Iran's Electricity Renewable Resource Planning

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Abstract: Iran’s domestic consumption and production have steadily grown together since 1984 and it is still heavily reliant on traditional thermal energy sources of electricity, with a small fraction being produced by hydroelectric plants. In this regard, the governments in energy sectors would like to investigate in renewable resources. Infrastructure resource planning in long term has an important role in maintaining future demand and also economical and environmental aspects of energy generation and consumption are recent worries about future for the ministry of energy in Iran. This paper surveys on the future infrastructure resource planning and long term demand forecasting for Iran electrical energy sector.

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1. Introduction

Energy resources in Iran consist of the third largest oil reserves and the second largest natural gas reserves in the world. Iran is in a constant battle to use its energy resources more effectively in the face of subsidization and the need for technological advances in energy exploration and production. Energy wastage in Iran amounts to six or seven billion dollars (2008). The energy consumption in the country is extraordinarily higher than international standards. Iran recycles 28 percent of its used oil and gas whereas the figure for certain countries stands at 60 percent (IGMC, 2008). Iran paid $84 billion in subsidies for oil, gas and electricity in 2008 (Tavanir14727, 2009). Iran is one of the most energy intensive countries of the world with per capita energy consumption 15 times that of Japan and 10 times that of EU. Also due to huge energy subsidies, Iran is one of the most energy inefficient countries of the world, with the energy intensity three times higher than global average and 2.5 times the Middle Eastern average (Tavanir16641, 2009).

Iran is one of the leading members of OPEC (Organization of Petroleum Exporting Countries) and the Organization of Gas Exporting Countries (GECF). Iran received $47 billion dollars in oil export revenues, which accounts for about 50% of state revenues. Natural gas and oil consumption both account for about half of Iran’s domestic energy consumption. With its heavy dependence on oil and gas revenues Iran continues to explore for new sources of natural gas and oil. Recently Iran has focused its energy sector on the exploration of the South Pars offshore natural gas fields in the Persian Gulf (Officialwire, 2008) Iran has become self-sufficient in designing, building and operating dams and power plants and it has won a good number of international bids in competition with foreign firms.

Generation expansion planning (GEP) has historically addressed the problem of selecting the most adequate technology, the expansion size, the sitting, and the schedule for the construction of new plants considering economic criteria while ensuring that installed capacity adequately meets the expected demand growth. (Pereira and Saraiva, 2010)

The major objective of power system planning in regulated power systems is to meet the demand of loads, while maintaining the power system reliability. In this environment, infrastructure expansion planning is frequently organized by ministry of energy due to the low level of existing uncertainties. Besides, planners can achieve the required information for planning. Consequently, planners can design the least cost expansion plan based upon the certain reliability criteria (Dehghan, et al., 2009).

In Power system, GEP include determining capacity that is required for long-term planning horizon, technologies of generation units and construction time interval and location for each unit. GEP problem in restructured and modern power system toward conventional systems is very complex. Generation technologies are classified into two categories (Javadi, et al., 2011):

- Conventional energy (Coal, Oil, Gas, Nuclear, and Hydro)

- Unconventional and Renewable ones (Solar, Wind, Fuel cells, Biomass, Geothermal, Micro gas-turbines, etc).

One of the methods for improving the efficiency is augmenting these units. In large units, Combines Cycle Generation Technology (CCGT) can decrease the costs. The supply of fuel source for combined cycle units is very important. Because of more and greater efficiency, less pollution and low level of equipment depreciation, competitive electricity market has tendency to utilize natural gas (Shahidepour et al., 2005).

One of the most important characteristics of natural gas is their problem of reserving in comparison with other resources of fossil fuel and due to it identity to consume in consumption places and extraction points or special centers connected to gas supplying network which is very high (Hatice et al., 2009).

Based on TDCA's report, within the Middle East, Iran has the most gas resources and has the second rank in the worldwide ranking after Russia. However, producing of natural gas in Iran compared with resources is very less and has got fourth place of worldwide producing after Russia, US and Canada. This producing is only three percent of worldwide gas production (Javadi, et al., 2011).

Thus, natural gas can be one of the foresight potentials in future infrastructure expansion of Iran's energy. Demand for natural gas is expected to become more in coming decades, because of rapid growth of electrical energy generation units based-on natural gas (For example combined cycle units as one model of centralized generation units, or micro gas-turbine as one model of Distributed Generation (DG) units).

The investment decision process changed with the development of competition in the electricity sector since investment on new generation capacity became a commercial and risky activity. This is because investors are more interested in short-term investment return and are less interested in investing on generation capacity requiring large capital efforts and long recovery periods. This activity is also very much influenced by increasing load uncertainties, restructuring policy and market management rules. Apart from that, investors should pay attention to the possible behavior of the other competitors given the interactions existing in this decentralized decision making process. The formulation of such a decision making process should consider a number of issues as the evolution of the demand, market prices, variations of regulatory policies and changes of financial and economic data (Pereira and Saraiva, 2010)

2. Iran's Energy Resources

Power generation capacity of Iranian thermal power plants reached 173 terawatt hours in 2007. Accounting for 17.9 percent of power production in the Middle East and African region. Natural gas has been the main energy in Iran in 2007, comprising over 55 percent of energy needs, while oil and hydroelectricity accounted for 42 and 2 percent respectively. The region's energy needs will increase by 26.8 percent until 2012 (IGMC, 2007).

Iran has the second largest oil reserves in the world, and the third largest exporter of it. According to 2006 estimates Iran produced about five percent of total global crude oil production. They produced 4.2 million barrels per day (670,000 m^3/d) of total liquids and 3.8 million of those barrels were crude oil. Iran plans to invest $100 billion during the next four years in different sections of its oil industry (Javadi and Monsef, 2008). By the end of 2009, Iranian oil R/P ratio was 89.4 years which is the worlds highest. By 2009, Iran had 52 active rigs and 1,853 producing oil wells (IEA, 2009).

Iran possesses abundant fuels from which to generate energy. Since 1913 Iran has been a major oil exporting country. Oil industry output averaged 4 million barrels per day in 2005, compared with the peak output of 6 million barrels per day (950,000 m^3/d) reached in 1974. Following the 1979 revolution, however, the government reduced daily oil production in accordance with an oil conservation policy. Further production declines occurred as result of damage to oil facilities during the war with Iraq. In the early 2000s, industry infrastructure was increasingly inefficient because of technological lags. Few exploratory wells were drilled in 2005. Iranian oil was nationalized in 1953 and thus is owned and operated by the National Iranian Oil Company (NIOC).

Iran held 10.3% of the worlds total proven oil reserves and that figures out to be about 137.6 billion barrels (2.188×1010 m3) of oil reserves at the end of 2009. Oil also is found in northern Iran and in the offshore waters of the Persian Gulf. Nevertheless, in 2005 Iran spent US$4 billion dollars on gasoline imports, mainly because of contraband and inefficient domestic use that result from subsidies. Iran is one of the largest gasoline consumers in the world ranking second behind United States in consumption per car (IranDaily, 2010).

There is a growing recognition that prices must rise faster to curb consumption and ease the burden on the public finances. Cheap energy has encouraged wasteful consumption in Iran, and a brisk business in smuggling petrol into Iraq, Turkey, Pakistan and Afghanistan. Demand has also been supported by rapid increases in car production in recent years. In the absence of imports, the car industry has developed strongly (albeit from a low base) with output reaching over 1m vehicles in fiscal year 2006/07 (March 21-March 20) (IranDaily, 2007).

The growth in consumption of domestically produced oil has been modest, owing to refining constraints. By contrast, fuel imports rose to 180,000 barrels per day (29,000 m^3/d) in January 2005 from 30,000 barrels per day (4,800 m^3/d) in 2000, and petrol consumption is estimated to have been around 1,800,000 barrels per day (286,000 m^3/d) in 2007 (before rationing), of which about one-third is imported. These imports are proving expensive, costing the government about US$4bn in the first nine months of 2007/08, according to parliamentary source. Nearly 40% of refined oil consumed by Iran is imported from India.

3. Renewable Power Purchasing Agreements

Almost all coal, nuclear, geothermal, solar thermal electric, and waste incineration plants, as well as many natural gas power plants are thermal. Natural gas is frequently combusted in gas turbines as well as boilers. The waste heat from a gas turbine can be used to raise steam, in a combined cycle plant that improves overall efficiency. Power plants burning coal, oil, or natural gas are often referred to collectively as fossil-fuel power plants. Some biomass-fueled thermal power plants have appeared also. Non-nuclear thermal power plants, particularly fossil-fueled plants, which do not use co-generation, are sometimes referred to as conventional power plants (NITC, 2009).

Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). In 2008, about 19% of global final energy consumption came from renewable, with 13% coming from traditional biomass, which is mainly used for heating, and 3.2% from hydroelectricity. New renewable (small hydro, modern biomass, wind, solar, geothermal, and bio-fuels) accounted for another 2.7% and are growing very rapidly. The share of renewable in electricity generation is around 18%, with 15% of global electricity coming from hydroelectricity and 3% from new renewable.

Wind power is growing at the rate of 30% annually, with a worldwide installed capacity of 158 gig-watts (GW) in 2009, and is widely used in Europe, Asia, and the United States. At the end of 2009, cumulative global photovoltaic (PV) installations surpassed 21 GW and PV power stations are popular in Germany and Spain. Solar thermal power stations operate in the USA and Spain, and the largest of these is the 354 megawatt (MW) SEGS power plant in the Mojave Desert. The world's largest geothermal power installation is The Geysers in California, with a rated capacity of 750 MW. Brazil has one of the largest renewable energy programs in the world, involving production of ethanol fuel from sugar cane, and ethanol now provides 18% of the country's automotive fuel. Ethanol fuel is also widely available in the USA.

While many renewable energy projects are large-scale, renewable technologies are also suited to rural and remote areas, where energy is often crucial in human development. Globally, an estimated 3 million households get power from small solar PV systems. Micro-hydro systems configured into village-scale or county-scale mini-grids serve many areas. More than 30 million rural households get lighting and cooking from biogas made in household-scale digesters. Biomass cook stoves are used by 160 million households.

Climate change concerns, coupled with high oil prices, peak oil, and increasing government support, are driving increasing renewable energy legislation, incentives and commercialization. New government spending, regulation and policies helped the industry weather the global financial crisis better than many other sectors (Wikipedia, 2011).

Commercial electric utility power stations are most usually constructed on a very large scale and designed for continuous operation. Electric power plants typically use three-phase or individual-phase electrical generators to produce alternating current (AC) electric power at a frequency of 50 Hz or 60 Hz (hertz, which is an AC sine wave per second) depending on its location in the world. Other large companies or institutions may have their own usually smaller power plants to supply heating or electricity to their facilities, especially if heat or steam is created anyway for other purposes. Shipboard steam-driven power plants have been used in various large ships in the past, but these days are used most often in large naval ships. Such shipboard power plants are general lower power capacity than full-size electric company plants, but otherwise have many similarities except that typically the main steam turbines mechanically turn the propulsion propellers, either through reduction gears or directly by the same shaft. The steam power plants in such ships also provide steam to separate smaller turbines driving electric generators to supply electricity in the ship. Shipboard steam power plants can be either conventional or nuclear; shipboard nuclear plants are with very few exceptions only in naval vessels. There have been perhaps about a dozen turbo-electric ships in which a steam-driven turbine drives an electric generator which powers an electric motor for propulsion.

In some industrial, large institutional facilities, or other populated areas, there are combined heat and power (CH&P) plants, often called co-generation plants, which produce both power and heat for facility or district heating or industrial applications.

Table.1 Installed Generation Capacity

Capacity	Type	Operational
1.1 MW	Biogas	2009
250 MW	Geothermal	2010
467 MW	Solar	2009
250 KW	Solar	2009
28.2 MW	Wind	2008
100.8 MW	Wind	1994
200 KW	Fuel cell	2009
125 KW	Run of the river	1991
90 MW	Hydro	1961
87 MW	Hydro	1962
520 MW	Hydro	1963
45 MW	Hydro	1967
50 MW	Hydro	1970
10 MW	Hydro	1973
2,000 MW	Hydro	1976
151 MW	Hydro	1976
30 MW	Hydro	1984
85 MW	Hydro	1993
2.3 MW	Hydro	1994
2.8 MW	Hydro	1995
520 MW	Hydro	2001
2,000 MW	Hydro	2002
35.1 MW	Hydro	2002
11 MW	Hydro	2004
2,280 MW	Hydro	2005
16.8 MW	Hydro	2005
18 MW	Hydro	2006
13.5 MW	Hydro	2007
100 MW	Hydro	2007
550 KW	Hydro	2008
70 MW	Hydro	2008
47 MW	Hydro	2009
480 MW	Hydro	2009
13 MW	Hydro	2009
1,000 MW	Hydro	2010

AC electrical power can be stepped up to very high voltages for long distance transmission with minimal loss of power. Steam and hot water lose energy when piped over substantial distance, so carrying heat energy by steam or hot water is often only worthwhile within a local area or facility, such as steam distribution for a ship or industrial facility or hot water distribution in a local municipality

Table.2 Expansion Candidates

Capacity	Type	Operational
Out:1040MW	Pumped-storage	2011
Out:1000MW	Pumped-storage	NA
20 MW	Run of the river	NA
5.6 MW	Run of the river	NA
60 MW	Wind	NA
7 MW	CHP	NA
Under Study	Solid waste	2012
48 MW	Hydro	2011
450 MW	Hydro	2012
1,000 MW	Hydro	2012
315 MW	Hydro	2014
2,500 MW	Hydro	2015
1,500 MW	Hydro	2016
1 MW	Hydro	NA
8.4 MW	Hydro	NA
680 KW	Hydro	NA
900 KW	Hydro	NA
227 KW	Hydro	NA
65 KW	Hydro	NA
2.8 MW	Hydro	NA
8.5 MW	Hydro	NA
264 MW	Hydro	NA
466 MW	Hydro	NA
324 MW	Hydro	NA
265 MW	Hydro	NA
930 MW	Hydro	NA
80 MW	Hydro	NA
135 MW	Hydro	NA
33.5 MW	Hydro	NA
240 MW	Hydro	NA
496 MW	Hydro	NA
250 MW	Hydro	NA
292 MW	Hydro	NA
580 MW	Hydro	NA
2,638 MW	Hydro	NA

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