup>st</sup> Mortgage. Assets attached to finance as they don’t enjoy the benefits. Moreover, the risks are not lower as peoples are still into liquidation if they carry 1<sup>st</sup> Mortgage. Home equity loan is not available to low income people but the green house loan insurance is accessible to those who have acquired less than 20 percent of home equity (Lohmueller, June 2010) and would create some jobs through deeper retrofits which involves overall house architecture changes for achieving greater cost savings. (Architects, 2013)

Table 6: Evaluation of Home Equity Loan Program

| <b>Objective</b>        | <b>Evaluation Output</b> |
|-------------------------|--------------------------|
| <b>Deep Reductions</b>  | <b>No</b>                |
| Low Interest Rates      | Blended                  |
| Minimizes Debt of Owner | No                       |

|   |                |
|---|----------------|
| Minimizes Debt of Municipality                        | Yes            |
| Lowers the cost per house to Program facilitator      | Yes            |
| <b>Retrofits larger homes in terms of percentages</b> | <b>Blended</b> |
| Provides upfront Capital Cost                         | Blended        |
| Assets attachments to Finances                        | Blended        |
| <b>Affordable Capital Access</b>                      | <b>Yes</b>     |
| Lowers Investor/ Lenders risks                        | Yes            |
| <b>Benefits to the Society</b>                        | <b>Blended</b> |
| Availability for levels of income                     | Blended        |
| Economic Benefits                                     | Blended        |

4- Chattel Mortgages

This mortgages allows the financing of the moveable equipment and energy improvements for the owner, if they decide to move, they can take with them wherever they wish to move as it can be seen from the Table 7 which describes summary of the Chattel Mortgages program. It works in relations to Ontario Personal Property Security Act (Westeinde, June 9, 2010 ) in which owner borrows’ energy retrofitting done by taking chattel mortgages for obligation on moveable equipment (CMACM, 2015). But it has higher interest rate, higher than those of the 2<sup>nd</sup> mortgage as a result of which debt is not minimized and municipality again has no role to play. It provides the upfront cost but not available to low income individuals but here if owner moves then he can take the assets with him wherever he wishes to move. For the society it is not at all available to low income people due to the fact of higher interest rate and high levels of payments requirement and would however create some jobs. The problems involve lot of documentation and difficulty of financing in terms of combination of both moveable asset and fixed asset (Corps, June 2010).

Table 7: Evaluation of Chattel Mortgages Financing Program

| <b>Objective</b>                                      | <b>Evaluation Output</b> |
|---|--------------------------|
| <b>Deep Reductions</b>                                | <b>No</b>                |
| Low Interest Rates                                    | No                       |
| Minimizes Debt of Owner                               | No                       |
| Minimizes Debt of Municipality                        | Yes                      |
| Lowers the cost per house to Program facilitator      | No                       |
| <b>Retrofits larger homes in terms of percentages</b> | <b>No</b>                |
| Provides upfront Capital Cost                         | Blended                  |
| Assets attachments to Finances                        | Yes                      |
| <b>Affordable Capital Access</b>                      | <b>No</b>                |
| Lowers Investor/ Lenders risks                        | No                       |
| <b>Benefits to the Society</b>                        | <b>Blended</b>           |
| Availability for levels of income                     | Blended                  |
| Economic Benefits                                     | Blended                  |

## 5.2 Government/Public Sector Financing Options

Under government financing mechanisms there are various programs for the implementation of the energy retrofitting in the buildings to improve energy efficiency and achieve their net emission reduction targets from one particular sector. These programs are aimed at promoting the retrofitting, however there are some loopholes involved and therefore evaluation of the policy options is done to determine whether the goals/objectives are met or not and up to what level.

1-ecoENERGY Program

It is the initiative of Government of Canada's plan to achieve reduction in emissions along with maintaining nation's economic advantage. The 5 strategic areas for priority decided are: energy efficiency, clean electricity and renewables, bioenergy, electrification of transportation and unconventional oil and gas (NRCan, 2016). There were no upfront financing options as the eligibility of the program was improvements over of 4,000 tons of GHG emission over 20 years in which applicant can request maximum up to \$250,000 per project and the analysis involved feasibility studies, engineering and environmental assessments methodology, partnerships and community development, costing etc. so interest rates are non-applicable and debt are not visible as there should be up-front grant for the debt visibility and therefore no burden on the municipalities for this sort of financing program. Also, it is unlikely that government have budget for all retrofitting all homes. Therefore, the second objective is also not achieved. As far as keeping the risks low, it was a great success as investor/ lenders were not in any sort of initial financial obligations or debts. Benefits are derived lesser to lower and middle income people for deeper retrofits as it works in either way because they need money to make changes and show emission savings to the government which is less likely a possibility for them. The programs would create Jobs and ensure other benefits to the communities as it is all summarized in Table 8 which describes the evaluation of eco-Energy program. (EANCP, 2016) (nrcan, 2016)

Table 8: Evaluation of eco-ENERGY Program

| <b>Objective</b>                                      | <b>Evaluation Output</b> |
|---|--------------------------|
| <b>Deep Reductions</b>                                | <b>Blended</b>           |
| Low Interest Rates                                    | N/A                      |
| Minimizes Debt of Owner                               | Blended                  |
| Minimizes Debt of Municipality                        | Yes                      |
| Lowers the cost per house to Program facilitator      | Yes                      |
| <b>Retrofits larger homes in terms of percentages</b> | <b>Blended</b>           |
| Provides upfront Capital Cost                         | No                       |
| Assets attachments to Finances                        | N/A                      |
| <b>Affordable Capital Access</b>                      | <b>Yes</b>               |

|                                   |                |
|-----------------------------------|----------------|
| Lowest Investor/ Lenders risks    | Yes            |
| <b>Benefits to the Society</b>    | <b>Blended</b> |
| Availability for levels of income | Mixed          |
| Economic Benefits                 | Mixed          |

2-Ontario Affordable Housing Program

With an aim to provide a secured loan for northern region and remote communities, the program was developed. It provided finance for repairs and rehabilitation to private homes, including energy retrofitting. It combined the fund through CMHC and Ontario and Municipal funding but was a separate plan program form municipality local improvement plan. It is clear from the Table 9 as shown below which evaluates the Ontario Affordable Housing program that this program was only accessible to lower income peoples from the start of the program, it had low interest-rates, however the debt remained at the owner and municipality sheets. It provided upfront capital costs however assets were attached to the finance but was in the blended way as the financing balance was not transferrable in case it was a new owner. It kept the risks low but still in the debt, makes the objective of the program for affordable capital access as blended. Also, the program was only available for low income, it supported middle income class having due requirements. So blended in that aspects too (Housing, 2015) (CMHC, Affordable Housing Programs in Ontario, 2016) (Affairs, 2016) (Affairs M. o., August 2014).

Table 9: Evaluation of Ontario Affordable Housing Program

| <b>Objective</b>                                      | <b>Evaluation Output</b> |
|---|--------------------------|
| <b>Deep Reductions</b>                                | <b>Blended</b>           |
| Low Interest Rates                                    | Yes                      |
| Minimizes Debt of Owner                               | No                       |
| Minimizes Debt of Municipality                        | No                       |
| Lowers the cost per house to Program facilitator      | Unknown                  |
| <b>Retrofits larger homes in terms of percentages</b> | <b>No</b>                |

|                                   |                |
|-----------------------------------|----------------|
| Provides upfront Capital Cost     | Yes            |
| Assets attachments to Finances    | Blended        |
| <b>Affordable Capital Access</b>  | <b>Blended</b> |
| Lowers Investor/ Lenders risks    | Blended        |
| <b>Benefits to the Society</b>    | <b>Blended</b> |
| Availability for levels of income | Blended        |
| Economic Benefits                 | Blended        |

3-Municipal Community Improvement Plan Program

The Municipal community improvement plan was developed for improving finances for municipality works which allows the area specific municipalities to provide loans in their designated area to private owners for improvements including energy retrofitting to achieve energy efficiency in homes. As summarized from the Table 10 below, the CIP program is not available to the home-owners with low income as they provide upfront capital cost but needs to be repaid (Makuch & Associates and David Bronskill, 2012). Therefore, debt is not minimized on owner’s total. There is an option available for securing loan without any security but then high interest rates would be incurred (Persram, 2010). Moreover, title of the ownership is attached to the municipality and therefore, there is possibility of new owner transfer-ship (Makuch, 2010). It doesn’t keep the risks low as debt remains and therefore not available to low income people also. Due to financial mechanism and setting up of Municipal Business Corporation (MBC) for providing CIP loans, even though municipalities have low interest rates than private sectors, it is not possible as for CIP there is higher interest rates and therefore not accessible by very low-income families (staff, Fall 2009). (Kingston, 2016) (Housing O. M., 2015)

Table 10: Evaluation of Municipal Community Improvement Plan (CIP) Program

| <b>Objective</b>        | <b>Evaluation Output</b> |
|-------------------------|--------------------------|
| <b>Deep Reductions</b>  | <b>Blended</b>           |
| Low Interest Rates      | No                       |
| Minimizes Debt of Owner | No                       |

|   |                |
|---|----------------|
| Minimizes Debt of Municipality                        | Blended        |
| Lowers the cost per house to Program facilitator      | No             |
| <b>Retrofits larger homes in terms of percentages</b> | <b>Blended</b> |
| Provides upfront Capital Cost                         | Yes            |
| Assets attachments to Finances                        | Yes            |
| <b>Affordable Capital Access</b>                      | <b>Blended</b> |
| Lowers Investor/ Lenders risks                        | No             |
| <b>Benefits to the Society</b>                        | <b>Blended</b> |
| Availability for levels of income                     | Blended        |
| Economic Benefits                                     | Blended        |

4-Property Assessed Payments for Energy Retrofits (PAPER)

The program is delivered on revenue neutral basis by the municipalities and therefore minimizes the costs both to the taxpayers and the municipalities. It is clear from the evaluation of PAPER Program in Table 11, PAPER provides upfront capital costs and it also ensures that savings from energy efficiency exceeds the retrofitting cost and annual payments to be paid (ontario, 2012) (Foundation, 2011). Therefore, PAPER is accessible to all income levels of homeowners. So here the obligations do not lie to the owner himself/ herself and so do not lie just on owner’s total. There is greater collaboration of government, private sector and NGOs and therefore it helps minimizes cost to the facilitator and moreover, the financing loan that municipality takes for improvements is adjusted to LIC loan plans. In terms of assets attachment to the finance, there is property lien which means payments are attached to the property and therefore the balances that is being obligated is continued by new owner to make payments (consulting, n.d.). After all, this program maximizes the economic benefits and create a win-win situation due to deep energy retrofitting involvement. (Eric, September 20, 2010) (Center, March 2010) (PACE, March 2010)

Table 11: Evaluation of Property Assessed Payments for Energy Retrofits (PAPER) Program

| <b>Objective</b>                                      | <b>Evaluation Output</b> |
|---|--------------------------|
| <b>Deep Reductions</b>                                | <b>Yes</b>               |
| Low Interest Rates                                    | Yes                      |
| Minimizes Debt of Owner                               | Yes                      |
| Minimizes Debt of Municipality                        | Yes                      |
| Lowers the cost per house to Program facilitator      | Yes                      |
| <b>Retrofits larger homes in terms of percentages</b> | <b>Yes</b>               |
| Provides upfront Capital Cost                         | Yes                      |
| Assets attachments to Finances                        | Yes                      |
| <b>Affordable Capital Access</b>                      | <b>Yes</b>               |
| Lowers Investor/ Lenders risks                        | Yes                      |
| <b>Benefits to the Society</b>                        | <b>Yes</b>               |
| Availability for levels of income                     | Yes                      |
| Economic Benefits                                     | Yes                      |

## **6 Policy Recommendations**

### **6.1-Policy recommendations for building envelopes**

For proper energy efficient building there are several barriers that needs to be overcome. The following are the some of the main elements that can help decision-maker for energy-efficient strategies:

#### **-Improving governance**

Clear promotion of energy efficiency is necessary. In many countries, there is separate ministry responsible for energy supply, distribution and other regulatory affairs whereas ministry of transportation looks after the construction and development, materials and other operational aspects. In some countries it may fall under the same ministry but due to the fact that individual attention is not possible to give, it is often separated from each other. It is therefore necessary that, realizing development of energy efficient building envelopes is responsibility of the government proper governance should be developed to address the issues. (IEA, 2010) (Jensen, June 2013)

**Merits-**Clear governance will help the retrofitting to be achieved with ease and would also take less time for the various programs developed to achieve the success. The whole lifecycle of development will be under one department and therefore will also reduce the time needed for communication between inter-department for the project. It will also help clearly understand the problems faced during the project and can be resolved with much faster than that if it would fall under different departments.

**Challenges-**Financing is always going to be a separate ministry involved and the major obstacle for the projects however lies with regards to financing only.

#### **-Fostering suitability of energy prices**

Advanced energy-efficient building development involves materials and technologies that are not in par to market prices for nominal construction costs. Therefore, establishing appropriate prices is the major concerns as once constructed can be refurbished in shorter period of time. So this serve as a major barrier in energy-efficient constructions. (Agency, 2013)

Merits-Reduced material costs would ultimately lead to efficient ROI and reduce the debt of the owner and thereby reducing the both owners and investors risks.

Challenges-Market competition faced and tariffs that producers have to pay needs to be cut down, which affects the government collections.

-Developing infrastructure and human capital

Modern energy efficient buildings involve wide technical requirements and skill labors. Say for instance energy efficient buildings involves proper testing as per the performance, monitoring, labelling and certifications for the quality assurances. So for that skill labors are needed to conduct the performance test and be able to monitor the performance of the building, ensures compliances are met and most importantly it involves understanding of local conditions in which project is to be carried out. (Agency, 2013)

Merits-Energy efficiency success is guaranteed and more green Jobs are created.

Challenges-Infrastructure performance testing cost liability needs to be determined, whether it would be included as a part of the construction cost and the contractor will carry out as per the agreements or it will be the owner's responsibility and if the it's the owner's responsibility, the issue lies that will he/she will bear the cost or will take some extra amount as the part from the resident annual payments. Apart from the cost, developing skill trades through institution involves government support to start such programs.

-Commodity-rates material availability

As mentioned the high-tech modernized energy-efficient buildings involves some materials that are higher in terms of rates than the nominal ones. Moreover, there are less manufacturers involved due to the fact that they are costly and so less in demand. And, therefore the final cost includes more shipping costs, thereby making materials availability costly. So, it is necessary for the government to promote the manufacturers also associated with energy-efficient building developments. (OECD, 2013)

Merits-Manufacturer are also the part of stakeholder for energy retrofitting and therefore they are also taken care of.

Challenges-Promoting manufacturers involves extra costs that needs to be borne by the government and therefore government would like to not to fall into extra cost burden. Moreover, setting up more facilities to reduce shipping costs and lean time would require investors but on other hand will also led to market competition for rates.

-Stimulating the markets through programs

The primary program can involve setting up of standard guidelines for consumption of energy and measuring performance relative to its consumption. This can be done through preparing leaflets or handbooks or through awareness by presenting it in seminars etc. and promoting various other schemes and programs that are available for energy retrofitting to achieve efficiency. This can be government-led or by any NGO working related to this field.

Merits-Awareness and information is created amongst the common people and targeted audience.

Challenges-Extra costs in organizing seminars and professionals to speak would make government feel as if they are making unwanted expenditure after some period of time if it is not able to attract the people or program success. Then if no further seminars or such things are organized, that would create wrong and negative impressions amongst the people.

-Making building codes mandatory

To promote energy efficiency in the new buildings or the existing one to be refurbished, mandatory building codes implementation has been crucial across the world too. However, due to local considerations it is neither possible to make a mandatory building codes differently regional-wise nor it is possible for the building developers to construct fully as per the compliance code of standards taking into considerations local conditions. However, monitoring the performance as per the standardization can be carried out in order to ensure the success and achieve the critical goal. ((UNDP), 2013)

Merits-standardization and helps country achieve the emission reduction targets

Challenges-Fully adherence to compliance in building is not possible as there is always variance in local conditions. Moreover, it is not possible for any Country's to build many different standards based on local needs but the performance monitoring is always possible.

To Conclude, each region should determine the best suits for their needs based on the above main elements or how they can combine the two from above to assess their requirements.

### 1-Building code development and implementation

Whether it is a new construction of the building or refurbishment of the existing one, strong building codes are necessity for achieving energy efficiency. Strong building codes ensures that buildings are designed and promulgated in accordance to the standardized developed legal compliance. And, this ensures that energy efficiency is met. However, there are several considerations in developing this building code such as climatic conditions, economic prosperity and market maturity for the materials ((UNDP), 2013). Moreover, apart from the building envelopes, the heating and cooling unit needs to be weighted equally important as they decide the energy usage from the consumer side. There are several factors that prevents from successful implementation of this policy. One such factor is that as the population is growing, needs are arising for constructing houses and buildings (especially in developing country this is predominant) and therefore constructor build with their old standards and designs. Moreover, there is lack of understanding along with skills needed to interpret and build as per the codes. In addition, the technology is also not available in cost-effective manner to build the stocks. Therefore, both market and institutional barriers faced should be eliminated by taking into consideration the GHG emissions reduction target seriously through informing the common people to the most possible ways. As they are the end consumers playing crucial role in the energy usage.

Therefore, the above policy roadmap involves stakeholder collaboration such as government for promoting efficient market for progressive building codes, Manufacturers for cost-effective material prices and R&D institutes for development efficient building materials that can fall under building code compliance too for installations and achieving efficiency.

### 2-Deep energy retrofiting and renovations

Throughout the world, each year about 1% of the buildings undergoes renovations (BPIE, 2011). However, even after renovations these buildings are not energy efficient as they do no undergo

deep renovations. Deep renovations involve the refurbishment in the architecture of the building such that it is cost-efficient and is also concerned with household equipment upgradation, thereby achieving reductions not only related to the energy consumptions but also with respect to capital costs ((EBC), 6 November, 2014). So the policy should involve that whenever the building is undergoing refurbishment, it should undergo deep renovation. There should be immediately available grants set up by the government to support this policy so as to ensure deep renovations is carried out without any delays or any second thoughts in the mind of the owner or the building occupants when planned for major retrofitting. These incentives should be in some percentage of the total costs to start the project and in accordance to the adherence to the deep renovations design submitted by the constructor. The future performance can be assumed based on the benchmark established and grants can be disbursed accordingly. There should be some specific criteria established say for example minimum 50% of energy consumption reduction, proper ratings of heating and cooling equipment installed etc. before disbursing the grant amount so as to ensure that the risks is reduced both on lender and investor side. (OECD I. , 2012)

Moreover, this policy can also be applied in bringing changes to the existing building stock, not planning for any retrofitting. It can be due to the fact that the building has become too old and needs to be retrofitted so as to bring aesthetic changes or the energy consumption bills are too high. Therefore, aim should be developed in strategic plan to increase to about 2% of building per year for deep renovations, however many countries in Europe are aiming for about increase to 3% per year (Voice, 2013).

Pros-Jobs are created and tax benefits achieved through incentive schemes and other grants. Moreover, it ensures that buildings are retrofitted in accordance to some standards and therefore guarantees energy efficiency. It also helps remove initial financial barriers faced for the retrofitting purpose.

The building owner and residents enjoys less energy bills on consumption. Moreover, apart from this the owner experiences non-energy benefits such as building's new aesthetic by changes, increased resident productivity and added market value to the building.

The Challenges is that it will involve documentation and necessary to ensure that evaluation of the building design before disbursing takes on-time to avoid owner's second thought. Definite

financing mechanism needs to be established within government or sub-contracting with the money lenders credit unions or banking institutions for developing finances.

Therefore, the above policy also involves collaboration between different stakeholder such as government, NGOs, builders and investment institutions, R&D institutes.

### 3-Material and technological developments

If the building envelope consists of modernized technology and materials, it could achieve energy efficiency with greater success possibility and in more cost-effective way also. Therefore, appropriate policies for market maturity is required. This involves steps such as fostering R&D for innovative technologies, manufacturer supports, market incentives programs and making a clear case study to gain investor confidence (Desjarlais, 9 December, 2010) (IEA, Transition to Sustainable Buildings: Strategies and Opportunities to 2050, 2013-2). Developing a business case can gain greater confidence into manufacturer and amongst the investors, because today unrealistic energy savings are achieved and therefore it is implicated that no more research and development is needed to achieve but as there is always new innovations and technological developments in the markets each day, it is possible to create low-cost along with market-based viable technologies and materials to achieve energy efficiency. The newly developed materials and technologies should be developed such that they are as per the building codes for installation and are standardized for any markets irrespective of the climatic conditions.

This leads in achieving more energy retrofitting market penetration by eradicating market and institutional barriers.

However, government initiative to fund and support R&D is less likely to be possible when they already possess the incentives scheme for retrofitting developments.

Therefore, the above policy also involves collaboration amongst the stakeholder as each stakeholder has a crucial role to play, like government for supporting competitiveness through R&D in association with educational institutes & utilities companies and NGOs support for developing a business case.

## **6.2-Policy Recommendation for Building's stock (Heating and Cooling Technology)**

The building sector comprises of various decision making personnel i.e. engineers, architects, residents or home-owners etc. involved in making their decision process. Each have their own approach which is referred as segmented by markets. Consumers are little concerns about environmental problems and more concerned about economic problems comparatively unless they are given some sort of incentives which makes them think on both economic and environment aspects (Rami Zwick, 1999).

It is necessary that policies to be developed are broad enough to tackle all the involved challenges in achieving energy efficiencies and deep enough to address the decision makers. So four main strategic policy goals addressed are:

1-Technological improvements through R&D for heating and cooling technological developments to serve the purpose of energy efficiency.

2-Providing information to consumers on savings by proper utilizing the equipment and therefore achieving financial gains from the equipment lifecycle.

3-Market transformation for technology deployment in long run and to achieve zero-emission from the heating and cooling technologies.

4-Internal collaboration and stakeholder engagement to maximize the program and achieve policies benefits. So knowledge and technological transfer across the regions and deployment across the countries.

1-Development of regulatory and policy framework for heating and cooling systems in building and deployment through market transformation.

The building sector involves large number of sub-policies i.e. fire safety, electricity and local regulations, energy efficiency policy and apart from this small number of developed policies as per the building's own requirement. However, it is likely to happen there is successful co-ordination of all these policies at one time. Some policies are designed by stakeholder say for

example landlord or building corporation if building belongs to any management or boards. There are possibilities that these policies framed are sometimes in misalignment to the local regulations or may hinder one or another in some form. Therefore, the very first importance needs to be given to this, ensuring that all policies are coordinated as per the relevance of needs whether local, regional or national. The government agencies should only be the coordinating actor for building policies. However, the involvement of all stakeholder is necessary as it develops the ownership sense amongst all, but should be limited to helping them making suggestions to the policies.

Moreover, this misalignment and poor coordination would also lead to regulatory barriers for new technology deployment in the market place. Achieving market transformation completely is a very difficult policy task due to large number of decision-maker involvement. The Market Transformation involves several failures that needs to be properly addressed such as principal-agent problems in which the landlords who takes the decision of purchasing heating and cooling equipment for the occupants without considering involved life-cycle costs (Sathaye, 2006), lack of proper information, inappropriate numbers of market participants, various extra transaction costs for deals and delays and more importantly inadequate mechanisms for financing. Therefore, the policy recommendations for market transformation will include as follows:

- Improve the knowledge of heating and cooling systems amongst the direct actors involved such as: engineers, architects, technician for newly developed low carbon and zero-emission technologies.
- Reduce costs by reducing economies of scale in trading, considering world as one single market.
- Ensure confidence is gained and maintained amongst all stakeholder and especially the investors involved.
- Improve decision making ability for decision maker by properly informing and removing regulatory, fiscal, policy and other barriers.

This approach will lead to standardized policy formation of building thereby eradicating the problems faced due to misalignment and poor policy coordination. Furthermore, it will address the problems of market transformation which is a very important from the view point of the technology deployment.

Cons-Stakeholder may lose sense of ownership in decision making for formulating and implementing policy which may lead to negative consequences in long-run. Difficult to change the behavior of principal-agent as they feel that they are the owners and have decision-making powers with them on the building purchases which in turn might create a negative relationship with the occupants. Trade barriers are still going to be there due to regulatory differences amongst the countries thereby increasing transactions costs and delays for market deployment (Prindle, 2007).

Therefore, proper engagement of agents and reducing trade barrier by easing the regulatory differences persisting amongst countries, considering economies of scale and world as single market, the above challenges can be over-come.

2-Effective policies formulation by informed availability, qualitative and impactful communication.

There is lack of proper information on the technological availability in the present conditions and its effective utilization for reducing the emissions. It is a simple fact that by making consumer aware and understand the specific technology and its beneficiary aspects, technology acceptance increase and this further increases the deployment. Proper understanding of standardized and international standards (ISO) not only just for information purpose but for evaluation procedures also will have a meaningful impact. The customer will have good sense of the product and will affect its buying decision. This will allow a growth for market maturity. This lack of information is drives consumer decision and therefore it should be the first policy preference. (Associates, 2004)

The one such way is the labelling of the appliances where decision makers are provided standardized information on the ratings of the individual appliances. The one such alternative is mentioning metrics of lifecycle costs and technological benefits involved. Moreover, mandating estimated lifecycle emissions at P.O.S (Point of Sale) and with a document mentioning the elaborated system designs and quotes supporting the heating and cooling equipment. In addition to this, from the manufacturer side, international standardized testing procedure (ISO standards) to evaluate performance standards of the appliance should be compulsory before deploying it into

market. As far as labelling is concerned, compulsory labelling and supporting document in home appliances to measure their energy performance this would serve useful during retrofitting to determine the energy consumption and variances if replaced by new ones.

Moreover, developing effective communications so that:

- Ensure that both the consumers and the building sector stakeholders are well aware of the information and have a good know-how on where and how to use this information.

- Making all realize their contribution and importance is making decisions for reducing emissions and proper technology utilization.

Detailed information on a single database accessible by all is needed for simplifying the scenarios.

Pros-Accessible data can be utilized for any future retrofitting purpose. Effective communication will help decision maker to formulate sound policy. Better ROI is possible and therefore would help reduce debt and minimize the risks involved in retrofitting pay-back.

Cons-Spreading of all information would be harmful to the manufacturer. Also understanding of ISO to all the consumer is much like beyond the scope as educating to all people is not possible, however development of standard guidebook can be done for self-understanding purpose. Moreover, it involves extra costs to maintain and update database on regular bases.

This obstacle can be overcome by giving away only energy related information to the customer and not about any technical specifications to keep manufacturer on safer side. Moreover, keeping it in a standardized format as per ISO standards (like standard marking scheme) can help consumer understand with ease and can compare equipment without having full knowledge of ISO standards i.e. just by evaluating which has better numbers.

### 3-Deployment of policies and regulatory through range of policy tools

It is necessary that regulations and policies in legislation focus on long-term certainty. For the deployment of regulations and policies as mentioned it is necessary to ensure that no conflicts occur such as gas and electricity regulations, fire safety, local regulations and planning, health and safety to those of building's heating and cooling equipment. It should be pre-requisite to coordinate

this policy in an organized way before their deployment for the success. Government can enhance public procurement opportunities for the people in which the heating and cooling equipment are incentivized. This can encourage the common people to install energy-efficient heating and cooling equipment. A portfolio can be prepared such as decision and constructive suggestions from all the stakeholder involved for both residential and commercial building sector, for cross-decision making purpose to consider the best tailor-made solution.

The range of policy tools for deployment can be as follows:

-Feed-in-Tariff: Generally applicable to electricity and focus more on renewable usage to reduce GHG emissions.

-Financial Incentives: Grants or incentives for the purchase of heating and cooling equipment at low price for the energy retrofitting purpose.

- “White” Certificate markets: Specific component of heating or cooling unit to be more focused on energy efficiency.

-Obligations: Subjected to some criteria, builders are required to install or replace energy efficient heating and cooling technologies.

-Fiscal Incentives: It can be in the form of tax credits or any other form such as ‘value-added’ retrofitting tax.

-Minimum Energy Performance Standards: Eliminating the poor energy performance appliances and replacing with standard technologies.

Pros-Deployment of range of policy tools will ensure the energy efficient strategies are being carried out effectively if properly implemented. These tools support the energy retrofitting business and helps overcome market barriers and if policies are successfully implemented than institutional barriers are automatically overcome. Lastly, it also addresses the financial barrier to some extent.

Cons-Myriads of policies to coordinate with legislation for building sector seems difficult due to the fact of involvement of many actors. Success of the policy tool in deployment is difficult to measure, especially in developing countries due to all sorts of cross-sectional barriers it is likely to be implemented successfully.

Through proper stakeholder engagement and defining their roles, coordination is possible and success in the developing economies can also be ensured by international collaboration.

#### 4-Improvising on knowledge of overall building sector and international collaboration.

Improvising in terms of knowledge not only refers to the present heating and cooling technologies but also the emerging technologies and further R&D vision at this stage. Moreover, it not only involves one or two group of people, but all actors/ stakeholder directly or indirectly related to the building sector. This policy approach is cumulative of all above mentioned policy recommendation in which entities such as utilities companies should provide guidance to the consumers, government should invest in providing education and setting up a single standardized infrastructure both in terms of energy certifications, its training and database management. Tailor-made solution should be derived from the all the opinions generated. Addressing and making aware on some of the common issues and things that causes energy related problems. These can be any form or through any source as the major concern is that it should address the target audience and not on how it is outsourced.

For greater market penetration and utilize the R&D to the fullest for the development of low cost and energy efficient heating and cooling technologies for retrofitting market, International collaboration is a key to the success. Moreover, developing international codes and standards would also ease the problem of training and educating & measuring and comparing the performance & furthermore maintaining the database, which would ensure overall success and emissions reduction targets successfully as far as the building sector is concerned.

## **7 Conclusions**

To conclude, proper selection of retrofitting business model and programs as per the needs can support the retrofitting process and create a harmonized situation for the communities and building sector as whole.

Based on the policy recommendation there are some long term strategy suggested to achieve the target of net-zero energy homes and buildings (refer Appendix-C)

Moreover, there is unique importance of stakeholders for the development of the building sector and therefore their near-term actions are described (refer Appendix-D)

## Bibliography

- (EBC), E. i. (6 November, 2014). *Business and Technical Concepts for Deep Energy Retrofits of Public Buildings: Findings from IEA- EBC- Annex 61 Investing into Energy Efficiency Projects: why and how?* Brussels.
- (EPA), U. E. (2014). *Greenhouse Gas Equivalencies Calculator*. Retrieved from <http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results>
- (UNDP), U. N. (2013). *Modernising Building Energy Codes*. Paris: IEA Policy Pathway, OECD/IEA.
- [OMEI], O. M. (2010). *Ontario's Long-Term Energy Plan*. Government of Ontario.
- Affairs, M. o. (2016, May 13). *Housing*. Retrieved from Government of Ontario Ministry of Housing and Municipal Affairs: <http://www.mah.gov.on.ca/Page125.aspx>
- Affairs, M. o. (August 2014). *Investment in Affordable Housing for Ontario 2014 extension program guidelines*. Ontario Ministry of Housing, Ontario Ministry of Municipal Affairs.
- Agency, I. E. (2013). *Transition to Sustainable Buildings: Strategies and Opportunities to 2050*. OECD/IEA.
- al., H. e. (2006). Hybrid modelling: new answers to old challenges. *The Energy Journal, Special Issue on Hybrid Modelling of Energy-Environment Policies: Reconciling Bottom-up and Top-down*.
- Architects, T. A. (2013). *Deep Energy Retrofits: An Emerging Opportunity; An architect's guide to the energy retrofit market*. Rocky Mountain Institute.
- Associates, R. M. (2004). *A study in showed that being able to correctly interpret information in home energy performance data and understand the usefulness of that information was a prerequisite to to consumer interest in home energy performance*. California.
- Association, A. P. (2010). *The Effect of Energy Efficiency Programs on Electric Utility Revenue Requirements*. 1875 Connecticut Avenue, NW Suite 1200 Washington, DC 20009-5715: American Public Power Association.
- Association, P. c. (2016). *Strong Building Codes Save Lives, Reduce Damages*. Retrieved from How Consumers Benefit from Strong Building Codes: <http://www.pciaa.net/industry-issues/catastrophic-risks/strong-building-codes-save-lives-reduce-damages>
- Baker, M. F. (March 2012). *United States Building Energy Efficiency Retrofits; Market Sizing and Financial Models*. DBCCA climate change investment research, The rockefeller foundation, Deutsche bank, corporate real estate.
- Belliveau, W. (Spring 2011). *How the Principal-Agent Problem Affects Energy Consumption in the Commercial Building Sector*. Colorado: University of Colorado, Boulder.
- Birgit, M. U. (July 2012). *Theoretical background on the modelling of policy instruments in energy system models*.

- Board, O. E. (2015, October 15). New winter electricity prices for households and small businesses. Toronto, Ontario, Canada.
- BPIE. (2011). *Europe's Buildings Under the Microscope – A Country-by-Country Review of the Energy Performance of Buildings*. Brussels.
- Callander, M. B. (2016, April 20). *Rate hiked to cover reduced use of electricity*. Retrieved from nugget: <http://www.nugget.ca/2016/04/20/rate-hiked-to-cover-reduced-use-of-electricity>
- Canada, N. R. (2012). *Implementing an Energy Efficiency Awareness Program*. Office of Energy Efficiency. Retrieved from [https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oeefiles/pdf/publications/commercial/Awareness\\_Program\\_e.pdf](https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oeefiles/pdf/publications/commercial/Awareness_Program_e.pdf)
- Canada, N. R. (2015). *Grants and Financial Incentives*. Retrieved from Natural Resources Canada, Government of Canada: <http://www.nrcan.gc.ca/energy/funding/efficiency/4947>
- Carr, B. D. (May 31, 2011). *Zapped: The High Cost of Ontario's Renewable Electricity Subsidies*. C.D. Howe Institute, e-brief.
- Center, H. P. (March 2010). *Best Practices for Residential Energy Retrofit Program Design: Financing Incentives and Recommendations*.
- CIEE. (2009). *Behavioral assumptions energy efficiency programs for business*. Oakland, CA: California Institute for Energy and Environment.
- CMACM. (2015). *what is Chattel Mortgage*. Retrieved from Canadian Money Advisor: <http://www.canadian-money-advisor.ca/what-is-a-chattel-mortgage.html>
- CMHC. (2002). *Better Buildings, Energy Efficiency case study, Toronto*. Toronto: Canada Mortgage and Housing Corporation.
- CMHC. (2014). *Canadian Mortgage and Housing Corporation*. Retrieved from [http://www.cmhc-schl.gc.ca/en/co/moloin/moloin\\_008.cfm](http://www.cmhc-schl.gc.ca/en/co/moloin/moloin_008.cfm)
- CMHC. (2016). *Affordable Housing Programs in Ontario*. Retrieved from Canadian Mortgage and Housing Corporation: [https://www.cmhc-schl.gc.ca/en/inpr/afhoce/fuafho/iah/afhopracca/afhopracca\\_009.cfm](https://www.cmhc-schl.gc.ca/en/inpr/afhoce/fuafho/iah/afhopracca/afhopracca_009.cfm)
- Comission, E. a. (Jan 2014). *Enabling Framework to Scale up Investments in Energy Efficiency*. Document No. 213/101; International Chamber of Commerce.
- commission, E. (2016, February 16). Towards a smart, efficient and sustainable heating and cooling sector.
- Commission, R. E. (2016, July 25). *Energy Performance Contracting*. Retrieved from Joint Reseach Centre, European Commission: <http://iet.jrc.ec.europa.eu/energyefficiency/european-energy-service-companies/energy-performance-contracting>

- consulting, S. a. (n.d.). *Collaboration on: Property Assessed Payments for Energy Retrofits (PAPER)*. Retrieved from Sustainable alternatives consulting: [http://www.sustainable-alternatives.ca/PAPER\\_collaboration.htm](http://www.sustainable-alternatives.ca/PAPER_collaboration.htm)
- Corps, C. (June 2010). *Asset Strategies*.
- Council, C. G. (Jan 2016). *National Energy Benchmarking Framework*. Vancouver BC: Integral Group.
- Council, E. E. (2015). *Energy Professional Development*. West Melbourne, Victoria.
- Daniel Kirby, J. C. (2013). *Change is in the Air: Ontario Closer to a Cap-and-Trade System*. <http://www.osler.com/NewsResources/Change-is-in-the-Air-Ontario-Closer-to-a-Capand-Trade-System/>.
- David Hoppock, J. M. (November, 2008). *Transforming Utility and Ratepayer support for Energy Efficiency*. Duke University.
- Desjarlais. (9 December, 2010). *Envelope R&D*. Florida.
- Duke. (2008). *Transforming Utility and Ratepayer support for Energy Efficiency*.
- EANCP, n. (2016, March 30). *Indigenous and Northern Affairs Canada's ecoENERGY for Aboriginal and Northern Communities Program (EANCP)*. Retrieved from Indigenous and Northern Communities Program, Government of Canada: <http://www.aadnc-aandc.gc.ca/eng/1100100034258/1100100034259>
- Energy, O. M. (2014). *FIT and microFIT Program*. Retrieved from Retrieved from Ontario.ca: <http://www.energy.gov.on.ca/en/fit-and-microfit-program/>
- Energy, O. M. (2015, December 8). *Incentives Programs for Business*. Retrieved from Energy Ministry, Government of Ontario: <http://www.energy.gov.on.ca/en/incentives-program-for-business/>
- Energy, U. d. (2010). *EIA*. Retrieved from Department of Energy.
- Energy, U. D. (2015). *Guidelines for Home Energy Professionals*. Washington, DC: Office of Energy Efficiency and Renewable Energy.
- EPA, U. (2006). *National Energy Plan for Energy Efficiencies*.
- Erdal Aydin, N. K. (October 24, 2015). *Energy Efficiency and Household Behavior: The Rebound Effect in the Residential Sector*. Netherlands.
- Eric. (September 20, 2010). *Canadian Mortgage Market Primer*. [http://www.td.com/economics/special/el0610\\_cdn\\_mort\\_market.pdf](http://www.td.com/economics/special/el0610_cdn_mort_market.pdf).
- Foundation, D. S. (2011). *Property Assessed Payments for Energy Retrofits: Recommendations for Regulatory changes and Optimal Program Features*.
- Fox, P. G. (2011). *Omitted Costs, Inflated Benefits: Renewable Energy Policy in Ontario*. Bulletin of Science, Technology & Society.

- Fuller, M. (2008). *Enabling Investments in Energy Efficiency – a study of energy efficiency programs that reduce first-cost barriers in the residential sector.*
- Housing, M. o. (2015, November 5). *Investment in Affordable Housing Program: Report.* Retrieved from Ontario Ministry of Municipal Affairs Ministry of Housing:  
<http://www.mah.gov.on.ca/Page10065.aspx>
- Housing, O. M. (2015, December 16). *Community Improvement Planning Handbook.* Retrieved from Government of Canada: <http://www.mah.gov.on.ca/Page1297.aspx>
- IEA. (2010). *Energy Efficiency Governance.* Paris: OECD/IEA.
- IEA. (2013-2). *Transition to Sustainable Buildings: Strategies and Opportunities to 2050.*
- IESO. (2015). Retrieved from <http://www.ieso.ca/Pages/Power-Data/Supply.aspx>
- Jaccard. ( 2009 ). Combining top down and bottom up in energy economy models. *International Handbook on the Economics of Energy.*
- Jens. (september, 2010). *Community Power Fund.* Co-founder and Partner, CU Consulting Group and Treasurer, .
- Jensen, J. O. (June 2013). *Motivating local home-owners to energy retrofitting as examples on Urban Climate Governance in Danish Municipalities.* Denmark: Danish Building Research Institute, Aalborg University.
- Jorgenson, H. a. (1977). Economic and Technological Models for Evaluation of Energy Policy. . *In: The Bell Journal of Economics, Vol. 8 (1977), No. 2: 444-466.*
- Karen Palmer, M. W. (October 2011). *Assessing the Energy Efficiency Information Gap: Results from a Survey of Home Energy Auditors.* washington, DC: Resources: for the future.
- Kats, G. (Updated: March, 2012). *Energy Efficiency Financing- Models and Strategies.* Capital for the Energy Foundation, American Council for an Energy-Efficient Economy (ACEEE).
- Kingston, C. o. (2016). *Community Improvement Plan.* Retrieved from The corporation of city of Kingston: <https://www.cityofkingston.ca/residents/environment-sustainability/land-quality-brownfields/community-improvement-plan-brownfields>
- Labandeira, L. a. (2010). *Journal of Economic Surveys .* Vol. 24, No. 3, pp. 573–592 .
- LaScelles, E. (June 17, 2010 ). *Canadian Mortgage Market Primer,*. [http://www.td.com/economics/special/el0610\\_cdn\\_mort\\_market.pdf](http://www.td.com/economics/special/el0610_cdn_mort_market.pdf): TD Securities' Chief Canada Macro Strategist.
- Lawrence. (2010). *A Survey of the US ESCO Industry.* Lawrence Berkeley National Laboratory.
- Lohmueller, J. (June 2010). *Credit Union Communications.* Credit Union Charters.
- Makuch & Associates and David Bronskill, L. p. (2012). Ontario Ministry of Municipal Affairs and Housing staff. (C. o. Scott Pasternack, C. o. Jane Welsh, C. o. Peter Moore, C. o. Gregg Barrett, C. o. Brian Turcotte, & C. o. Carolyn Dawe, Interviewers)

- Makuch, S. (2010, April). Turcotte, Brian, City of London.
- McKinsey. (2009). *Pathways to a low carbon Economy*. MAC curves analysis .
- McKinsey. (2009). Unlocking the Energy Efficiency in the US Economy.
- MEEFS. (2011). *Multifunctional Energy Efficient Facade System for Building Retrofitting*. Retrieved from MEEFS Retrofitting, European Commission's 7th Framework Programme for Research and Technological Innovation : <http://www.meefs-retrofitting.eu/markets.html>
- Mehrdad Pirnia, J. N. (October 2011). *Ontario Feed-in-Tariffs: System Planning Implications and Impacts on Social Welfare*. The Electricity Journal, Vol. 24, Issue 8, 18-28. .
- Network, G. o. (2015, October 21). *Private sector Financing*. Retrieved from Government of Canada: <http://www.canadabusiness.ca/eng/page/2735/>
- Nock, L. (2010). *Energy Efficiency Retrofits for Commercial and Public Buildings Energy Savings Potential, Retrofit Business Cases, Financing Structures, Policy and Regulatory Factors, Demand Drivers by Segment, and Market Forecasts*. Pike Research.
- NRCan. (2016, June 03). *ecoENERGY Innovation Initiative Background*. Retrieved from Natural Resources Canada, Government of Canada: <http://www.nrcan.gc.ca/node/17903/#eco>
- nrcan. (2016, July 22). *I want to renovate my home, Natural Resources Canada*. Retrieved from Government of Canada: <http://www.nrcan.gc.ca/energy/efficiency/housing/home-improvements/5009>
- NRDC. (2008). *Unlocking the Power of Energy Efficiency in Buildings*.
- OECD. (2013). *Energy Efficiency Market Report, OECD/IEA*.
- OECD, I. (2012). *Insights Series, Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements*. IEA/ OECD.
- ontario, g. p. (2012, November). *City of Ottawa must fast-track Property Assessed Payments for Energy Retrofit program (PAPER)*. Retrieved from Green Party of Ontario: <http://gpo.ca/city-ottawa-must-fast-track-property-assessed-payments-energy-retrofit-program-paper>
- PACE. (March 2010). *Best Practices for Residential Energy Retrofit Program Design: Case Study*. Boulder, Colorado: Home Performance Resource Center.
- Performance, H. (2011). *Home Energy Assesment* . Retrieved from Energy Assesment in ON and BC: <http://www.homeperformance.com/>
- Persram, S. (2010, April). Private-home owners in the City of London have benefited from these kinds of loans, years ago. (G. a. Barrett, Interviewer)
- Preonas, C. F. (2010). *Combining policies for renewable energy: Is the whole less than the sum of the parts?* . Resources for the Future Discussion Paper;RFF DP 10-19.
- Prindle. (2007). *Quantifying the Effects of Market Failures in the End-Use of Energy, American Council for an Energy-Efficient Economy (ACEEE)*. Washington, D.C: ACEEE Report Number E071.

- Prosperity, S. (2010). *Ontario's Feed-in Tariff for Renewable Energy: Lessons from Europe*. .  
www.sustainableprosperity.ca.
- Rami Zwick, I. E. (1999). *The Psychological and Economical Perspectives on Human Decisions in Social and Interactive Contexts*. New Jersey.
- Retrofitting, M. (June 2013). *Policy and Markets*. Multifunctional energy efficient facade system.
- Riggs, V. E. (August 1991). *MANAGING RETROFIT PROJECTS*. Austin, Texas: Department of Civil Engineering, University of Texas.
- Roadmap. (2010). European Carbon Foundation.
- Roma Malik, K. B. (2014). *Why Account for the Full Costs of Energy?* www.cleanairpartnership.org.
- Rosendahl, C. B. (2010). *Green Promotes the Dirtiest: On the Interaction between Black and Green Quotas in Energy Markets*. Journal of Regulatory Economics, forthcoming.
- Sathaye, M. a. (2006). *Quantifying the Effect of the Principal-Agent Problem on US Residential Energy Use*. San Francisco: Lawrence Berkeley National Laboratory, LBNL.
- Smith, R. (2015, October 20). *As Conservation Cuts Electricity Use, Utilities Turn to Fees*. Retrieved from Wall Street Journal: <http://www.wsj.com/articles/as-conservation-cuts-electricity-use-utilities-turn-to-fees-1445297729>
- Smith, R. (2015, April 20). *Utilities' Profit Recipe: Spend More*. Retrieved from The Wall Street Journal: <http://www.wsj.com/articles/utilities-profit-recipe-spend-more-1429567463>
- Solutions, C. f. (2015). *Cogeneration Combined Heat and Power*. Retrieved from <http://www.c2es.org/technology/factsheet/CogenerationCHP>
- staff, O. M. (Fall 2009). (Sonja, Interviewer)
- Torbert, R. (2012, June 22). *Busting landlord-tenant barriers for greater energy efficiency*. Retrieved from GreenBiz: <https://www.greenbiz.com/blog/2012/06/22/busting-landlord-tenant-barriers-greater-energy-efficiency>
- Toronto, C. o. (2016). *Home Energy Loan Program (HELP)*. Retrieved from City of Toronto, living in Toronto, Grants, incentives and tips Programs for residents :  
<http://www1.toronto.ca/wps/portal/contentonly?vnextoid=7e00643063fe7410VgnVCM10000071d60f89RCRD>
- Tsenkova, S. (2013). *RETROFITS FOR THE FUTURE: AFFORDABLE HOUSING AND ENERGY EFFICIENCY PROGRAMS IN CANADA*. Cities, Policy and Planning; Environmental Design University of Calgary.
- Tversky, D. K. (1979). *Prospect Theory: An Analysis of Decision Under Risk*. Econometrica.
- Vaughan, E. (2012). *The Value and Impact of Building Codes*. Policy Director, Environmental and Energy Study Institute.
- Voice, E. (2013). *Green Technologies", Passive Houses*. Brussels: European Voice .

WBSCD. (2009). Transforming the market.

Westeinde, J. ( June 9, 2010 ). co-founder and CEO of Windmill Development Group . CaGBC conference.

Weyant, S. a. (1979). The Energy Modeling Forum: Past, Present, and Future. *EMF PP6.1, Energy Modeling Forum, Stanford University, Stanford, California, Fall 1979.*

Witta Ebel, W. F. (2016, Feb 17). *Economy and financing of efficiency: new buildings, renovation and step by step retrofit*. Retrieved from Passipedia, the passive house resource:  
[http://www.passipedia.org/basics/affordability/investing\\_in\\_energy\\_efficiency/economy\\_and\\_financing\\_of\\_efficiency\\_new\\_buildings\\_renovation\\_and\\_step\\_by\\_step\\_retrofit](http://www.passipedia.org/basics/affordability/investing_in_energy_efficiency/economy_and_financing_of_efficiency_new_buildings_renovation_and_step_by_step_retrofit)

Wood, J. (2011). *"Feed-in" tariffs in Ontario: UnFIT energy policy*. Fraser Forum:33.

## Appendix:

### A-Energy Modelling instrument for Policy Evaluation

In 1970's Hoffman and Jorgenson (Jorgenson, 1977) developed energy system models due to oil crisis and this model was reflected in the creation of the Energy Modeling Forum (EMF) with aim to "improve the use and usefulness of energy models in energy issues"

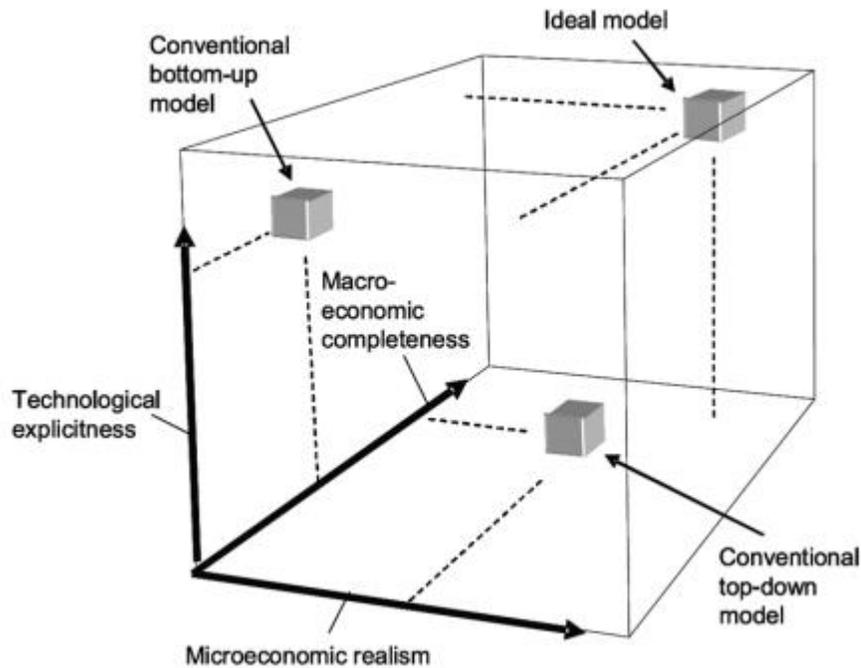


Fig.1. Ideal Energy Model dimensions for Policy Evaluation (al., 2006)

So in order to assess energy models as per their applicability to policy evaluation, differentiation has been made from beginning two broad category model top-down and bottom-up approach. Top-down models look at the energy system "from above", i.e. from a macroeconomic perspective. This involves high level of aggregation and equilibrium framework is applied by taking all unexpected consequences into consideration. While top-down models are rooted in economic principles, bottom-up energy system modelling approaches have been mainly developing in Engineering. These model depict the energy system "from below", i.e. the entire energy system from primary energy supply to energy services demand in the different end-user sectors, in process-oriented steps. Thus, a large variety of technologies both on energy supply side and demand side, are functionally modeled with their economic, technological and ecological parameters. In the model, the energy system is then represented as a network of processes (technologies) and commodities (energy carrier, materials, etc.), the so called Reference Energy System (RES). (Jaccard, 2009 ) (Jorgenson, 1977) (Weyant, 1979).

## **B-Feed-In Tariff Program**

### **1 Introduction**

The province of Ontario launched the Feed-in Tariff program in accordance to Green Energy Act enacted in 2009 and Ontario's long term Energy Plan which was updated in 2010, an economic approach to incentivize and encourage renewables energy technological developments. And, this Ontario's FIT program is administered under IESO (Independent Electricity System Operator). It allows Business owners, private developers to sell renewable energy generated by them at a guaranteed price for contracted period of over 20 years to the province (Energy O. M., FIT and microFIT Program, 2014). The program is divided into two parts FIT Program and Micro-FIT Program. FIT program is for project capacity of more than 10 KW to 500 KW and Micro-FIT is available for the project capacity of less than 10 KW (Energy O. M., FIT and microFIT Program, 2014). It has been nearly more than six years the program is running and is considered as one of the most popular program across the whole of Ontario. Therefore, it's cost-benefit analysis is carried out.

### **2 The Issue**

From the report of Parker Gallant and Glen Fox (Fox, 2011), they estimated the increased cost of renewable electricity deployment using the baseline as Ontario's Long Term Energy Plan for comparison and found that the additional benefit created for Aboriginal groups and communities would be 60.94\$/MWh. Moreover, from the report of Benjamin Dachis and Jan Carr (Carr, May 31, 2011), they argued that annual average cost would be \$310/ household and through government new initiative so called 'Creating New Clean Jobs' for Energy sector (Energy O. M., FIT and microFIT Program, 2014), they estimated that cost would come around \$179,000 per job in terms of job creations. Therefore, the controversy overview above lies under the cost problems that is associated with the program.

Moreover, the OEB (Ontario Energy Board) calculates and fixes the prices by averaging from all the energy sources. These fixed prices would also include the FIT Program costs. Therefore, promoting the generations of renewable energy technology through program seems to likely incur more costs in the electricity bills of the consumers (Wood, 2011). The predicted forecasts in 2010 was about 46% increase for the next five years from 2010 by Ontario's Long Term Energy Plan, with 56% attributable because of renewable energy investments ([OMEI], 2010). However, Parker Gallant and Glen Fox (Fox, 2011).

In addition, the report by Mehrdad Pirnia, Jatin Nathwani and David Fuller (Mehrdad Pirnia, October 2011) analysis indicates that the program will have substantial burden socially. They concluded that based on the policy selected there will be higher commercial, Institutional and Industrial costs passed to the people, ranging anywhere per year from \$117 to \$1,215. (Mehrdad Pirnia, October 2011) However, the analysis acknowledged the benefits that it would led to environment but didn't mentioned it in a detailed form.

Therefore, with all such costs related concerns for the FIT program, it is necessary to analyze it from both economic and environmental view point to know it's real worth.

### 3 Economic and Environmental Analysis

An initiative for tackling climate change, the FIT program was developed in the province (Energy O. M., FIT and microFIT Program, 2014). Therefore, cost benefit analysis is carried out to see its effectiveness with regards to costs in terms of achieving the environmental goal.

Energy comprises of costs such as Environmental, Health and Social which are never reflected or appeared on our electricity bill (Roma Malik, 2014). One such example includes premature deaths and hospitalizations on an annual basis due to coal fired generations (Roma Malik, 2014). Therefore, the below table represents the externality costs associated with each of the energy source and its inclusion in electricity generation costs.

|   | <b>Coal</b> | <b>Wind</b> | <b>Solar</b> | <b>Biomass</b> | <b>Hydro</b> |
|---|-------------|-------------|--------------|----------------|--------------|
| <b>Average Cost-levelled cents/kWh</b>    | 9.48        | 9.7         | 21.07        | 11.25          | 8.64         |
| <b>Average Cost-Externality cents/kWh</b> | 8.54        | 0.43        | 1.02         | 3.59           | 0.43         |
| <b>Total</b>                              | 18.02       | 10.13       | 22.09        | 14.84          | 9.07         |

Even though, renewable energy is so-called zero-emission, its lifecycle emission cannot be neglected, i.e. all project phases such as from commissioning, construction, operation and maintenance and decommissioning. The table below represents GHG Emissions cost over the lifecycle for varied sources of energy.

|   | <b>Coal</b> | <b>Wind</b> | <b>Solar</b> | <b>Biomass</b> | <b>Hydro</b> |
|---|-------------|-------------|--------------|----------------|--------------|
| <b>Intensity of Emission tons CO<sub>2</sub>e/GWH</b> | 888         | 26          | 85           | 45             | 26           |

So from the FIT program it is hard to determine attributed GHG reductions. So the analysis involves two comparisons to begin with: one involves Status quo that represents present mix of energy output (Table below) and the second assumption is made in which all renewable energy output is replaced by coal-fired generation in the above mentioned status quo situation. The

renewables promoted by FIT program counts here only for Solar, Wind and biofuel as hydropower is already the dominant as far as Ontario's energy is concerned.

|                   | <b>Nuclear</b> | <b>Hydro</b> | <b>Coal</b> | <b>Oil/Gas</b> | <b>Wind</b> | <b>Biofuel</b> | <b>Solar</b> |
|-------------------|----------------|--------------|-------------|----------------|-------------|----------------|--------------|
| <b>2014 TWH</b>   | 94.9           | 37.1         | 0.1         | 14.8           | 6.8         | 0.3            | 0.0185       |
| <b>Percentage</b> | 62%            | 24%          | <1%         | 10%            | 4%          | <1%            | <1%          |

If FCS=Full Cost Saving; E=Emission; R=GHG Emission Reduction, then calculations for the following equations:

$$\text{FCS} = \text{FC (replaced)} - \text{FC (status quo)}$$

$$\text{R} = \text{E (replaced)} - \text{E (status quo)}$$

Therefore, from the results obtained ((EPA), 2014), the full cost saving by coal replacement with renewables is estimated \$545.3 million, and GHG emission reduction of 6.13 million tons CO<sub>2</sub>e for the lifecycle, which is equal to reducing 1,291 passengers from the road on annual basis. ((EPA), 2014)

Many renewable generation under FIT are connected or under-development to distribution system. However, the above table do not include generators that are operated within local service distribution (IESO, 2015). Therefore, if all those projects are taken into supply mix for calculation, the desired benefits could be huge for GHG Emission reductions as shown in table below:

|                                 | <b>Wind</b> | <b>Solar</b> | <b>Bio-energy</b> | <b>Hydroelectric</b> |
|---------------------------------|-------------|--------------|-------------------|----------------------|
| <b>Present Supply Mix in MW</b> | 2,483       | N/A          | 302               | 8,119                |
| <b>FIT Program MW</b>           | 1,001.23    | 922.2        | 26.2              | 22                   |

And, as mentioned earlier in order to calculate the fixed prices, it is averaged across all energy source by the OEB and FIT program cost is also included in it (Wood, 2011). And as mentioned it counts for Solar, Wind and Biofuel only, following table indicates GHG avoided by utilizing the FIT prices in units cost per ton.

|                                    | <b>Wind</b> | <b>Solar</b> | <b>Biomass (Biogas)</b> |
|------------------------------------|-------------|--------------|-------------------------|
| <b>Cost (\$/t CO<sub>2</sub>e)</b> | 91.20       | 819.66       | 160.95                  |

Therefore, extra cost is added to the savings. So actually full cost savings differs. It can be calculated as:

$$\text{FCS (actual)} = \text{FCS} - \text{EC};$$

where FCS is Full Cost Savings and EC is Extra Costs

So the actual cost is -42.16\$ million, which shows that cost of GHG reduction through FIT program is \$42.16 million higher than replacement of renewables if promoted through coal-based.

Moreover, calculating natural gas costs using average prices with carbon offsets (through 8 major offsetting Canadian companies), the price to reduce GHG to offset a ton is shown in table below:

|                                    | <b>Natural Gas</b> | <b>Wind</b> | <b>Solar</b> | <b>Biomass</b> |
|------------------------------------|--------------------|-------------|--------------|----------------|
| <b>Cost (\$/t CO<sub>2</sub>e)</b> | 27.00              | 91.20       | 819.66       | 160.95         |

Therefore, it can be concluded that it costs less to purchase carbon offsets than to depend on renewables for achieving GHG reductions. Now If in the generation costs, costs of carbon offsets are taken into considerations, the electricity generation costs from natural gas would be \$0.09/kWh, which is actually lower than the lowest FIT price guaranteed during program implementation (Wood, 2011).

The above provide quantitative analysis related with environmental and costs benefit in relation to FIT program showing a clear indication to reduce cost burden associated with it which otherwise would cause public adverse to the FIT approach, as a means for mitigating GHG emissions and promoting renewable energy in the province of Ontario.

#### 4 Policy Implications for FIT

Cost is significantly involved as analyzed through various reports. And, with FIT in Ontario, renewable electricity holds largest share for the generation option. However due to cost burden, there are full possibilities that electricity retail price would also increase. This could be harmful to the end-users, Politically, a negative impact and would pose an economic threat (Prosperity, 2010). Therefore, to successfully continue running the FIT program, the policy maker needs to ensure that cost is control or in other words keeping to the lowest as much as possible the future increasing costs. Also as per the report (Prosperity, 2010) lessons can be learnt from the Germany Policy which adjusts the downward rates as per the newly developing technologies and improvements going on, in which they support the new technological development (which is going to be ever on-going) and contract at lower rates, thereby keeping rates downwards. (Prosperity, 2010)

Moreover, Ontario is involving Cap-and-Trade System for GHG emissions reduction strategy (Daniel Kirby, 2013). However, report by Fischer and Preonas (Preonas, 2010) showed that FIT program if implemented with Cap-and-Trade system may not result into any additional GHG emissions reduction. Also the report by Bohringer and Rosendahl (Rosendahl, 2010) FIT program would cause market value reduction in tradable permits of the cap-and-trade system which would in-turn serve as beneficiary to the generation sources which are most emitting GHG. In addition to above, decision on the carbon offsets purchase also needs to be made based on economic and environmental analysis by the policy maker.

To conclude, it is necessary to re-evaluate FIT program feasibility to other policy or to determine whether the program is really needed or not before advancing to the program on full capacity. As FIT program is a market-based policy it is necessary to consider its implications to the decision-maker so as to ensure that province is tackling the issue of climate change with right sort of programs in-placed.

## **C-Long Term Strategy for achieving Net-Zero Energy Homes**

Achieving Net-Zero Energy Homes (NZE), would be one of the most important considerations in the future considering the sustainability aspects related to Building sector and therefore developing long term strategy plans for achieving the objective of net-zero energy in house should be a priority and stakeholder are important aspect for successfully achieving this objective. The process of achieving the goal, starts from building design (that relates to building envelopes in above policy recommendation context) to installment of equipment and technology in the building (that relates to building heating and cooling technology in above policy recommendation context) and obviously the owner's need and occupant behavior playing a key role in developing strategy. Therefore, the section is based on making recommendations for achieving long-term strategy with respect to the following three:

1-Designing

2-Equipment and Technology

3-Needs and Behavior

### **1.Designing**

This refers to building as a whole. Here the focus is on addressing the entire building envelope instead of focusing on the technology components and equipment of the building.

As far as evaluation of building performance based on standards is concerned, customers are likely to be successful in making decisions and evaluations as in some case customers might not even be aware of their usage patterns. The home inspections method is traditionally one of the way to evaluate it but the process is not so robust today due to improper knowledge of all construction and major installation within it with regards to energy performance. Secondly, there is no standards set such that home owner buying a new house or second house can purchase house with low maintenance costs as no one takes responsibility in guaranteeing this. Moreover, there is lack of knowledge in selecting effective technologies and materials to achieve NZE both in new buildings and existing building undergoing retrofitting.

Therefore, potential guiding tool for this may include as follows:

#### **1.1-Consumer labelling for both new homes and existing homes**

Benchmark scoring guide for comparison to new development or retrofitting scores considering the whole lifecycle costs. The criteria should be durability of the building, energy performance and reduced costs of maintenance.

During predesign, design review and regular inspections to ensure adherence to compliance during construction phase. Post-construction phase should include testing and certifications maintenance to ensure success.

Steps to development and implement Involves:

- Setting clear standards and metrics
- Life-cycle methodology
- Getting insurance companies and other banks to be involved
- Training and educating building auditors, certification authorities etc.

### 1.2-Availabilty of information for Design guidelines

Information available for designing net-zero homes are in varied forms and sources. However, some are accessible and some aren't. Therefore, gathering the design guidelines details and evaluating it to select the most suitable in prevalent conditions of building sector and making it accessible by all. This can be relation to new infrastructure or retrofitting conditions.

The challenges and Barriers involved here is gathering all available information and organizing this information into coherent manner readily acceptable to the building sector.

Therefore, steps to development and Implement Involves:

- Compiling information for building sector in a central location (can be bifurcated state-wise)
- Organize and categorize, thereby clearing mentioning housing guidelines
- Relates the gap information from existing available information to address any pertinent issue that needs for more attention

### 1.3-Transparent communication of design tools

It is necessary to share the design tools among the whole building sector. This should not be for taking someone's innovative design or copying it but to ensure that materials, safety standards, construction designs are such that it ensures the maximum energy efficiency output from the prospective developments.

This can ensure energy efficiency in building is maintained from the pre-commissioning stage. Due to IPR and copyrights regulation it is less possible that anyone would stole design ideas but the challenge lies in making constructors, engineers and architects agree to the suggested tools.

Therefore, steps to development and Implement Involves:

- Conducting solid research to support the design tools and its related developments
- Evaluating that the new suggested tool would fit into their criteria which was set for developing buildings
- Educating the building community as a whole on new possible approaches so that consultants are aware and try to incorporate in their designs

#### 1.4-Affordability of home financing

The affordability of house is an important aspect and should factored in interest rates charged, insurances and taxes incurred. So it is necessary to have proper property valuation to know the energy efficiency improvement capacity and incentives or funds requirement.

Therefore, steps to development and Implement Involves:

- Establishing this evaluation based on standards that can be applied nationally
- Educating the whole financing community the importance of energy valuation
- Working with insurance, financing institutions and other real estate communities to incorporate best practices for energy valuation in new constructions or existing houses and buildings

#### 2-Equipment and Technology

This refers to the building components such as heating and cooling technology and other related equipment that can ensure energy efficiency. These may include anything from building HVAC (heating, ventilation and air conditioning) to lightings and appliances.

The main risk factor is involved amongst those groups or individual is that they adopt technology that are unfamiliar to them. In addition to this, they have limited information regarding technology in regards to benefits that can be derived, financing mechanism available etc. Moreover, the lack of evaluation of performance of the purchased technology adds to the risks. There are some externalities also involved that plays a crucial role in determining proper energy efficiency. For example, in some countries there are no provisions for storage of extra electricity returned from homes back to local grids. Also volatility in energy costs makes estimations difficult.

Therefore, potential guiding tool for this may include as follows:

## 1-Home components control and automation

It is necessary to develop guidelines for controls and automation of home components such as appliances, lighting, on-site generations etc. Integrating automation and controls would lead to reduction in energy usage throughout the house or building. Interaction of smart grids with building houses and inclusions of technology like sensors or other energy management controls can help increase energy efficiency in the buildings if those technology works with proper interoperability.

However, the challenges are consumer knowledge to the usage of technology and understanding of the automation system.

Therefore, steps to development and Implement Involves:

- Reviewing existing available guidelines for automation and selecting the best suits from it.
- Testing the prototypes and evaluating the most suitable
- Ensure consumers are educated with the understanding of automation
- Collaboration with original equipment manufacturers for developing more interoperability opportunities at affordable prices for homes and buildings

## 2-Enhancing design in relation to day-lighting

Day lighting guidelines plays an important role in maximizing energy efficiency. This refers to the proper usage of natural lighting in day to save power usage in home or building. There should be clear guidelines developed showing benefits of utilizing natural lighting in day time and indicate that natural lighting in day has nothing to do with worker's working efficiency or productivity. However, this should always consider some factors such as local climate, orientation of building, site height, window glazing and other requirements as per building codes. This can be helpful in design of new buildings or retrofitting existing ones.

Therefore, steps to development and Implement Involves:

- Literature findings and reviewing all day light benefits beyond energy usage reductions
- Developing a case that can serve as an example to incorporate these day-lighting guidelines into their daily practices
- Stakeholder participation especially designer inputs and contribution in developing guidelines

## 3- Maintaining IAQ (Internal Air Quality)

This emphasizes on better air infiltration. It is necessary to incorporate it into building design as air flows plays an important role in determining the inside room temperature of the building too. There should be consideration for several factors such as weather/climate, air quality, occupant expectations (both existing and new). Through better ventilation system, internal air quality can be maintained. However, the materials used in roofing and insulation, furniture and wall paints and other assemblies plays a role in disturbing the inhalation of the residents from the natural air. Especially, Insulation and Roofing plays an important role to determine the inside temperature as it has different capability of absorbing air and also varies over span of time.

The challenges include balancing internal air quality to the residents varying expectations and quantifying the trade-offs between occupant's comfort and health.

Therefore, steps to development and Implement Involves:

- Identify and define the scope from existing studies, reports and other documents
- Engaging stakeholders to generate portfolio of opinions
- Raising awareness and foster implementation of guidelines
- Identify, Evaluate and rectify any gaps with some more extra efforts

#### 4-Development of guidelines for Building's internal system

This refers to envelope load control such as conduction and convection of heat from the building walls of the envelope, air, moisture and humidity content and other related factors such as infiltration. A standardized document in simple format understandable by all is needed for making people realize the importance of these above mentioned aspects in determining energy performance of the building. It should incorporate factors such as full life cycle analysis, building's material and construction durability and unfamiliarity of modern technologies installed. Also making people understand the possibility of potential consequences in poor structural development or corrosion, moisture leading to air tightness in building walls in case if building is not properly designed and constructed

The challenges and barriers include high cost of modern technology usage frequently such as sprays and foams on the building walls and roofing and other misconception regarding building designs such as air tightness etc.

Therefore, steps to development and Implement Involves:

- Collecting and identifying the best possible building envelope designs from the existing latest sources.
- Engaging stakeholders and creating awareness and informing the importance of these aspects in buildings

- Reviewing and drafting guidelines from the sources
- Continue to update on regular basis to satisfy the most current and ever changing building needs

### 5-development of actual performance measurement guidelines for home equipment

This refers to the performance measurement in the actual conditions such as environments which as laboratory-controlled. This is because determining accurate efficiency in the regular working installed conditions is likely to incur an error. Say for example testing any home equipment in the standard inside/outside temperature doesn't necessarily produces and reflects the actual output. The same equipment tested in laboratory controlled environment where all proper facility and temperature are maintained, would help determine actual performance of the equipment.

There are lot of challenges and barriers associated such as difficulty in setting up such laboratories which involves high costs laboratory equipment or bringing this sort of facility to the site during the construction and operation of the building.

Therefore, steps to development and Implement Involves:

- Identifying the currently available related literature and sources (which are very little)
- Developing a case to gain interests from financing and insurance entities
- Engaging stakeholders and spreading awareness through informing potential benefits that can be derived out of this.
- Proper market transformation and deployment through international collaboration and R&D to utilize national competence.
- Evaluate and Identify the gaps involved in development of guidelines as through proper support from all relevant stakeholders, it is possible to achieve this target for accurate performance measurement.

### 3-Needs and Behavior

This refers to addressing the needs of building and Industry owner along with occupants/resident behavior. As these aspects plays a crucial role in determining energy usage and energy savings that can be achieved.

There are number of challenges and barriers involved such as the Information availability and its accuracy to the homeowners. No feedback mechanism for the consumer for their usage so then the question lies that on what factor would the consumer plan and set their goals for energy usage. Also, some buying decision are made on the base of the status like costly houses which are not so energy efficient in terms of operations but are governed more on the fact of the aesthetics of the

house and more importantly constructors are not given any sort of incentives for designing every houses energy efficient and so they aren't much concerned when it comes to build costly houses. Thirdly, no training and education for the building sector stakeholders. As discussed the workforce lacks knowledge of constructing the net-zero homes and consumers lacks too on making any informed choices on the technology selection for the homes. Making it clear on Investment costs and ROI for consumers would create more interests in consumers.

Therefore, potential guiding tool for this may include as follows:

#### 1-Developing Green energy guidelines for Building communities

This refers to promoting and encouraging community to develop better behavior towards energy in houses and communities through collaborative learning from the best practices adoption in the building communities that are regarded as small-scale energy systems for clean energy production. The technology focus on adaption to these sector should include encouragement on use of Renewables for clean-energy production.

However, there are challenges involved such as lack of proper information and other utility regulation that binds community and limits in selecting best practices for being energy-efficient.

Therefore, steps to development and Implement Involves:

- Developing scope by engaging stakeholders and work in collaboration with building designers and constructor
- Evaluating performance and monitoring variances out of it
- Involvement and encouragement from local and state government, Utility companies and Homeowner.

#### 2-Guideliness for making home energy usage data accessible

This refers to an approach to collect the data and gather relevant information, analyze it and making it accessible for all users. It can be formatted into two types in which one would be technical that designers and constructors could access it and other accessible for consumers which can be easy to understand and interpret and more importantly plan the future goals based on the current usage data pattern.

However, there are challenges involved such as addressing the missing data and accurate interpretation and conversion for designers and consumers.

Therefore, steps to development and Implement Involves:

- Working with building sector designers and constructor to develop resources
- Utility companies support for the energy bills

- Homeowners support for establishing the metrics for planning and setting future targets.
- Manufacturers for developing technology as per standards and guidelines

### 3-Fostering marketing of high energy-efficient buildings

Developing internal guidelines can benefit for building high-profit along with high energy efficient buildings and houses for the markets. This would ensure diversity and would broader building communities participation by involvements and input of opinions that would lead to achieve the energy efficiency without increasing construction costs significantly.

Therefore, steps to development and Implement Involves:

- Collaboration of all stakeholders in developing standard guidelines
- Developing guidelines in accordance to the existing business models
- Regular follow-up to update guidelines
- Developing a business case to gain confidence among investors and financing institutions

### 4-Wholesale purchase to reduce cost in developing NZE homes

This refers to purchase from the manufacturer who develop, design and manufactures the modernized and innovative technology and equipment needed for net-zero homes and buildings. It works on the fact that mass purchase from the manufacturers would lead to wholesale prices for the purchasing entities and therefore would reduce the costs of building net-zero houses.

However, the challenge is involved that most of the constructor are resistant to purchase mass inventory due to the lack of funds as they perceive risk due to the fact funds are required ahead for other purposes too during building development phase.

Therefore, steps to development and Implement Involves:

- Seeking reviews from potential buyers and other entities to identify the issues being faced by them
- Making sector aware of the possible costs savings involved
- Transparent and timely management of bidding process
- Developing models and categorizing home specifications according to technologies so as to reduce the lean times in making orders and enhance purchasing decisions

## 5-Developing guidelines to increase the knowledge

This refers to development of guidelines for all peoples who are involved in Buying, Operating and Ownership. This makes them to make better decisions and choices thereby raising their level comforts with Net-Zero Home concepts. Thus, addressing the knowledge of 'whole system entities'.

However, the challenges involved are conflict of opinions and lack of knowledge to operate and maintain homes/ buildings efficiently.

Therefore, steps to development and Implement Involves:

- Conducting detailed research analysis on home owner/ home buyer and operator preferences
- Outreaching and marketing
- Engaging stakeholders for developing portfolio of market opinions and credible participation
- Developing final guidelines in the form which is simple, user-friendly, easy understandable and accessible by all.

## 6-Developing credentials and education

This refers to inclusion in the educational system curriculum of high schools, technical colleges and universities and making the young generation aware of the facts and underlying issues as young generations are future responsible citizens of the country. Moreover, as discussed in policy recommendation proper credentials of workers, skilled labor and labelling of buildings for developing infrastructure help consumers to determine the qualified experts and helps them in making proper choices.

However, there are challenges involved such as lack of curriculum based training and impart of knowledges and integration of labelling and other programs.

Therefore, steps to development and Implement Involves:

- Developing a proper curriculum, say for examples addressing basic issues at high school level and technical aspects in colleges and post-secondary institutions, research in universities such as development of cost-effective technologies etc.
- Stakeholder support especially government
- Mandatory requirements of policy tools mentioned above in recommendations such as labelling, white certificates, certifications and obligations to ensure credentialing and energy efficiency to develop net-zero homes and buildings.

## **D-Stakeholders Actions: An overview based on policy recommendations and long term strategy**

### Manufacturers/ Trade Associations

- Work in direction of developing sustainable cases and business models that has ratings and codes that ensures energy efficiency of products thereby reducing burdens on other stakeholders
- Conducting research and development in the field of modern technology and advanced materials for building sector
- Expanding trades and fair deployment in the market to ensure success in global market and build a solid infrastructure for energy efficient products
- Guiding the workforce and consumers on new developments and outreaching so that consumers specially are aware of new technology for being energy efficient in their homes
- Help governments and stakeholders identify the less accessible and sub-markets (can be small community or any group of people) that are interested but not taken much care-of internationally through market deployment

### Utilities

- Developing financial model for better support
- Developing information guides for their consumers and especially supporting government on policies deployment
- Developing nationalized and international schemes for product and equipment certifications and various quality assurance programs to promote net-zero homes
- Explore various other possibilities internally for them in association with other stakeholders such as developing smart energy grid in which heating and cooling equipment and technology for being energy efficient can be integrated into one network and also to work on achieving cost-effective system designs with support from entities such as government, manufacturers, research institutes and universities
- Offering incentives and thereby encouraging deep renovations from their business model perspective.

### Researcher/ Universities/ Academia

- Work on research related to development of new innovative technology and materials to achieve energy efficiency in the modernized buildings

- Compulsory incorporation on the material in the curriculum for spreading energy efficiency importance amongst the young generations, as they are the future citizens of the country
- Participation nationally and internationally to ensure consumers are aware of the latest developments
- Educating and developing skill workforce for carrying out building testing and performance quality and therefore developing the human capital in the building sector
- Outreach consumers as a part of their research work and evaluating opinions and generating portfolio of opinions
- Collaboration with other stakeholders in overall development of communities and sector as a whole

#### Designers and Architects/ Builders

- Staying in line to latest developments taking place across the globe and their possibility to incorporate into the new building developments
- The main goal of designers must be aimed towards developing sustainable building designs and also making recommendation of new developments of products, technology and sustainable designs to the constructor to ensure energy efficiency in homes and buildings
- Builders should focus on deep renovations so as to add extra value in terms of energy savings to the buildings
- Fair bit of investment in training and educating thereby developing qualified workforce
- Participate on educational information dissemination and spreading the importance of achieving energy efficiency in buildings with other stakeholders involved. This can be helpful especially for the consumers in making proper decisions

#### Government

- Funding the various research institutions for research and development to promote energy efficiency
- Developing policy tools for encouragement of high-performance technologies and eliminating low-performance through obligations as mentioned in policy recommendations
- Supporting market deployment and eradicating trade barriers. This would also help supporting manufacturers to reduce their lean time

- Support workforce developments through education and training and setting standardized certificates for skill sets
- Ensure that Market-neutral programs and policies are formed and implemented
- Improvising on governance and building codes mandates
- Improving the methodology on statistics collection and developing manual indicating energy usage trends in consumers
- Leveraging market potential to achieve net-zero energy homes
- Developing various strategies and national plans to achieve the target and inclusion of a roadmap with clearly defining responsibilities of various entities.
- Accurate and transparent data collections so as to ensures that good future decisions are made based on the collected data
- Working with other stakeholders to spread information and awareness
- Working internationally on codes and standards for energy efficient buildings to utilize national competence
- Ensure financial and regulatory supports through development of proper financing mechanisms and policies that encourages the whole building sector communities and actors

## Ministries

- Allotment of incentives to manufacturers for quick large-scale production and assurance of long-term support so as to gain confidence in Manufacturer
- Remove trade barriers by reducing tariffs and taxation on heating and cooling technologies to promote their use in homes and buildings
- Address cost barriers by developing an integrated financing model taken into consideration the existing business models and financing mechanism
- Reforming regulatory regimes by making profits more shareable amongst beneficiaries
- Ensure that any unintended consequences are not derived out of government policies and regulations
- Necessary to determine the benefits and spread this benefit analysis amongst the stakeholders to make them more comfortable and confident, especially cost-benefit analysis by doing ex-post analysis of policies

- Determine the key milestones that needs to be achieved in setting up the policies so as to track the success at any stage of policies, once enforced and implemented
- Ensure long-term stability over the building sector policy framework

#### Local and State Government

- Implementation of policies set in localized regions that falls under their responsibility
- Equal distribution of funding acquired from the central government
- Continuous monitoring, evaluation and tracking the progress and intervening to make recommendations in case of any deviations
- Encourage and support for the established and newly developing programs pertinent to greenhouse gas reduction from building sector
- Promoting awareness through information and public campaigns by working in cooperation to other stakeholders such as industries and NGOs
- Working with NGOs to initiate from the local level and outreach small communities

#### Building sector officials/regulators

- Work in direction to form strong building codes taking into consideration net-zero homes and buildings as long-term vision
- Support in research activities and providing data needed for making improvements in building codes
- Eradicating the regulatory and investment barrier that hinders the target of achieving net-zero energy buildings
- Proper coordination of local policies to the building sector policies to avoid internal conflict amongst actors
- Seeking government support in any of the above mentioned for implementation at any phase and therefore collaborating with other stakeholders to ensure success

#### Non-Governmental Organizations (NGOs)

- Promote public awareness and showing support to other stakeholders

-Endorsing the benefits in publications through some research and data collection supporting activities

-Working with others stakeholders to prepare guiding manuals and providing input in policy formation

-Initiate and encourage already formed programs and policies amongst communities

Standard supranational organizations

-Continuous monitoring and tracking of the energy efficiency technologies and programs

-Assist government and other stakeholder in terms of gathering data and other relevant information needed for setting up a standard database

-Held regular workshops and publish journals, periodicals and other reports both internally for tracking the progress and externally to make consumers and other actors aware and up to date.

-Lead and access the market to help understand the needs and requirements of stakeholder and markets and exchange information to each other to make them better understand the each other's situation by trying to address the barriers and generating opinions and incorporating it taking into consideration every facets and stakeholders importance