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Energy Efficiency Markets: A Snapshot to the Models, Practices, and Experiences and Insights for the Iranian Electricity Sector

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Critical literature review

Abstract. Energy efficiency has been at the centre of attention in various jurisdictions and countries as a promising solution to the challenges posed by climate changes caused by the rise of greenhouse gas emissions, energy security, etc. Experiences regarding energy efficiency initiatives worldwide indicate that adopting market-oriented approaches to achieve energy efficiency targets is more effective than relying solely on regulations. This article intends to provide some recommendations for developing a competitive environment for Iranian energy efficiency measures by reviewing energy efficiency market models, their characteristics, and the pertaining practices and experiences across the world. For this aim, market-based instruments and energy efficiency markets are introduced. Energy efficiency market models are comparatively evaluated. Barriers regarding the development of energy efficiency markets are expounded and the challenges of launching energy efficiency markets are described. The results indicate that there is a serious exiguity of investment in providing energy efficiency initiatives in the Iranian electricity generation sector. Hence, due to electricity shortage in peak periods, it is proposed to take advantage of the Iranian capacity market potential to develop energy efficiency measures in Iran.

Keywords: *Energy Efficiency Markets; White Certificates; Electricity Markets; Capacity Market; Applicable Demonstration Projects.*

1. INTRODUCTION

Energy efficiency has drawn much attention in recent decades. The energy sector is primarily responsible for considerable greenhouse gas emissions in the world. Energy efficiency fosters economic and social development (Rosenow et al. 2017). Energy efficiency improvement can contribute to meeting widely accepted goals of energy policy such as improved security of supply, economic efficiency, increased business competitiveness together with job creation, and improved consumer welfare (Bertoldi and Rezessy 2006). Hence, it is considered one of the priority fields in the energy, economic, and climate policies of several countries (United-Nations-Economic-Commission-for-Europe 2011).

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Furthermore, energy efficiency is introduced as the least-cost way to meet new demand for energy services (Castro-Alvarez et al. 2018). Energy saving is one of the quickest, most effective, and cost-efficient ways to mitigate GHG emissions (European Commission 2005). Governments that improve investment in energy efficiency and implement supporting policies save citizens money, reduce the potential for crisis and conflict, and decrease air pollution (Castro-Alvarez et al. 2018).

It should be kept in mind that there is a distinction between energy conservation, which is meant to alter the behaviour of the consumer to consume less energy, and energy efficiency, which focuses on consuming less energy while keeping the output at the same level.

In recent years, the Covid-19 crisis has raised an extra level of stress on energy efficiency initiatives and in that regard, investments have drastically declined. As a result of the crisis and continuing low energy prices, there is a doubt in achieving global climate and sustainability goals (International-Energy-Agency 2020). However, energy efficiency programs and measures have not lost their salient position in the energy industry.

There are several policies and regulatory tools that have been implemented to foster energy efficiency. Among them, market-based instruments (MBIs), which can be tax or tradable certificates, serve as a tool to internalize the cost of negative externalities due to inefficient use of energy through an incentive mechanism (Rosenow et al. 2017).

Energy efficiency markets, which are also called energy savings markets, are the markets within which energy-saving commodities and services are exchanged between suppliers and consumers. The main product of the market is Negawatt, an Efficiency Resource Units, which refers to a unit of power or energy saved by increasing efficiency or reducing consumption (Clean-Energy-Advisory-Council 2017).

The main merit of energy efficiency markets is the flexibility given to suppliers to decide whether to take energy efficiency measures or pay the incompliance penalty to achieve the pre-determined energy efficiency targets. As a result, energy efficiency programs and schemes are implemented at a lower cost.

There is a growing interest in energy efficiency markets due to their role in delivering cost-effective efficiency gains and reducing the need for direct government expenditure (Rosenow et al. 2017). When referring to energy efficiency markets in literature, we refer to keywords such as ESCO markets, white certificates, capacity electricity markets, etc.

While demand response initiatives intend to reduce energy consumption temporarily in peak hours, energy efficiency measures result in permanent and sustainable energy consumption. Demand response and energy efficiency both impact customer end-use of energy (York and Kushler 2005). In this article, we refer to both energy efficiency and demand response resources in energy markets and hereafter we call both energy efficiency markets.

In many developed countries, the energy efficiency market is dominated by energy-efficient technologies and sustainable energy efficiency services (supply and demand) through specific energy efficiency policies and regulatory instruments. These instruments include awareness raising, information campaigns and, capacity building of EE experts, financial institution staff and, government officials (United-Nations-Economic-Commission-for-Europe 2011).

In some markets, public and regulatory bodies have set up large-scale energy efficiency organizations. Efficiency Vermont and Efficiency One are two examples of sub-national state-level in North America, where the former is in the State of Vermont, USA and the latter is in the Province of Nova Scotia, Canada (Warren 2019).

This study aims to gain insight into energy efficiency markets due to their prominent role in achieving energy efficiency targets. Here, more emphasis is on electricity-related energy efficiency markets, most prominently capacity markets. Furthermore, a brief look is taken at the implications of the electricity market in energy efficiency initiatives.

The structure of this article is as follows. In the next section, energy efficiency market-based instruments are presented. A glance is taken at ESCO markets in section two. Section three is dedicated to the models of energy efficiency markets. In the next section, the barriers to energy efficiency markets are expounded. Next, the introduced energy efficiency market models are comparatively evaluated. Some effects of electricity markets on energy efficiency measures are stated in the following section. Then, the Iranian electricity market is briefly introduced. In the next section, highlighting the challenges of launching energy efficiency markets in Iran, some suggestions and recommendations are proposed for developing these markets and fostering energy efficiency market mechanisms in the Iranian electricity market context. Conclusion remarks are presented in the last section.

2. MARKET-BASED INSTRUMENTS FOR ENERGY EFFICIENCY

Traditionally, energy efficiency measures were undertaken by hard regulatory tools, with less flexibility for energy companies and end-users. However, as the results of this approach were not promising, market instruments have gradually developed and implemented.

Recently, policy initiatives have shown increasing support for market-based instruments as a means of delivering energy efficiency worldwide (Rosenow et al. 2019).

Market-based instruments for energy efficiency are defined as a policy framework specifying the efficiency goals (e.g., energy savings, cost-effectiveness) to be delivered by market actors, without prescribing the delivery mechanisms and the measures to be used. MBIs offer the potential for policymakers to access more cost-effective efficiency gains (Rosenow et al. 2017).

Generally, there are two types of MBIs (Rosenow et al. 2017; Rosenow et al. 2019): Energy efficiency obligations (EEOs) and Auction mechanisms.

Energy efficiency obligations require utilities to undertake a defined level of activity delivering energy savings (Rosenow et al. 2019). This MBI, which is known also as energy saving obligations, energy efficiency resource standards, energy efficiency performance standards, or white certificates, is considered a market-based policy mechanism, setting a policy framework specifying the outcome to be delivered by market actors without prescribing the delivery mechanisms and the measures, adopted in more than 50 jurisdictions on 6 continents (Rosenow et al. 2019). The verified energy savings are certified as tradable energy efficiency certificates in some EEOs applications so that obligated parties can earn these certificates with their energy efficiency and saving measures, purchasing certificates from other parties, or selling their excess certificates to other parties to achieve their obligations (Ünal et al. 2022).

Auction mechanisms allow market actors to put forward bids to deliver efficient outcomes. Forward capacity auctions that allow energy efficiency to compete against other supply- and demand-side resources to meet energy system adequacy requirements are among these mechanisms (Rosenow et al. 2017).

There are 52 instruments identified and most of them are now operational on all continents. Globally around $26 billion of investment in energy efficiency is delivered through these instruments (Rosenow et al. 2019).

Some reasons are presented for the popularity of MBIs among policymakers. First of all, MBIs are less prescriptive than traditional regulations and grants as they focus on outcomes (e.g., energy savings) as opposed to the means of delivery (e.g., technology, sector, fuel, or delivery method, i.e., who provides the energy efficiency measures to end-users). Secondly, policymakers' objectives can potentially be met more cost-effectively through the direct involvement of profit-based companies, either as obligated parties or auction bidders. Thirdly, in the case of obligations, the utility costs, which are paid by consumers through energy prices, are not considered on government balance sheets (Rosenow et al. 2019).

MBIs are distinguished by the way their fund and savings are pinpointed in energy efficiency markets. In obligation mechanisms, the amount of funds and savings are predetermined and fixed. While the amount of savings depends on the number of transactions in energy efficiency auctions, the amount of funds is predetermined. In capacity markets, both factors are determined in the market by the interaction of the corresponding supply and demand. In some markets, although the energy savings that must be fulfilled is predetermined, the required fund to achieve is determined in the market. Figure 1 illustrates various types of MBIs based on two factors: savings and funds.

Some general and specific features are introduced for MBIs (Rosenow et al. 2017). These features are illustrated in Table 1 and Figure 2.

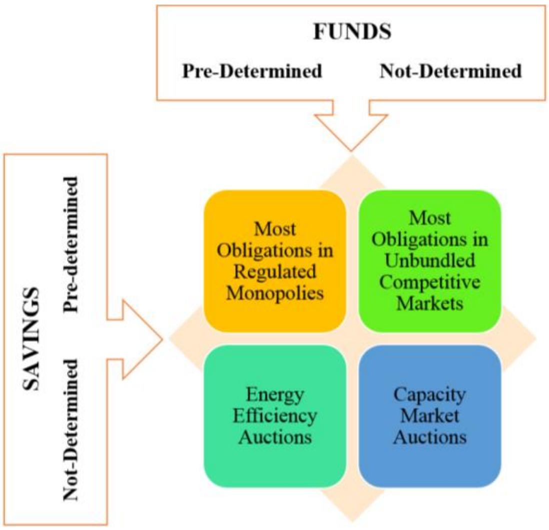

Figure 1. Differences between MBIs regarding predetermination of funds and savings (Rosenow et al. 2017; Rosenow et al. 2019)

Table 1. General and specific design features of MBIs

General Features	Obligation-specific Features	Auction-specific Features
• Fuel coverage • Sectors • Eligible measures • Lifetimes • Calculation of savings • Monitoring and verification • Evaluation	• Obligated parties • Target • Customers • Cost recovery • Compliance periods, banking, and borrowing • Trading • Penalties and performance reviews	• Funding source • Pricing and payment • Project size • Competition with energy supply

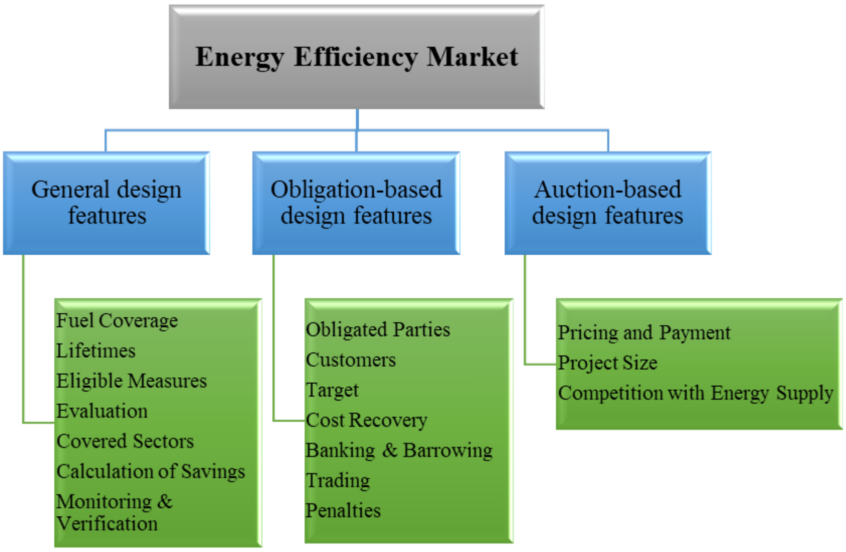

Figure 2. Design features of MBIs (Rosenow et al. 2017)

3. ESCO MARKETS

Energy efficiency markets include markets for delivering energy services. In this market, energy service providers, called Energy Services Companies (ESCOs), make efforts to improve the energy efficiency of an energy consumer by pertaining initiatives, and the gains from this improvement are shared between two sides through a contract.

An energy services company (ESCO) manages and coordinates all phases of an energy project and provides a variety of services (Jafari 2018).

ESCOs could help to remove hindrances to energy efficiency and micro-generation, by providing information, finance, installation, operation, and maintenance under a long-term contract (Bertoldi and Rezessy 2006).

ESCOs are the main players in ESCO markets, which are markets that deal with providing energy efficiency services and products for energy consumers through the corresponding contracts. In the contracts, the relationship, responsibilities, and financial commitments of the two sides are stipulated. The main issue in this context is the share of each side in recovering the associated uptake investment of the EE measures.

Generally, there are a plethora of reports, articles, and documents provided by international energy associations regarding ESCO markets in different parts of the world (Rosenow et al. 2017; Rosenow et al. 2019; Boza-Kiss et al. 2015; Boza-Kiss et al. 2017; International-Finance-Corporation 2011; Marino et al. 2010).

There is less experience in deploying MBIs in ESCO markets. USA has successfully developed MBIs and ESCOs in a promising manner. In other parts of the world, the evidence on MBIs is scarce. Brazil, China, Italy, and South Africa are other nations that have applied MBIs in their ESCO markets (Rosenow et al. 2017).

UK is another country that has developed and implemented an ESCO market. There are three distinct types of market for energy services in the UK (Bertoldi and Rezessy 2006):

Performance contract model: this model is also known as the ‘facilities management’ model. This model is applied in the commercial and industrial sectors, where the ESCO offering is most developed, and has great potential.

Community model: in this model, decisions are taken by or on behalf of a group of customers in the same location, with particular opportunities in new-build, social housing.

Household model: in this model, energy suppliers, contractors, or equipment suppliers to existing residential customers may evolve to include energy efficiency and micro-generation.

The facilities model is the most well-known model in the UK, while ESCOs specialized in servicing households are virtually almost non-existent (Bertoldi and Rezessy 2006).

4. ENERGY EFFICIENCY MARKET MODELS

There are various forms in which energy efficiency markets evolve, indicating the way suppliers and buyers transact, the way prices are settled, and other aspects. There are three market models for energy efficiency (Clean-Energy-Advisory-Council 2017):

1. Energy efficiency credits or certificates
2. Capacity markets
3. Applicable demonstration projects

To enable supply and demand to interact more freely within the boundaries of the energy efficiency market construct, the rules of engagement are established by the system operator, regulator, and increasingly, program administrators (Clean-Energy-Advisory-Council 2017).

A. Energy Savings Certificates

Energy saving certificate (ESV), also known as the White Tag, White Certificate, or Energy Savings Certificate (Clean-Energy-Advisory-Council 2017), is one of the energy efficiency market models. Globally, this model is the most common, based on the exchange of tradable certificates issued for energy savings.

ESVs enable utilities to achieve their energy efficiency goals, which provides them with opportunities to gain more profits by selling their extra efficiency achievements as certificates (Khomaini 2021).

Policymakers seek several objectives by trading ESVs which include promoting energy efficiency, reducing energy costs for consumers, improving the stability and reliability of power networks, and reducing GHG emissions (Khomaini 2021).

There are different ways to define energy efficiency certificates. According to Bertoldi and Rezessy (2006): “A white certificate is an instrument issued by an authority or an authorized body providing a guarantee that a certain amount of energy savings has been achieved. Each certificate is a unique and traceable commodity that carries a property right over a certain amount of additional savings and guarantees that the benefit of these savings has not been accounted for elsewhere”.

In another definition, this certificate is introduced as a document certifying that a specific amount of energy savings – usually one MWh – has been measured and verified. Various eligible measures are defined in various energy efficiency programs. Generally, they include commercial and industrial lighting upgrades, cogeneration or combined heat and power (CHP), insulation, heating, ventilation, and air conditioning (HVAC) improvements (Clean-Energy-Advisory-Council 2017).

Increasing the level of investment, promoting transparency and credibility, and the reduction of compliance costs are stated as some benefits of energy efficiency certificate trading (Khomaini 2021).

In this model, in the first stage, energy-saving targets are set by a regulatory body for energy suppliers or distributors. They are obliged to implement energy efficiency measures to achieve their targets within a certain time frame. Then ESVs are awarded to the obliged parties according to the results of their initiatives. Parties that are unable to reach the predetermined targets, have to purchase enough ESVs to cover the gap to their targets. By contrast, the parties that reach beyond their targets have the opportunity to sell their certificates in the market. Financial institutions and brokers have the opportunity to participate in this energy efficiency market model (Khomaini 2021).

The time frame in which obligated parties or participants have to achieve their energy efficiency targets can be the estimated savings over the expected lifetime of the measure or the annual energy savings (Clean-Energy-Advisory-Council 2017).

ESVs provide multifarious benefits. Their core values are stated as follows (Khomaini 2021):

- Cost-effectiveness
- Flexibility
- Ease of implementation
- Complementary with other schemes
- Additionality

Energy Efficiency Certificates are issued and traded among market participants in several European countries such as France, Great Britain, Italy, Australia, and some states of the United States, namely Connecticut, Pennsylvania, and Nevada (Khomaini 2021).

Elements required to deploy energy efficiency certificates in practice in a given market are the following (Bertoldi and Rezessy 2006):

1. The creation and framing of the demand
2. The tradable instrument (certificate) representing the savings and conferring property rights to the holder, and the rules for trading
3. Institutional infrastructure and processes to support the scheme and creation of the market
4. Supporting managerial and supervision systems
5. Cost recovery mechanism

B. Energy Efficiency in Capacity Markets

Energy capacity is the applied capital intensive to compensate for initial investments in power generation over the long term. In capacity markets, capacity certificates are traded among participants, as the tradable form of the assets that can be applied to meet electricity demand requirements. Capacity markets have been established to ensure the availability of capacity when it is required (Fetter et al. 2012).

Capacity markets aim to attain a reliable system operation by purchasing sufficient capacity and concentrating on a resource's effect on concurring peak (Clean-Energy-Advisory-Council 2017). Although capacity markets were designed based on the central power station generators, a movement toward more competitive wholesale electric markets altered this dynamic toward new resources (Fetter et al. 2012).

The contribution of energy efficiency in capacity markets is attained through two resources: demand response and energy efficiency. There is a great potential for demand response and energy efficiency to have a much greater contribution in capacity markets worldwide. At the same time, the role of the demand-side resources in capacity markets is to receive more attention from governments around the world (Warren 2019). However, there are limited practical experiences regarding energy efficiency contribution in capacity markets worldwide. In capacity markets, energy efficiency resources are engaged by bidding on permanent electricity savings and reductions over the lifetime of measures to submit the required capacity in a given period, most prominently in peak periods (Warren 2019).

Energy efficiency as a resource, which involves permanent, continuous reductions in customer energy use that are not reflected in the system's forecast of peak load, is distinguished from demand response initiatives which primarily aim to change the demand pattern (Warren 2019).

The ISO-NE, a power grid operator in New England state, introduced energy efficiency resources to the US electricity capacity markets in 2006. However, the first "delivery" of energy efficiency took place in 2009. PJM followed this initiative in 2009, with initial delivery set for 2012 (Warren 2019). Figure 3 delineates energy efficiency contribution in PJM capacity markets. In the auction held for procuring sufficient resources to meet electricity demands in 2020-2021, a total of 640 MW of new energy efficiency and demand-reduction (demand response) measures were cleared, which is the equivalent of a large power plant. The cumulative amount of EE and DR resources participating in the market was approximately 3,200 M, which is about 9% of the total capacity. The clearing price was $5.30 per kilowatt/month. This is while in PJM, 1,515 MW of efficiency cleared in the 2019-2020 auction and 613.7 MW of demand response cleared as capacity performance (Clean-Energy-Advisory-Council 2017).

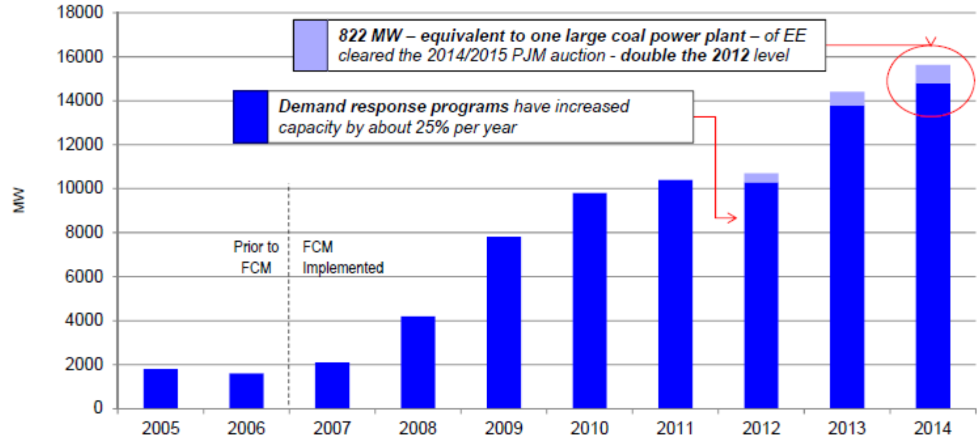

Figure 3. Growth in Demand Response and Energy Efficiency in PJM (Sotkiewicz 2011)

Following the US markets, the UK launched a pilot scheme in 2014 to deploy the potential of enduring reductions achieved through electricity efficiency programs as a promising resource in the capacity market (Warren 2019).

While eliminating the obstacles to introducing demand response and energy efficiency resources in capacity markets, adequate attention should be paid to the ability of providers to address and cope with the risks pertaining to uncertain funding and planning (Liu 2017). Furthermore, it is imperative to regulatory support and outline appropriate incentives to put demand-side options beyond on-site generation on an equal basis with supply-side options (Warren 2019).

C. Applicable Demonstration Projects

The demonstration projects are intended to display new business models that are expected to provide new revenue stream opportunities for third parties and electric utilities by informing decision-makers concerning energy efficiency initiatives (Gleißner et al. 2013).

The demonstration projects are primarily developed in some states of the USA. In New York, demonstration projects have been developed according to an energy vision called Reforming the Energy Vision (Werho et al. 2016). REV is provided to ensure energy efficiency and clean, locally produced power at the core of the energy system of the state (Department-of-Public-Service-of-New-York).

Under some regulations, the New York Public Service Commission, which is the public utilities commission of the New York state government that regulates and oversees infrastructure including electric, gas, water, and telecommunication industries in New York, directed six electric utilities to develop demonstration projects.

The demonstration projects under REV in New York state are regarded as a Distributed System Platform development, intending to gauge customer response to programs and prices regarding REV markets, demonstrating the most efficacious and effectual implementation of distributed energy resources, and promoting the delivery and deployment of energy efficiency and renewable energy technologies (Clean-Energy-Advisory-Council 2017).

The following are some REV demonstration projects that aim to sustain and promote energy efficiency markets, customer engagement, and distributed energy resources (Clean-Energy-Advisory-Council 2017):

- The Clifton Park Demand Reduction Demonstration Project
- The Fruit Belt Neighbourhood Solar Demonstration Project
- CONnectED Homes Platform Project
- Building Efficiency Marketplace Project
- Community Energy Coordination (Lawanson et al. 2018) Demonstration Project

National Grid has implemented two demonstration projects to examine the potential for scalability and supporting a variety of customer needs: *The Clifton Park Demand Reduction Demonstration Project,* and *The Fruit Belt Neighbourhood Solar Demonstration Project* (Clean-Energy-Advisory-Council 2017). The former project aims to engage and inform customers about their energy use to help them better manage their consumption (Clean-Energy-Advisory-Council 2017).

The Fruit Belt Neighbourhood Solar Demonstration Project is another Demonstration Project aiming to provide Low-and-Moderate-Income (LMI) customers with access to solar energy resources, solar bill credits, and energy efficiency offerings to intensify the motivations for further energy bill savings and improved energy efficiency. The results of this demonstration project could clarify to what extent underserved customer groups' demands can be responded to by clean energy (Clean-Energy-Advisory-Council 2017).

Con Edison's *CONnectED Homes Platform* and *Building Efficiency Marketplace* are intended to educate customers and strengthen and support the relationship between energy consumers and energy efficiency market parties. The main goals of these demonstration projects are expressed as to substantially improve the efficiency of market activities, enable customers to more quickly grasp the merits of energy efficiency and demand management programs, and further improve the engagement of customers by applying data-driven approaches. This project provides several tools to proactively associate the targeted residential customers with cost-effective products and services in the energy efficiency context and distributed generation offers to help eliminate the obstacles and impediments that prevent residentials from adopting distributed generations and provide strong links between customers and third-party vendors for assistance and implementation (Clean-Energy-Advisory-Council 2017).

To remove customer barriers to the utilization of distributed generation technologies, New York State Electric and Gas have carried out a demonstration project known as *Community Energy Coordination*. Under this project, NYSEG aims to enhance and promote the marketing of three distributed generation technologies directly for its customers: residential solar, community solar, and energy efficiency services. This motivates customers to enter the online service marketplace to garner information and help them connect with third-party service providers (Clean-Energy-Advisory-Council 2017).

5. CHALLENGES AND OBSTACLES OF ENERGY EFFICIENCY MARKETS

There are several obstacles and drawbacks in the way of developing EEMs. Generally, the main barriers that impede EEM development are defined in several thematic categories including information and awareness, institutional and legislative, financial, market and external, technical and administrative, and behavioural (Bertoldi and Boza-Kiss 2017; Boza-Kiss et al. 2017).

The versatile benefits of energy efficiency improvements in terms of increased asset value, increased productivity, and health improvements are rarely recognized and considered when making an investment decision (Boza-Kiss et al. 2017). Banks and other energy efficiency projects' financiers are not adequately aware of energy efficiency measures and projects, resulting in an overestimation of investment risk, tending less motivation towards investing in these projects.

Complicated and stringent public procurement procedures, exiguity of reliable energy data, and lack of standardized contracts are stated as other factors that could hobble EEMs (Panev et al. 2018).

Although the barriers and challenges to EEC development are tremendous, they do not seem to be insuperable, as indicated by successful white certificate schemes worldwide (Aldrich and Koerner 2018c, 2018a).

One dominant hinderance to establishing white certificate markets is the absence of a unique and clear definition for them globally. Even this instrument is not recognized as a singular name throughout various jurisdictions since it is mentioned in distinct titles in their underlying legislation. There are considered remarkable distinctions between EEMs in terms of the units for white certificates, and the types of technologies eligible for white certificate generation (Aldrich and Koerner 2018b).

Another major veritable hindrance of EE projects that needs to be addressed, is cost recovery. Energy prices are low in many jurisdictions due to remarkable cross subsidiaries. Small-scale projects do not justify energy efficiency initiatives.

Costs burden, borne by obliged parties, overly depends on energy prices and other market and economic factors in EEC programs. For instance, the costs borne by obliged parties in France are approximately six times lower than in Great Britain (Giraudet et al. 2012). Moreover, the social costs of EECs in different jurisdictions might be notably diverse (Giraudet et al. 2012).

In particular, the complexity of setting rules and applying them in EEC markets, the uncertainty of the cost evaluations including expected costs, adverse expected impact of EECs on prices and insufferable uncertainty about expected energy savings, overvalue setting of EE targets, and insufficient degree of publicity are expressed as other challenges of EECs (Secretariat 2010). In addition, EECs provide more transparency about energy savings, but less transparency around costs in contrast to demand-side management schemes (Giraudet et al. 2012).

Both demand response (DR) and EE resources may participate in forward capacity markets, directly competing against other resources in the capacity auction, or be procured through dedicated auctions (Liu 2017). Capacity product definition, the treatment of demand-side resources, and M&V procedures are stated as key obstacles in the participation of demand response and energy efficiency sources in capacity markets (Liu 2017). The definition of capacity products provides the tradability feature of DR and EE resources. In this way, the requirements of the system and resources' market potential should be taken into account. To support the growth of the market, it is worth introducing capacity products that establish meaningful contributions to capacity adequacy, with lower delivery requirements (Liu 2017).

6. COMPARATIVE ASSESSMENT OF ENERGY EFFICIENCY MARKET MODELS

In this section, a comparative assessment of EEM models is conducted by an evaluation matrix. Assessment of policies, strategies and economic conditions through an evaluation matrix has been widely applied to assist policy-makers, managers and high-level decision-makers in determining their priorities. This is achieved through subjectively measuring various criteria such as market or strategy attractiveness, feasibility, and acceptability (Gleißner et al. 2013; Connell 2010; Bondarenko et al. 2020; Mohammadzadeh et al. 2021; Zolfani et al. 2021; David et al. 2017). Accordingly, in this section, EEM models are evaluated and compared based on three broad criteria: market and investment attractiveness, required foundations, and social awareness and acceptance.

Market and investment attractiveness is defined as the extent to which market participants/players tend to take part in each EEM model. It is measured by the market liquidity, market maturity, expected return rate of investment, and other dominant economic and monetary factors.

Legal and administrative foundations for EEMs pertain to the steps and competencies required to underpin and operate a market sustainably and efficiently. Apposite regulatory and legal support from markets reinforces the position of the market, which ensures the participants of its efficient operation. Regarding this criterion, providing transparency and accountability is pivotal in order to establish a promising market governance.

Here, social acceptance is defined as the extent to which individuals, energy consumers, investors, energy players, and policymakers are familiar with a market or deploy an EEM model. It is directly dependent on their awareness of EEM models and the complexity underlying their procedures, processes, and best practices. Proper knowledge and understanding of a market model pave the way for substantial participation of energy consumers and producers, resource allocation and legislation from policymakers, providing adequate funds from banks and investors, and determining other likely players.

Regarding market and economic attractiveness criterion, EEC and CM seem to be among the options with higher degrees. Of course, the EEC model is the most common worldwide, contributing to a higher transaction volume, and more mature markets. In contrast, ADP is rarely deployed and has fundamentally less market attractiveness than other EEM models.

As far as the legal and administrative criterion is concerned, EEC has less burden for policymakers to implement, as evidenced by its wide application over the globe. EEC is the most prevalent and auspicious EEM model in all countries, including the US, UK, Australia, Italy and France among others (Aldrich and Koerner 2018a; Secretariat 2010). The legal and administrative foundations of this EEM model encompass certificate insurance, M&V, verification and tracing of EE certificates (Aldrich and Koerner 2018b), market oversight mechanisms, contract selection and preparation, etc. The CM model is applied to forward capacity markets of some jurisdictions such as the US and Great Britain (Liu 2017). This model is far less popular than the EEC model. It needs more foundations including, among others, establishing aggregators (Spees et al. 2021), and adaptation to electricity market regulations and rules, considerations associated with interaction with other markets (Liu 2017). Moreover, the scope of the CM model is confined to electricity energy. The ADP model is restricted to the design and implementation of specific EE projects and the dissertation of the pertaining results, leading to a more restricted scope, implying a need for minor foundations and the least desideratum as well, which implies that it has the least market and economic attractiveness.

The social awareness and acceptance of the EEC model are more cumbersome since this model involves more players and entities due to its broader scope. The lack of social awareness is highlighted as one of the main prominent challenges in the underlying market. However, it is demonstrated that the implementation scale of EEC is wider than other EEM models, indicating that, from a holistic view, the social acceptance for this model is of a higher degree.

It is measured by the easy entrance (time for certificate issuance, obliged/optional, sectors), liquidity level, and availability of markets. Feasibility indicates availability to markets, necessary foundations, ease of implementation, cooperative international companies, extensive application, government support, and international support.

The EEC model is the most available market for EEM participants and players. A cornucopia of markets operates based on this model throughout the world. However, capacity markets are less popular, including countries and jurisdictions with more mature electricity markets. In contrast, from a market point of view, ADPs primarily intend to support commercial professionals by learning how sustainable energy prototypes are brought to the market (Bossink 2017), focusing on creating supply-demand networks that serve the increasing number of markets (Bossink 2020). A variety of learning techniques, including those that occurred in niches where sustainable energy technologies and markets are being developed interactively, are studied in the pragmatic setting of sustainable energy technology demonstration projects (Bossink 2020). As a result, demonstration projects in the sustainable energy context enable technical, organizational, policy, and market learning of the relevant participants, which promotes applied knowledge in terms of development, production, marketing and the use of renewable and sustainable energy in business, markets and society (Bossink 2017).

Table 2 indicates the evaluation matrix of EEM models, showing the degree of each EEM model according to the introduced criteria. While green colour represents the highest score, yellow colour indicates the lowest one.

Table 2. Evaluation Matrix of Energy Efficiency Market Models

Energy Efficiency Market Models	Market & Investment Attractiveness	Legal & Administrative Foundations	Social Awareness & Acceptance
Energy Efficiency Certificates	High	High	High
Capacity Markets	High	High	Medium
Applicable Demonstration Projects	Low	Low	Medium

7. EFFECTS OF ELECTRICITY MARKETS ON ENERGY EFFICIENCY MEASURES

The effect of energy market liberalization on energy efficiency relies on a complex set of factors. However, competition could contribute to reducing energy price volatility, which in turn leads to raising motivation for incentives to energy efficiency measures (Bertoldi and Rezessy 2006).

At the same time, suppliers have sufficient incentive to promote demand-side energy efficiency to maintain consumers and motivate and engage new ones by offering energy services. These modern services are considered an ‘added value’ to electricity, a homogenous commodity. Accordingly, the restructuring and liberalization measures in the energy sector context may result in a need for new kinds of incentives that comply with liberalized market principles for the sake of fostering the improvement of end-use energy efficiency. Hence, developing long-term and sustainable synergies between energy sector liberalization and end-use energy efficiency is crucial for policymakers. This is the reason a plethora of policymakers and supporters of energy efficiency plans insist on including energy efficiency and energy services in laws and regulations to fulfil electricity and gas market liberalization. On the other hand, failures in energy markets would result in the reduction of investment in energy efficiency measures (Bertoldi and Rezessy 2006).

8. IRANIAN ELECTRICITY MARKET OVERVIEW

Complying with the general policy of the electric power industry of Iran, the Iranian electricity market (IEM) was established on 23 October 2003 (Heidarpanah et al. 2023). Iran's electricity market is a day-ahead, unilateral, discriminatory wholesale electricity market. It is a discriminatory, hourly auction, in which all producers of the market are obliged to participate. In this market, there are no retail or reserve markets, and the supply function is constructed by the submitted bids of individual generators (Nazemi and Mashayekhi 2015). Concluding bilateral contracts is allowed in IEM (Yousefi et al. 2017).

The main part of the Iranian electricity market is a mandatory pool where all producers and consumers submit their bids to the market every day before 10 a.m. (Bigdeli and Afshar 2009). To prevent anti-competitive behaviour, a tight price cap is put on producers' bids (Nazemi and Mashayekhi 2015). Payment to the suppliers is conducted based on the Pay-As-Bid mechanism (Nazemi and Mashayekhi 2015; Asgari and Monsef 2010). Payments to generators are categorized into two parts: capacity payment and energy payment (Bigdeli and Afshar 2009). Moreover, pursuant to Iran's electricity market regulations, it is presumed that generators operate unless the market operator gives permission (Nazemi and Mashayekhi 2015).

Electricity prices in this market consist of two main components: fixed and variable. While the former refers to the preparedness price, which is paid for the capacity of the power plants that are ready to run as the operator permits, the latter directly relates to the amount of energy produced by power producers. The current IEM structure seems to be inefficient, leading to growing adverse consequences (Gholizad et al. 2017).

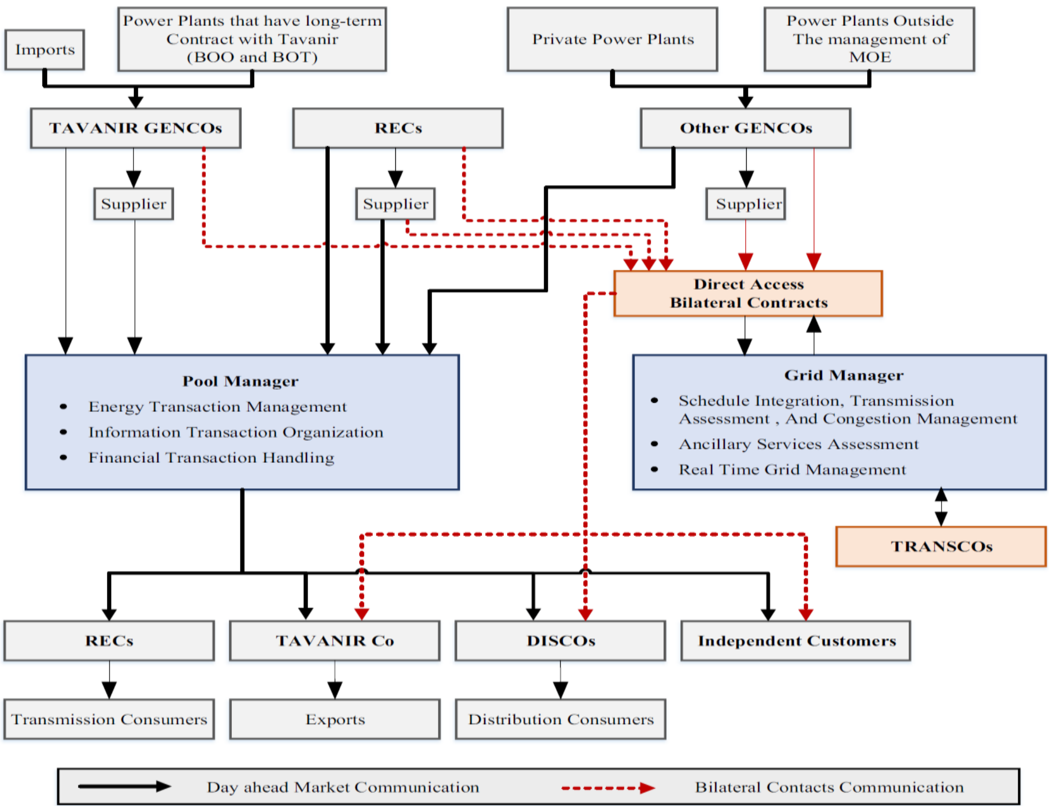

Figure 4. Iranian Electricity Market Structure (Ghaziadeh et al. 2007)

IGMC is a market and network operator, in charge of holding the wholesaling market and issuing certificates of bilateral transactions. Furthermore, IEMRB is the market regulator, monitoring law enforcement and acting as the market referee (Shahri 2011; Yousefi et al. 2017).

The capacity market mechanism has been operated in the Iranian power exchange so that a power plant capacity owner can be allowed to offer a capacity certificate on the power exchange, equivalent to the capacity in hand. The purchaser could then buy their capacity certificate (Mardani and Ghazizadeh 2022). The structure of the Iranian electricity market is shown in Figure 4.

9. DEVELOPMENT OF ENERGY EFFICIENCY MARKET MODELS IN IRAN: CHALLENGES AND RECOMMENDATIONS

It is vividly demonstrated by experience that the market solutions are more straightforward and streamlined to ensure achieving energy efficiency goals. However, despite a plethora of laws, acts, regulations, and bylaws that have been ratified in the context of energy efficiency in the Iranian electricity industry, infelicitous results have been attained. In other words, the regulation-oriented policy has not achieved the pre-determined targets.

Accordingly, several efforts have been undertaken by legislators in recent years including enacting the “Bylaws for Creating the Market for Energy Efficiency and Environment” in March 2018, Article 12 of the “Law on Elimination of Barriers to Competitiveness and Improving the Country’s Financial System” in April 2015, and rampant bylaws and guidelines to facilitate demand response schemes. However, no conspicuous and noticeable progress has been achieved in this context yet. Hence, it is a requisite to tend more seriously towards market perspectives to implement energy efficiency policies and measures.

It is believed that legislators and policymakers have insufficient understanding of EEMs and their pertaining mechanisms. Therefore, the main elements and drivers of EEMs are not meticulously considered in the mentioned regulations. As a result, investors and consumers do not find adequate motivation to participate in this market. Accordingly, it is envisaged to gain more insight into EEMS, their fundamental elements, the required arrangements and procedures to launch the markets, and other associated managerial issues.

It is proposed that the foundations and requirements for trading energy efficiency commodities in the form of demand reduction and energy efficiency certificates be provided in the Iranian capacity market and the Tehran Stock Exchange (TSE).

It is noted that one of the main challenges of designing effective energy efficiency market-oriented policies in IEM is the substantial gap between electricity generation cost and electricity tariffs of end-consumers. Low electricity prices seem to be the most dominant obstacle to accomplishing market-oriented schemes. This calls for taking more priority over demand response programs by the decision-makers of the electricity sector.

It is highly recommended to develop and support applicable public/state demonstration energy efficiency projects to promote the benefits and advantages of energy efficiency initiatives and recognize their pertaining risks and administration of measurement, reporting and verification (MRV) issues.

It is strongly recommended that the required foundations in which IEM operates are considered while devising demand response programs. In the first stage, pilot schemes should be launched to coordinate demand reduction trading mechanisms with other electricity market mechanisms. Once the energy efficiency market is developed, it should be sustainable in terms of economics, by ensuring the liquidity of the market in the long-term.

It is imperative to pave the way for establishing small-scale electricity demand aggregators. Moreover, supportive policies and initiatives are required to promote ESCOs and their activities. The government should encourage energy-intensive consumers such as steel, aluminium, and cement manufacturers to become involved in the energy efficiency market.

The most paramount issue that has been overlooked in developing market mechanisms is the active participation of the main stakeholders in designing and implementing EEMs. Stakeholders play a crucial role in the sustainable operation of markets and may directly or indirectly influence the efficiency of EEM mechanisms and the performance of the whole market. Accordingly, considering their suggestions, limitations, challenges, and drawbacks regarding various EEM aspects seems to be vital for developing and sustaining EEMs. Hence, their comments and suggestions should be taken into account before the implementation of critical functions.

As the Iranian power industry increasingly faces severe electricity supply shortages in the peak periods in recent decades and a great deal of bylaws have been provided for demand response programs, it is strongly recommended to define energy efficiency resources along with demand response resources, using extant market opportunities in Iran’s forward capacity market. To include EE and DR resources in IEM, it is proposed to provide needed foundations to establish the EE and DR aggregators or providers, design well-established EE and DR programs by providing sufficient economic motivations for power electric consumers, and review IEM’s rules to participate in demand response resources.

CONCLUDING REMARKS

In this article, EEMs and their related instruments and models were introduced and elaborated, delineating their main aspects. Moreover, the main challenges of the development of EEMs were pointed out. Lack of information and awareness, legal barriers, insufficient cost recovery, and administrative weaknesses were introduced as the main factors that hobble global EEMs. To help the recognition of EEMs, they were comparatively evaluated in terms of three introduced criteria: market and economic attractiveness, legal and administrative foundations, and social awareness and acceptance.

Next, the Iranian electricity market and its forward capacity market were introduced and their current situation, responsible entities, and main players were presented, pointing out its inefficiencies, particularly on the retail side. The results demonstrate despite the adequacy of EEM regulations and policies, Iran is confronted with extreme economic, market and managerial hindrances to develop EEM models. Low energy prices, lack of awareness towards energy consumers and policy-makers of all aspects of EEMs, and low rate of return on investment are among the most prominent challenges to launching EEMs in Iran.

As electricity shortages in peak periods growingly endanger the Iranian power industry, and regulatory requirements for implementation of demand response schemes are available, it seems there is a notable opportunity to introduce energy efficiency resources along with demand response responses to the future Iranian capacity market.

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