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A SURVEY OF INTELLIGENT ELECTRICITY NETWORKS IN BIG INDUSTRIES (SOUTHERN PARS)

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ABSTRACT

Like all other countries, by increasing electric energy consumption in our country, its importance is increased continuously. Thus, management in electric energy consumption is of great importance. Mostly consumers select industry sector due to its increasing demand and great share in electric energy consumption and energy loss in its various sectors and the pressure imposed on network at peak time and a part of phase 4 of Southern Pars is selected. One of the most effective and comprehensive ways for energy storage in the world is intelligent management system of consumption but using this management system is not common for electric devices all over the world.

By intelligent systems, key points as reduction of executive costs, increasing reliability in production and integration are achieved. Thus, using intelligent management system in industry can lead to some items as much storage of energy, supervision and control on consumption, flexibility, demand, minimizing costs and reduction of pollution. Based on the existing conditions to use intelligent networks, linear planning model is presented to minimize electric energy costs. Then, this method is discussed for the mentioned industry to evaluate the efficiency of proposed model. As the basis of proposed model is math logics, by changing the conditions and assumptions, we can use them in other sections.

Keywords: Optimization, Intelligent networks, highly consumed sector of industry, Electric energy, Pollution reduction

INTRODUCTION

It is about planning, execution and control of the activities dependent upon electric energy affecting its consumption and creating good changes in the form of load, time model and consumption of this type of energy. In other words, electric energy consumption management is a set of integrated activities between power plant and consumers performed for balancing consumed load of users and it leads to high efficiency and less cost and equal utility in consumption. By this method, much profit is dedicated to provider and consumer. One of the most effective and efficient methods of energy storage in the world is intelligent management system of consumption but application of designed automation methods (remote control via computer) is not common for power equipment all over the world. Some countries including Germany, Japan, and France as technology owners have achieved this case. The key points being achieved by electric energy intelligent systems include maintenance costs of devices, reduction of executive costs, adaptability and increasing production. Thus, an intelligent management system of electric energy in industry can provide some facilities as regular function of machineries, storage of energy, control, display, management and support based on

definite standard criteria, flexibility and minimizing costs besides providing demand. Intelligent network is modernized electric network with the ability of using ICT for data collection and performance. These data are like behavioral information of producers and consumers as applied automatically to improve return, reliability, economic view, stability of product and suitable distribution of power. Based on existing assuming conditions to use intelligent networks, linear planning model is presented to minimize the costs of electric energy. This method is implemented for the mentioned industry to evaluate efficiency of proposed model.

As the basis of proposed model is math logic, by changing the conditions, we can use them in other sections. The conditions of industry are investigation of the current condition of industry in terms of energy consumption and then by definite equipment, the consumption is estimated based on new conditions of each source and finally the comparison is made between these two cases.

Initial exploration includes factory activities and its products, required electric energy for various time periods, different devices and machineries existing in the factory.

Also, determining that which energy with which cost is consumed in industry, the

amount and reason of energy loss, as loss is occurred in which part of factory by which machineries and devices are the important points here.

Finally, future condition of industry is drawn by its intelligentization in terms of electricity consumption and then the costs of each sector are determined based on the important factor of time by model. Thus, if the required industry invests in this field, the equipment and capacities are achieved to save costs and generate income.

Theoretical basics of study

Does electricity intelligent system at a period reduce electric cost of industry (Southern pars)?

We want to decide, when, from which source we fulfill the demands with the lowest costs in industry. The sources selected to achieve this goal are Photovoltaics panels, wind turbines, electricity storage battery and fuel cells and main electricity network.

As it was said, the study area is a part of phase 4 of southern Pars. The capacity of each of installed resources is defined and the aim is to use which source to perform industry activities to reduce electric energy costs. On the other hand, based on special capabilities of intelligent network by electric energy storage and selling extra value of production by local sources from industry to network at

the hours, the main provider is under pressure can generate income for industry and it is the strong point of this type of network. As is shown, the main purpose of this planning is supply and demand management. It means that based on installed devices in industry, the consumer can select supply source by considering demand value and consumption management can be controlled. One of the points considered by users and consumers is to put on priority the electricity of renewable sources due to low pollution compared to fossil electricity.

Gangordambort (2006) discovered communicative networks for atomization of electricity systems. They presented a better perception of hybrid network architecture providing the applied requirements of heterogeneous electric systems as automatic.

Brown and Surianarayanen (2009) explained an industrial perspective for intelligent distribution system and identified the technologies applied for further studies for intelligent distribution system. Wong et al., (2011) reviewed communication architecture in electric systems as composition of communication network, technologies, duties, requirements, regulations and study challenges. Inherent potential and advantages of intelligent network are considerable. Electricity research institution estimated in

2011 that by investment as 338-476 billion dollar for full intelligentization of network, two billion dollars benefit for USA has been provided. Farkyi and Palmer (2011) stated that dynamic pricing was different rates of electricity at various times of day and year and the aim was showing reaction to consumption time of customers and had various costs in electricity supply.

Study model

Based on the assumptive conditions to use intelligent networks, linear planning model is presented to minimize costs of electric energy.

$$\text{MIN} \sum_t \sum_j \sum_I C_{i,j,t} X_{i,j,t}$$

i :This index indicates produced and stored electricity sources (G, PV,WT,FC and then Se, Re and finally Ex)

j : This index indicates the set of industry activities.

t: This index indicates the set of all hours of day.

G	main Electricity network
PV	The set of Photovoltaic panels
WT	All wind turbines
FC	Fuel cell
Se	Set of stored energy in battery
Re	Set of released energy of battery
Ex	Set of exported energy to network

The variable of model decision

$X_{G,t}$ The amount of consumed electric energy to fulfill demand at time t by the main network in kw/h
$X_{pv,t}$ The amount of consumed electric energy to fulfill demand at time t by the set of Photovoltaic cells in kw/h
$X_{WT,t}$ The amount of consumed electric energy to fulfill demand at time t by the set of wind turbines in kw/h
$X_{FC,t}$ The amount of consumed electric energy to fulfill demand at time t by fuel cells in kw/h
$X_{Re,t}$ The released energy from battery to fulfill demand at time t in kw/h
$X_{Se,t}$ The amount of stored electric energy in battery from the extra productions by other sources at time t in kw/h
$X_{Ex,t}$ The amount of exported energy from industry to network at time t in kw/h

Limitations:

Fulfillment of demand

$$X_{G,t} + X_{PV,t} + X_{WT,t} + X_{FC,t} + X_{Re,t} - X_{Ex,t} \geq d_t \qquad \text{For t}$$

$$X_{se,t} = X_{se,t-1} - X_{Re,t} + (\text{Max pv} - X_{pv,t}) + (\text{Max WT} - X_{WT,t}) + (\text{Max Fc} - X_{Fc,t}) + (\text{Max G} - X_{G,T})$$

Energy balance

$$X_{se,t} = 0$$

The initial value of storage in battery (start time) is zero.

The amount of electric energy exported to network

$$X_{Ex,t} \begin{cases} X_{se,t} - X_{Re,t} & t \in t_{peak} \\ \\ 0 & t \notin t_{peak} \end{cases}$$

$X_{Ex,t} \geq 0$

$X_{se,t-1} \geq X_{Re,t}$

The limited capacities and underlying logical conditions

Table 3-1 Electricity price tariff for industrial units (a) [2]			
Peak load	**Medium load**	**Low load**	**Time (H)**
520	310	270	**Price of each kw/h electricity of network (Toman)**

Table 3-2 The price of electricity sale from industry to network			
Peak load	**Medium load**	**Low load**	**Time (hour)**
700	290	225	**Sale Price of each kw/h electricity of network (Toman)**

Limitation of battery capacity

$X_{se,t} \leq Cap_{BS} \times \eta_{BS}$

The numbers of storage batteries are considered 50 and the capacity of these electric energy storages is 5000 kw. The cost of each kw/h stored energy in battery is 25toman and each kw/h released of battery is 16 Toman.

The limitation of the set of photovoltaic panels

$$X_{pv,t} \begin{cases} r_{pv} \leq X_{pv,t} & t \in t_{pv} \\ X_{pv,t} \leq Cap_{pv} \times \eta_{pv} & t \in t_{pV} \\ X_{pv,t} = 0 & t \notin t_{Pv} \end{cases}$$

$p_{pv} = v_{mpp}.I_{mpp}$

$v_{mpp} = v_{mpp,ref} + \mu_{v,oc}(T_C - T_{C,ref})$

$I_{mpp} = I_{mpp,ref} + I_{sc,ref}(G_T / G_{ref}) + \mu_{I, sc}(T_C - T_{C, ref})$

p_{pv} =Panel power
V_{mpp} = Maximum voltage of power
$V_{mpp, ref}$ = V_{mpp} under standard performance conditions
I_{mpp} = Panel current
$I_{sc,ref}$= Short circuit current under standard performance condition
$(w/m^3)G_T$ = Daily mean of sun
G_{ref}= Equal to w/m^3 1000 for performance under standard conditions
$\mu_{V, OC}$= (v/c^0)=Temperature coefficients for open circuit voltage
$\mu_{I, SC}$ =(A/C^0)=Shortcircuit current
$T_{c, ref}$ = Panel temperature under standard performance conditions (considered to 25^0)
T_c = The temperature of performance of Photovoltaic panel
$T_c(t) = T_a(t) + ((NOCT - 20)/800). G_T$

The number of the panels connected as series is denoted by $N_{pv,s}$ and is defined by bus voltage of DC and nominal voltage of panel:

$N_{pv,s} = V_{BVS}/ N_{PV,nom}$:

The capacity of panels was 20kw and we put the number 268. The cost of each kw solar electricity is considered as 45. Averagely, solar electricity can produce at times 8-16 and part of it is produced directly at peak time. This causes that it helps local electricity network and reduces the pressure of demand.

Limitation of wind field

12	11	10	9	8	7	6	5	4	3	2	1	**Hour**
3/71	3/2	1/8	1/86	0/71	1/87	2/25	2/19	1/92	2/12	2/4	1/96	**Wind speed**
24	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**Hour**
3/23	3/95	2/63	3/97	4/1	3/56	1/91	2/8	3/87	3/43	2/89	3/23	**Wind speed**

$P_{wr} = 1/2\ PAV^3$

$r_{wt} \leq X_{wt,t}$ as peak load of hours 9-12,17 -21

$$X_{WT,t} \leq \tfrac{1}{2}\ Pav^3\eta_{wT}$$

P_{wr}=Produced power by wind turbine
p =Wind density in kg/m^3
A =the area covered by turbine blades
V =Wind speed in m/s
The cost of each kW wind electricity is 226 Toman.
The limitation of the set of fuel cells

$X_{Fc,t} \leq Cap_{Fc} \times \eta_{Fc}$

The number of fuel cells is 10 and the capacity of set of fuel cells is 900 kw. The cost of each kw fuel electricity is 240 Toman..

The limitation of maximum contract receiving of electricity form network

$X_{G,t} \leq pL_t$

Table 3-3 The maximum value provided by network based on load type			
Peak load	**Medium load**	**Low load**	**Time (in hour)**
40000	**35000**	**32000**	**Maximum estimated demand by network (in kw/h)**

Limitation in pollution emission

$\sum Em_G X_{G,t} + Em_{FC} X_{FC,t} \leq C$

In this method, only two main network sources and the set of fuel cells produce pollution and based on international carbon tax rules, it is 11237kg per day.

The limitation of constraint of decision variables , $X_{pv,t}$, $X_{WT,t}$, $X_{FC,t}$, $X_{Re,t}$, $X_{se,t} \geq 0X_{G,t}$

MODEL ESTIMATION

The required demand is the basic point that should be estimated to prevent damage to the industry and the parameters of hour demand of required industry based on kw/h is reported and shown in the following Table.

12	11	10	9	8	7	6	5	4	3	2	1	Hour
40100	38800	40600	40000	32700	24100	20900	20400	19600	18400	18200	17800	Demand
24	23	22	21	20	19	18	17	16	15	14	13	Hour
33200	34600	33200	36200	35500	37500	39600	40200	36100	36700	34300	37800	Demand

The expressed model by GAMS 22, 1 and CPLEX is performed. The systematic conditions and results are as followings:

System Model Acer ASPIRE 5750G

Intel R Core TMi 5-2430M

Memory 4 GB DDR3

The optimized response is 243,111,130 Toman. According to the existing data in various hours, they are decided by each of resources by model.

Decision making for the main electricity network

	11	10	9	8	7	6	5	4	3	2	1	Hour
11276	18265	33550	32669	31900	22267	17511	17723	18041	16296	14746	15071	Consumption from network
24	23	22	21	20	19	18	17	16	15	14	13	Hour
15622	3201	23334	4191	319	16319	35362	28468	7923	17330	23005	21662	Consumption from network

Decision making for the set of photovoltaic panels

12	11	10	9	8	7	6	5	4	3	2	1	Hour
3360	3360	3360	3360	3360	---	---	---	---	---	---	---	Consumption from panel
24	23	22	21	20	19	18	17	16	15	14	13	Hour
---	---	---	---	---	---	---	---	3360	3360	3360	3360	Consumption from panel

Decision making about wind field

12	11	10	9	8	7	6	5	4	3	2	1	Hour
25464	16375	2890	3171	194	3260	5620	5221	3526	4460	6768	3736	Consumption from wind electricity
24	23	22	21	20	19	18	17	16	15	14	13	Hour
16778	30599	9066	31209	34381	22381	3438	10932	28817	20010	12035	16778	Consumption from wind electricity

Decision makings of the set of fuel cells

12	11	10	9	8	7	6	5	4	3	2	1	Hour
800	800	800	800	800	800	800	800	800	800	800	800	Consumption from fuel cell
24	23	22	21	20	19	18	17	16	15	14	13	Hour

800	800	800	800	800	800	800	800	800	800	800	800	Consumption from fuel cell

Decision making of the set of values released of battery (as productive)

12	11	10	9	8	7	6	5	4	3	2	1	Hour
4800	4800	4800	4800	0	0	0	0	0	0	0	0	Consumption from battery
24	23	22	21	20	19	18	17	16	15	14	13	Hour
0	0	0	4800	4800	4800	4800	4800		0	0	0	Consumption from battery

Decision making for the set of stored values in battery (as activity)

12	11	10	9	8	7	6	5	4	3	2	1	Hour
0	0	0	0	3554	2227	3031	3344	2767	3156	4114	1807	Storage in battery
24	23	22	21	20	19	18	17	16	15	14	13	Hour
0	0	0	0	0	0	0	0	4800	4800	4800	4800	Storage in battery

Decision making about the set of exported amounts to network

12	11	10	9	8	7	6	5	4	3	2	1	Hour
4800	4800	4800	4800	0	0	0	0	0	0	0	0	Exported to network
24	23	22	21	20	19	18	17	16	15	14	13	Hour
0	0	0	4800	4800	4800	4800	4800	0	0	0	0	Exported to network

CONCLUSION AND RECOMMENDATION

The proposed linear planning model manages supply and demand. In other words, the correct policy and thought is as we consider rights for consumer and based on the demand in each hour, the customer can select the supply source and consumption management control is achieved. By this method, the consumers find about the importance of this energy and save it and the costs of energy loss for supplier are reduced. By intelligent consumption management methods, not only the goods production and presentation of public services and social welfare are not reduced, but also with the same quality and cost leads to the increase of production of goods and services and development of social welfare with less electric energy consumption. The key points achieved by using intelligent systems include reduction of executive costs, reduction of maintenance of

devices, increasing production and adaptability. By increasing the capacity of technologies using renewable sources, their share in providing demand by local method (it is better the demand in consumption is fulfilled to avoid costs of transfer and loss of energy in transfer namely in remote areas) and the pressure imposed on the main network is reduced and existing capacities can be used mostly. The effective parameters in this study are determined as deterministic values to achieve a general solution. It is not so in the real world and the cases not being changed over time is less. To approach what is occurred in the current world, we should consider the parameters as uncertainty. In this study, the time is 24 hours and by considering mid-term and long-term we can show the impact of created changes better.

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