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Framework for energy efficiency white certificates in the Emirate of Abu Dhabi

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Abstract

Energy efficiency in the demand side is considered one of the cheapest ways to achieve reductions in Green House Gases emission, as well as to avoid heavy investments in production, transmission and distribution of electricity. In the context of the Emirate of Abu Dhabi, UAE, where buildings (residential, office, retail and villas) consume about 87% of the electricity, most of which is devoted to indoor air-conditioning, energy efficiency has a huge potential for development. Under the current political/economical scenario, a series of measures to diversify the economy and attract expatriates are in place. These include heavy subsidies on retail electricity prices—which has the side-effect of limiting the economic feasibility of investments in energy efficiency. In this study, a series of building retrofits were tested on a model of the average office building in the Emirate. The best performing retrofit was identified to be the chiller's Coefficient of Performance (COP) improvements, having the lowest cost/benefit ratio and resulting in an overall annual electricity savings of around 12%. Under the current subsidized electricity price, investments in energy efficiency of existing buildings are not attractive for the owner-consumer, as over the lifecycle of the measure, the return on investment is low or negative. In this paper we attempt to assess the applicability, in the Emirate of Abu Dhabi, of energy saving obligations and tradable white certificates as a mechanism to enable investment in demand-side energy efficiency and achieving average investment returns of 7% over a 25 years horizon. The application of white certificates can enable the market of energy efficiency to develop in the Emirate. The economic return of applying a chiller retrofit under the studied white certificate scenario avoids the increase of 17% of current electricity prices.

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Keywords: *energy efficiency, tradable white certificates, policy framework, building retrofit, electricity subsidy*

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1. Introduction

Carbon dioxide, the primary agent of climate change has increased its presence in the air from long-term mean average of 275 ppm to the current level of 400 ppm. Energy efficiency is a well-established option to decouple economic growth from the increase in energy consumption and thus reduce greenhouse gas (GHG) emissions by cutting the amount of energy required for a particular amount of end-use energy service. Apart from being a sound part of the environmental and climate change agenda, increased energy efficiency can contribute to meeting widely accepted goals of energy policy such as improved security of supply, economic efficiency, and increased business competitiveness coupled with job creation and improved consumer welfare.

According to the 2008 World Wildlife Fund's Living Planet Report, the UAE had the world's worst ecological footprint per person, experiencing only minor improvements by the publication of the 2012 report. The Emirate of Abu Dhabi can be expected to have a footprint that is even higher, being the largest economy and the major oil producer among the Emirates. In addition to the environmental consequences of unrestrained energy consumption, the fact that energy prices are subsidized in Abu Dhabi results in a significant financial burden for the government. Furthermore, since peak demand determines the capacity of the supply/transmission/distribution system, any reduction in peak load will be valuable in terms of minimization of investments in future asset expansions and optimization of the existing infrastructure.

Abu Dhabi's demand-side management efforts should be initially focused on air-conditioning. Following a recent study [1], the annual air-conditioning load for Abu Dhabi municipality area (built sector) reaches 57% of the total electricity consumption. For the peak hour of the year, the contribution of the air-conditioning load reaches 75%, evidencing the need and the potential for energy efficiency measures in this built environment. That is the rationale behind the Comprehensive Cooling Program (CCP) launched by the Executive Affairs Authority of Abu Dhabi in 2012. The objective of the CCP is to reduce electricity consumption from air-conditioning by 30% in the Emirate.

Bertoldi and Rezessy [8] provide an overview of the fundamental concepts of White Certificates and discuss design and operational features that are key to achieving the overall savings targets as well as processes to support the scheme, such as measurement and verification. The paper also provides insights on a number of open issues, notably the possibility of creating a voluntary market for white certificates via integration into the carbon market. Moth [9] investigates end-use electricity efficiency policies and Demand Side Management within the Indian electricity sector. He performs a comparative analysis on a number of trading schemes, with a focus on the White Certificate schemes and Energy Saving Obligations of the UK, France and Italy. Differences and similarities, together with lessons learned are highlighted. He concludes that no design modalities from other trading schemes should be simply copied and the specific regional requirements and constraints can significantly affect the design of the optimal scheme. Staniaszek and Lees [10] describe a framework for ensuring that the evaluation, by EU member states, of energy savings of White Certificates and Energy Savings Obligation schemes is done in a transparent, consistent, and coherent manner.

2. Energy efficiency barriers in Abu Dhabi

A series of barriers have limited large-scale deployment of DSM and Energy Efficiency projects in the region. The barriers in this sector are seen to different extents in all electricity markets and are by no means exclusive to the Emirate of Abu Dhabi. Different approaches have been used reaching different success rates in targeting such barriers.

1. Principal-agent barrier: As exemplified and deeply discussed in [2], this barrier happens when the tenant pays rent to the landlord in exchange for use of the building/ space. The tenant pays the energy costs that are largely determined by the infrastructure present in the building. The landlord makes (or declines to make) investments in the building so as to lower its energy consumption. The landlord has no incentive to make efficiency investments because only the tenant benefits from these reduced costs. The opposite situation can also exist, when the end user does not pay the energy costs, the landlord has the incentive to improve the building, but the tenant can have wastage behavior

2. Transaction cost barrier: Conceptually categorized as the cost of a) search for information (due diligence), b) negotiation, c) approval and certification, d) monitoring and verification and e) trading [3]. This concept applies to the building energy efficiency sector as a result of project formulation, search for partners and/or feasible technical and financial solutions, contract negotiations and monitoring the performance of the installed equipment [4]

3. Weak price elasticity: Given the extreme climatic conditions, air-conditioning is a vital necessity most of the year and usually seen as an irreducible constituent of comfort. Awareness campaigns have shown good results in raising set-point temperatures with little or no impact in comfort. As opposed to heating, the lack of substitutes for electricity for the purpose of cooling limits the usage of alternative sources

4. Lack of price transparency: Price signals are effective only when prices are transparent and cost-reflective; low/subsidized energy prices distort decisions, as energy costs are not a major concern for consumers and businesses relative to other costs, there is little incentive to invest in energy efficiency

5. Industrial strategy based on heavy (energy intensive) industry

6. Lack of energy data to constitute baseline energy consumption and assessing variations of energy usage.

7. Impossibility for policy makers to effectively implement DSM in the absence of a decision making platform that provides accurate prior estimates of anticipated savings from planned DSM initiatives.

8. Lack of public-private partnerships (PPPs) or similar frameworks to directly facilitate the financing/ positive economic outcome associated to energy efficiency

9. Lack of regionally specific consistent measurement and verification protocols to overcome uncertainties in quantifying the benefits of energy efficiency investments

10. Lack of minimum energy performance standards (MEPS) for the existing building stock and appliances

11. No standard life-cycle cost/carbon calculation methodology for the determination of cost-optimal levels of energy efficiency in the Emirate.

3. Average office building case

By targeting air conditioning load, by improving equipment efficiency and building envelope, high potential in terms of electricity reduction and carbon emissions can be contemplated. Based on data from the Abu Dhabi Urban Planning Council [5] of an average office building in the Emirate, the typical office building model was used as baseline of comparison for different building retrofits. Simulations were conducted for a typical year, electricity consumption profiles were identified and broken into the different end-use loads.

The main specifications for the building, modelled in EnergyPlus are listed in Table 1.

Table 1- Office building specification

Net floor area (m^2)	23,312
Volume (m^3)	81,593
# of floors	15
Window to Wall Ratio (%)	70
Air-Tightness (ACH)	0.3
Mechanical Ventilation	10 l/s-person
Chiller COP (constant)	2.8
Lighting Intensity (W/m^2)	15
Equipment Intensity (W/m^2)	11
People density (ppl/m^2)	0.085
Heat Recovery	65% sensible only
Wall U-value ($W/m^2 \cdot K$)	1.7
Roof U-value ($W/m^2 \cdot K$)	0.53
Glazing U-value ($W/m^2 \cdot K$)	2.4
SHGC (Solar Heat Gain Coefficient)	0.36
Cooling Setpoint (^oC)	22
Main occupancy period	6 am–8 pm

In order to improve the energy efficiency of a multistory office building (based on UPC average office building) a series of building retrofits were tested [7]:

- different types of wall insulation (wall sheathing)
- different types of high quality low U-Value windows for replacement of the BAU ones
- different levels of chiller COP improvement
- different levels of the airtightness improvement of the building

When different retrofits are implemented in the same building, the analysis of energy savings cannot be based on the impact of individual retrofits alone, but in the aggregate impact, as one retrofits is likely to impact the performance of a different retrofit (e. g. a lighting retrofit will reduce heat generated, impacting the cooling load and any cooling related retrofit). When the subsidized cost of electricity is taken into consideration, most retrofits involving an initial investment are not financially beneficial from an economic point of view for the 25 years analysed. On the other hand, using the price reflective cost of electricity, most building retrofits do have a positive financial outcome over the lifetime of the investment (positive Net Present Value). For this case study, a retrofit improving the chiller's COP performance is considered, as it is the most financially beneficial retrofit, assuming the "most likely" investment scenario of 25 years investment lifetime and 7% discount rate.

4. Tradable white certificates

Similarly to carbon credits, tradable white certificates (TWCs) create a separate revenue stream for energy efficiency projects. TWCs provide the flexibility for the energy efficiency targets to be achieved through market-oriented mechanisms. In markets where major energy actors—such as electricity distribution companies or retailers—are mandated to reach annual energy saving targets (Energy Saving Obligations, ESO), TWCs enable those actors who are unable to fulfil their obligations unilaterally to purchase certified energy saving credits (TWCs) from authorized agents such as Energy Service Companies (ESCOs) or major end-users. Such TWCs have been used in the Flemish region of Belgium, Denmark, France, Italy, and UK, alongside with Canada and New South Wales, Australia.

The Action Plan for Renewed Energy Conservative Efforts [6], of Denmark, issued in 2005 calls for energy savings through building codes and obligations, both in the public sector and through distribution companies. The Action Plan prescribed that energy distribution companies had to implement a certain target in energy efficiency project, and that the costs of such projects could not be forwarded to the customer. In 2003, as part of the Greenhouse Gas Reduction Scheme (GGAS), New South Wales implemented a white certificate scheme, later expanded to the Australian Capital Territory (ACT) in 2005. The obligations were to be fulfilled by all electricity retailers that supply customers in NSW and ACT, generators that supply electricity directly to end-use customers in NSW and ACT, and all NSW and ACT customers that buy electricity directly from the wholesale National Electricity Market. The white certificates scheme was introduced into the Italian legislation by the Ministerial Decrees of 20 July 2004, as subsequently amended and supplemented. The command and control component of the scheme, i.e., the energy efficiency obligation, was introduced with the implementation of the first European directives on the liberalization of the electricity and natural gas market. The created certificates are valid for 5 years and are issued by the electricity market operator (GME) to utilities and ESCOs.

In the UK, under the Energy Efficiency Commitment (EEC), since 2002, electricity and gas utilities are required to achieve energy efficiency targets in the households sector. Utilities are free to choose the means to fulfil their obligations, giving flexibility to the market. In order to facilitate the calculation of savings, a pre-defined list of measures that the suppliers can implement is published.

In France, since 2006, energy suppliers are obliged to achieve energy savings targets for a time period. A 2% average annual decrease in end-use energy intensity (end-use energy consumption divided by GDP) in the period until 2015, and from 2015 to 2030 a 2.5% average annual decrease. An energy supplier that, by the end of the period, was not able to fulfil its obligations, can buy certificates from other utilities that outperformed, otherwise it has to pay to the government 0.02 EUR/kWh.

5. Abu Dhabi's case study

For the case of an average office building in Abu Dhabi, a single retrofit impacting the chiller's COP performance was considered, i. e. improvement from a SEER11 to SEER16 rated chiller. This retrofit can produce savings on the chiller consumption in the order of 25% (807 MWh/y), equivalent to 12% of the total building's yearly electricity consumption [7]. An initial investment (capital cost) of 1,583,621 AED is estimated for the retrofit (at time zero), and after the lifetime of the chiller (at time 19) for its substitution.

Considering a TWC of 1 GWh (fraction certificate allowed), to be claimed every year over the 5 initial years of the project, a total of 4 TWC could be awarded for the typical building under study. In order for the project to reach zero net present value at the current Abu Dhabi electricity rate of 0.04 $/kWh, meaning that the project repays the original investment plus the required rate of return (7%), a minimum market value for the TWC is estimated to be at about $18,250 per GWh of electricity saved (final energy).

Given that the estimate is based on the retrofit with lowest cost/benefit ratio, the price for the TWC is about a half of the current average market price for TWC in Italy (24,000 EUR/GWh of final electricity). Also, in the Italian and European markets in general, many other mechanisms are enforced targetting energy efficiency in the built environment, e.g. green building codes, minimum energy performance standards for existing buildings, energy efficiency requirements for home/office appliances, high penetration of energy efficient bulbs, etc. making it more difficult (and expensive) to further improve energy efficiency in buildings in those markets.

Many specialists in the sector recommend the increase of electricity prices as the most effective mechanism to increase energy efficiency and reduce overall electricity consumption in the Emirate. This strategy has been debated for many years, but may not materialize for many more years to come—at least not in any significant way. The heavily subsidized electricity prices are part of a broader government mandate to contain living costs in the Emirate, fostering economic diversification and distributing the income from hydrocarbon exports to the population.

In the office building example given, the investment in the chiller's COP increase becomes attractive only when electricity prices are higher than 0.05 $/kWh—an increase of 17% over current prices. The implementation of TWCs at a market value of 18,250 $/GWh can create the same economic motivation for energy efficiency as an increase of 17% in electricity prices, without the negative impacts on the economy/population.

6. Conclusion

In this study a series of barriers towards the adoption of demand-side energy efficiency in buildings were identified. Given those barriers, one of the main issues encountered in the Emirate of Abu Dhabi, UAE is the lack of economic incentive, given the heavily subsidized electricity price. Tradable white certificates were analysed as a mechanism for improving energy efficiency, where a mandate from the government to purchases the certificates are applied, indirectly creates a market for energy efficiency, resulting in reduction of the need to increase capacity, fuel costs and subsidies.

An analysis using the model of an average office building in the Emirate was used. Lower chiller's energy consumption of 25% (representing 12% reduction of overall electricity consumption) is possible using chiller's retrofit directly affecting its Coefficient of Performance (COP).

Increasing electricity prices to the final customers is a simple way to achieve higher energy efficiency, but in the current context, such a measure is not envisaged. The proposed mechanism using TWCs shows that an increase of 17% in electricity prices can be avoided. By implementing the white certificates, the government would offset part of the investment in subsidies towards energy efficiency, creating a series of long terms benefits.

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