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Planning in Germany and Iran
Responding to Challenges of Climate Change through Intercultural Dialogue

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نقش نیروگاه های برق آبی به عنوان یک فناوری تولید انرژی پایدار در برابر تغییرات آب و هوایی

The Role of Hydroelectric Power Plants as a Sustainable Energy Production Technology due to Climate Change

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The Role of Hydroelectric Power Plants as a Sustainable Energy Production Technology due to Climate Change

Ali Sharifpoor, Gholamreza Shams, Mojgan Mirzaei

Abstract

According to climate change indicators in the last 50 years, the amount of electricity generated by hydroelectric power plants is expected to be affected by climate change in the future. Since the power generation of hydropower plants is directly dependent on the flow of the water flow, by examining the effects of climate change, we can learn about the vulnerability of these infrastructures in the face of climate change before construction to implement appropriate adaptive management strategies. In this article, we have tried to examine the current situation of hydropower plants due to climate change and, in order to maintain the share of renewable energy in Iran's annual energy, examine the obstacles and strategies for its development. Iran is located in a dry and semi-arid region of the world. According to the IPCC and HadCM scenarios, which show that Iran's rainfall will decrease by 2.5% by 2100, it is predicted that the progress of hydropower production will change due to climate change. Therefore, hydroelectric power plants in Iran will lose their position as one of the most significant sustainable technologies in energy production compared to the past if the recent 50-year development trend continues.

Keywords: Climate change, Hydroelectric power plants, Energy production

1. Introduction

In recent years, due to climate change and the importance that its effects can have on water resources, this phenomenon has created different conditions for the world's watersheds (Abbaspour 2009). Due to greenhouse gas emissions in the current century, significant changes are expected in the planet's climate, an effect of which is a change in the flow of rivers (Harrison 2001). About 16 percent of the world's electricity is generated by hydroelectric power plants each year. This energy source is considered a popular source of energy production due to its low cost, low greenhouse gas emissions, and high maneuverability in use (Azuara 2009).

In Europe, renewable energy production increased by 96.17 percent between 2002 and 2013 (Pérez-Sánchez 2009). During this time, the energy generated by hydroelectric power plants has increased by only 16.38 percent, while other types of energy (such as solar and wind) have increased. In Spain, for example, the increase in renewable energy production during this period was 152%, while hydropower production increased by 73% (Carravetta 2012).

Due to climate change and the reduction of river flow, small-scale hydroelectric power plants can be mentioned as one of the ways to maintain the position of hydropower plants among renewable energies. Of small-scale hydropower plants installed on urban water transmission lines around the world, we can mention: In Pompei, Italy, where the flow of the main water transmission lines is 20-50 liters per second, and the hydraulic head is 35-90 meters, the small-scale hydroelectric power plant has been able to generate 20-94 megawatt-hours of energy per year (Carravetta 2012). Small-scale power plants installed in Portland, USA, have been able to generate 150 MWh of energy per year (Lisk 2012). An eight-bladed spherical internal turbine is expected to generate 700 kWh of energy per year on Hong Kong's main water transmission lines (Pérez-Sánchez 2009). Also, the active power plant in Ireland can produce about 237 MWh per year from the flow of 17,910 cubic meters per day (Gaudard 2014).

2. Materials and methods

2.1 Production capacity of Iran’s hydroelectric power plants

50-year statistics of Iran's hydropower industry show that the share of electricity production in hydroelectric power plants has decreased from the energy produced by all power plants in the country. As mentioned in the 50-year statistics of the hydropower industry, hydroelectric power plants have lost their share among the total produced energy and have decreased from

37% in 1972 to 3% in 2009, the most important causes of which can be attributed to the following:

1. The results of studies show that precipitation on a stationary scale of about 67% of synoptic stations in the provincial capitals in the period of 1960 to 2010 has a decreasing trend, which results in not using the full nominal capacity of power plants (Nazeri Tehroudi 2014).
2. Lack of attention to homogeneous quantitative and qualitative development (new technologies) of power plants in the country.
3. Focus on large-scale hydropower plants and not paying attention to existing capacities in small-scale hydropower plants that can meet the following objectives (author):

I. Scattered energy production needs with the aim of supplying electricity from closer distances to consumers. Replacing the consumption of resources in the country whose energy are wasted if not considerate, instead of storable resources such as oil whose resources are not wasted, according to the priority of new energy development and cheaper electricity generation in macro policies.

II. Increasing energy production through non-polluting power plants compared to power plants operating on fossil fuels. Replacing more economical methods of supplying electricity to remote villages and manufacturing centers. Directing small-scale capital to small business activities in profitable productions instead of inflationary activities.

III. Appropriate geographical distribution of capital and interests of the country in order to prevent the migration of young job seekers from villages (to cities). In fact, providing jobs for residents during the implementation of the project and a relative increase in economic prosperity in the region.

IV. Country's serious need to replace capital-intensive activities with employment-generating activities and creating cultural and health facilities for the power plant employees will inevitably benefit local residents as well.

Table 5-1 50-year statistics of Iran hydropower industry (Haji Ghafoury Boukani, 2015)

Year	Nominal power of hydroelectric power plants (MW)	Nominal power of total power plants (MW)	Nominal power portion of hydroelectric power plants (percent)	Energy generated by hydroelectric power plants (GWH)	Energy generated by total power plants (GWH)	Hydroelectric energy portion of total generated energy (percent)
1967	308	934	33	658	4133	16
1968	308	1008	31	855	4625	18
1969	460	1313	35	1336	5539	24
1970	516	1396	37	1671	6758	25
1971	798	1997	40	2679	8105	33
1972	804	2094	38	3528	9553	37
1973	804	2794	29	2842	12093	24
1974	804	3215	25	3421	14005	24
1975	804	3449	23	3445	15700	22
1976	804	3689	22	3975	17311	23
1977	1804	5571	32	4213	18984	22
1978	1804	7024	26	6249	19847	31
1979	1804	7921	23	5419	21909	25
1980	1804	9628	19	5620	22381	25
1981	1804	10232	18	6229	24906	25
1982	1804	10308	17	6447	28823	22
1983	1804	10922	17	6203	33009	19
1984	1804	11419	16	5750	36594	16
1985	1804	12369	15	5550	39220	14
1986	1804	13011	14	7517	41571	18
1987	1826	13311	14	8390	42554	20
1988	1942	14301	13	7311	47600	15
1989	1952	15062	13	7522	52712	14
1990	1952	15423	13	6083	59102	10
1991	1952	15468	13	7056	64126	11
1992	1952	17143	11	9530	65998	14
1993	1952	19042	10	9823	73262	13
1994	1955	21249	9	7445	79134	9
1995	1955	22750	9	7275	82095	9
1996	1968	23257	8	7376	87981	8
1997	2006	24167	8	6908	94882	7
1998	2006	25353	8	7015	100565	7
1999	2009	26125	8	4943	109766	5
2000	2009	27207	7	3650	118492	3
2001	2009	28953	7	5057	127192	4
2002	3172	31525	10	8051	137848	6
2003	4422	34329	13	11094	149678	7
2004	5043	37300	13	10817	162869	7
2005	6044	41044	15	16147	178089	9
2006	6567	45322	15	18244	192682	9
2007	7422	49425	15	18017	203986	9
2008	7672	52972	14	4994	214530	2
2009	7737	56506	14	7210	221370	3
2010	8487	61459	14	9527	232959	4
2011	9246	65222	13	12145	240052	5
2012	10266	68894	14	12541	254275	5
2013	10786	70236	15	14582	262433	6
2014	11347	73144	15	13898	274437	5
2015	11354	74095	15	14201	280689	5
2016	11579	76428	15	16419	289181	6

2.2 Development limitations

2.2.1 Economic and technical factors

Small-scale hydropower plants are still considered as a group of large hydropower plants. Activities such as positioning, studies, and feasibility studies are based on large-scale experiences. Therefore, investing in them in the study phase may be too large and unreasonable for the size and importance of the project. Normally, costs of pre-implementation phase should not exceed 10 to 15 percent of total costs. One way to reduce the cost of small-scale power plants become so popular in recent years is to develop design tools so that water flow characteristics on each site can be estimated. The biggest obstacle to the development of small hydroelectric power plants is their high initiation cost, which is more severe in developing countries. On the other hand, small-scale hydropower generation depends heavily on the instantaneous flow of water and will therefore be a function of the predominant hydrological cycles. This can be a problem if a single small hydropower plant is supposed to supply electricity throughout the year. But these limitations do not apply to small hydropower plants that operate as reserve power plants in a joined network (author).

2.2.2 Social factors

One of the most important points in developing countries is always education and technology development, but the results are not always desirable. In other words, the underdeveloped existing technology and the cost of importing specialized personnel, foreign materials and equipment, even if there is foreign aid, has prevented the widespread and sustainable development of small hydropower plants. The social and economic benefits of providing and exploiting local resources are quite clear; But the presentation of their computations is in its infancy and they do not enter into economic evaluations. As a result, sometimes projects that have high benefits for the local population are removed from the agenda based on routine calculations. The big problem in planning small-scale power plants today is heterogeneous development due to the high concentration of central points.

2.2.3 Environmental factors

Today, in some developed countries, environmental and control regulations have become so costly and such a barrier to development that they are considered an important and deterrent factor in the development of power plants (Haji Ghafoury Boukani 2015). Figure 5-1 shows the amount of greenhouse gas emissions in the power plant sector in 2014, and Figure 5-2 shows the decrease in emissions due to energy production of hydroelectric power plants that have a significant role in reducing greenhouse gas emissions, especially carbon dioxide, which makes up the majority of greenhouse gases.

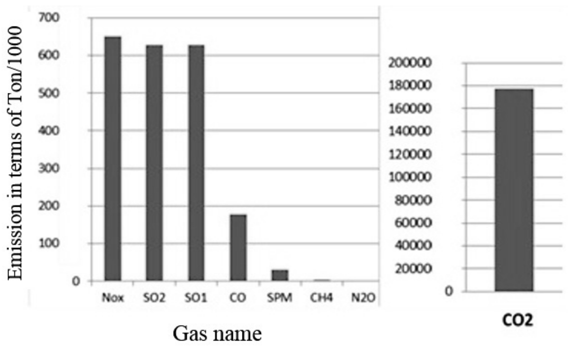

Figure 5-1 The amount of greenhouse gas emissions in Iran's power sector in 2014 (Ton) (Haji Ghafoury Boukani, 2015)

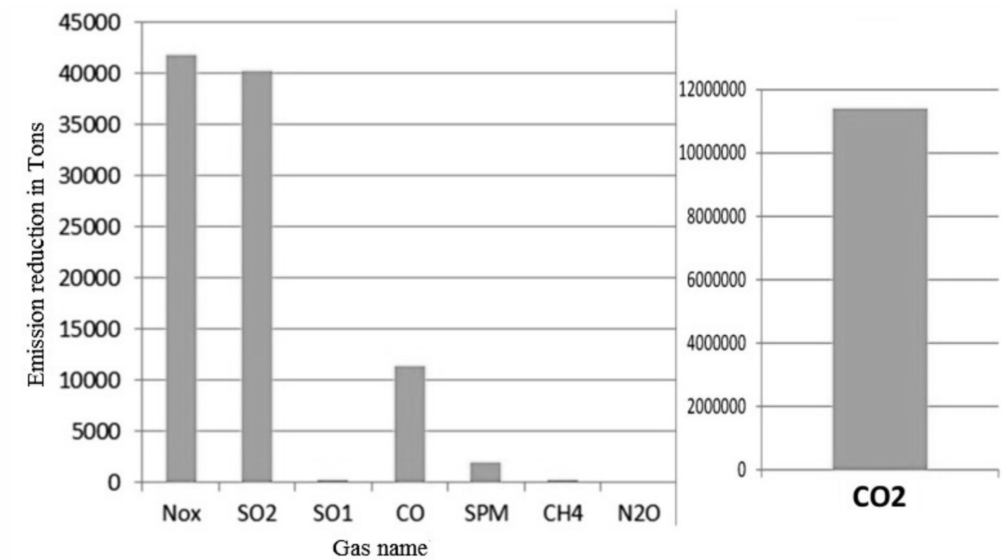

Figure 5-2 The rate of decrease in emissions due to energy production of hydroelectric power plants in Iran in 2014 (Ton) (Detailed statistics of the country's water power plants 2015)

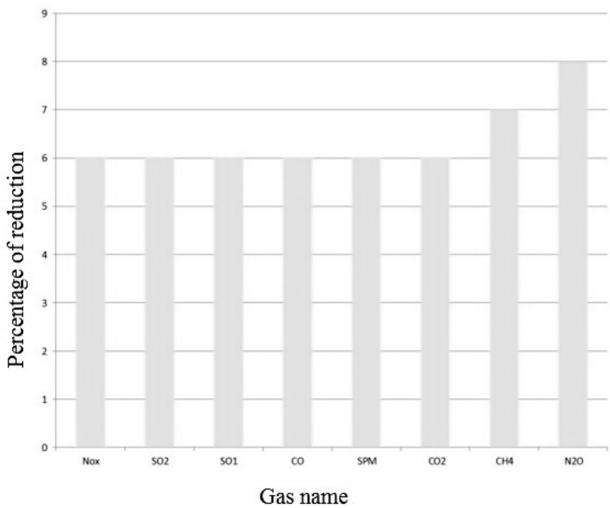

Figure 5-3 Reduction percentage of gas emissions due to hydropower generation

As shown in Figure 5-3, hydroelectric power plants have reduced greenhouse gas emissions by 6 to 8 percent, indicating a positive impact of hydropower plants on the environment.

3. Results and discussion

Iran is located in a dry and semi-arid region of the world. Based on the IPCC and HadCM scenarios, which show that Iran's precipitation will decrease by 2.5% by 2100, it is predicted that the progress of hydropower generation will change due to the upcoming climate change (Abbasi 2010).

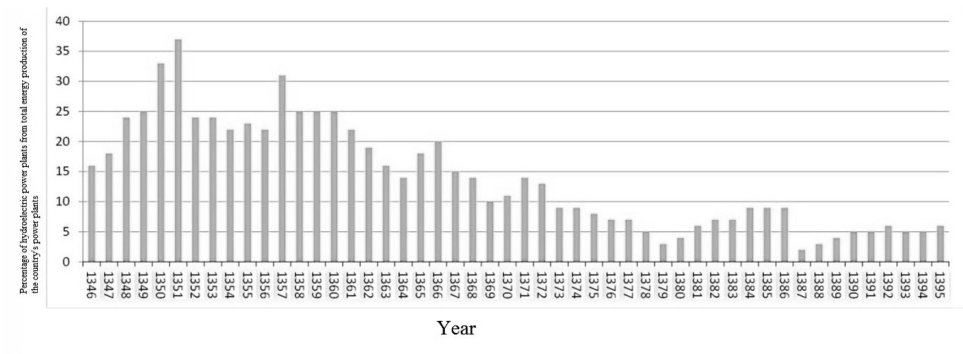

Figure 5-4 The share of energy production of hydroelectric power plants in the total energy production of power plants in the country in the last 50 years (percent)
(Detailed statistics of the country's water power plants 2015)

As shown in Figure 5-4, hydroelectric power plants have gradually lost their place in the energy production chart.

However, the answer to a key question: How can we generate more hydroelectric power and adapt to climate change while water resources are declining?

In order to restore hydroelectric power plants to a suitable position in Iran's energy production, small-scale projects that require less time and executive power can be put on the agenda. But the key step in this path is to predict the direction and future of hydroelectric power plants with respect to climate change and adaptation strategies. Not to mention that with the increase of private sector participation, the employment rate will also increase and will have a favorable social and economic impact on the country. It seems that one of the reasons for the decrease in the share of hydroelectric power plants is the high focus on large-scale power plants, which generally prevents uniform development, private sector participation, and sufficient attention to other hydropower projects due to high operational volume. Therefore, it seems that the share of hydroelectric power can be increased by increasing the focus on small-scale power plants. An examination of the current trend in the role of hydroelectric power plants in Iran's total energy production shows the negative impact of climate change on its place.

4. Conclusion

As it was investigated, the role of using hydroelectric power plants on adaptation to climate change is noticeable, and the share of hydroelectric power plants decreased from 37% in 1972 to 5% in 2014, which resulted in greenhouse gas emissions from non-hydroelectric and fossil power plants reaching 169,000 tonnes in 2014. As shown in Figures 5-1 and 5-2, the role of hydroelectric power plants in reducing greenhouse gas emissions is crucial. The increase in greenhouse gas emissions is also a factor in exacerbating climate change. Considering the position of sustainable energy production technologies in sustainable development indicators and promoting environmental adaptation to climate change, it is suggested that the position of hydropower plants be re-evaluated and its development plans are planned according to the existing forecasts of climate change in Iran.

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