Implementation of Smart Grid in Iran power system

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Iran Energy Efficiency Organization

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What is Smart Grid?

Iran Smart Grid roadmap

National Smart Metering Program in IRAN

The advantages of implementing FAHAM

Demand Response programs in IRAN

Investment methods
A smart grid puts information and communication technology into electricity generation, delivery, and consumption, making systems cleaner, safer, and more reliable and efficient.

**U.S. Department of Energy Definition:**

A smart grid integrates advanced sensing technologies, control methods, and integrated communications into the current electricity grid.
Smart Grid Functions

- Self-healing
- Enable high penetration of intermittent generation sources
- High quality power
- Optimize assets
- Enable electricity market
- Consumer participation
- Resist attack
- Accommodate generation options
Developments in knowledge and technology affecting power industry in the current decade:

- Ecosystem-friendly Technology
- Communication and Information Technology
- Power electronics devices
The main strategies of Iran power industry

- Improving energy efficiency in Generation, Transmission, Distribution and Consumption sectors
- Emission reduction
- Improvement in quantitative and qualitative indices as well as Development in export
- Promotion of science & technology
- Development in competition and reduction in costs by increasing the share of private sector
Motivations to drive smart grid in Iran

- **Challenges**
  - High *Energy consumption intensity* comparing to the global average
  - Around 40 to 50 billion dollars are spent on *energy subsidies* in the country
  - High amount of *power losses* in distribution section comparing to the global average

- **Capacity**
  - *Educated Human Recourses*
  - Significant capacity in *Renewable energy* (wind and solar) in Iran
  - The Iran power ministry plan for increase the penetration of *Distributed generations (DG)* by 30% (Especially CHP and Renewable power plants)
  - More than *17000 km optical fiber* in power transmission line (OPGW)
Iran’s Smart Grid Roadmap

2009 2010 2012 ... 2020 2025

**AMR**
- Monitor the power grid network

**AMI**
- Demand response
- Outage management
- Asset management
- Customer Information System
- Load Management

**Smart Grid**
- Distribution Automation
- Minimum Reserve
- Self - Healing
- Emission control
- Distributed Energy Resources
- Intelligent Application
- Congestion Management
- Cost Sharing
- AMI is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers.
National Smart Metering Program in IRAN

FAHAM
In 2009, IEEO has started Implementation and deployment of Advanced Metering Infrastructure in Iran power system as the first step of achieving smart grid goals and benefits. IEEO named this Project “FAHAM”

Obligations:

- According to the Energy Pattern Improvement Law, Ministry of Energy is responsible to roll out AMI over 5 years to the end of 2016.
- This plan has been stated in 5th national development program.
- Based on the government approval implementation of AMI is mandatory.
FAHAM: National Smart Metering Program in IRAN -
(following Government mandate in 2009)

Goal: Exchange of electricity meters for all customers (about 33,000,000 E-meters) in 7 years

Funded: Iran Power Generation, Transmission and Distribution Management Company (TAVANIR)

Client: Iran Energy Efficiency Organization (SABA)

Consultant: Monenco Iran Consulting Engineers
Implementation approach

1. Feasibility study and General Research

2. Providing all technical specifications and executive documents.

3. Implementing primary & small scale pilot

4. Pre-deployment pilot: installing 1 million smart meters in five regions (phase No. 1)

5. Massive deployment: infrastructure development in the whole of country with financial investment by private sector (phase No. 2)
Implementing pilot areas

- Mashhad: 175,000 metering points
- Tehran: 120,000 metering points
- Ahwaz: 190,000 metering points
- Bushehr: 200,000 metering points
- Zanjan: 200,000 metering points
Business Needs of FAHAM

- Correcting customer’s consumption pattern
- Applying energy management by the network operator in normal and critical conditions
- Improving meter readings and billing processes
- Reducing non-technical losses as well as monitoring technical losses in distribution network
- Improving the Quality of Service, reducing duration of power outage and supervision on electric power quality
- Developing distributed generation and renewable energy
- Possibility of electricity prepayment and establishing electricity retail markets
- Optimizing operation and maintenance costs
- Providing appropriate management of water and gas meters
The most important Proceedings

- Preparation of technical, Operational, Communication and security documentation of FAHAM
- Implementation of pilot projects
- Contracts with three EPC contractors for the implementation of the first phase (about one million customers) in five regions of the country
- Design, construction and testing of smart meters by 6 domestic manufacturer of smart meters
- Developing the FAHAM software by domestic companies
- Codification of regulations and instructions related to the project such as prepayment regulations and demand response and load management methods
The benefits of implementing FAHAM
FAHAM Social Benefits

Social Benefits

- No need for periodic trips to each physical location to read the meters
- Establishment of appropriate services for developing the electronic government
- Tariff diversification
- Power delivery with higher quality and reliability
- Reducing cost of electricity due to reduced operating costs
- Increasing billing accuracy and speed by eliminating the human error factor
- Providing better customer service
- Creating customer’s participation in consumption management and costs reduction
FAHAM Environment Benefits

- Reducing polluted gas and CO2 emissions
- Reducing consumption through network energy management and reducing network losses
- Demand management through sharing the information with customers
Economical Benefits

- Reducing non-technical losses
- Demand management (tariff management)
- Improving consumption patterns through the information shared with the customer
- Improving the payment system
- Reducing total costs of meter’s reading, operation and maintenance, and customer’s disconnection and reconnection
- Preparation for electricity retail markets

AMI implementation can reduce at least 4% in energy consumption and 3% in power grid losses.
Federal Energy Regulatory Commission (FERC):
Demand Response (DR) = Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.”
Demand Response Programs

DR programs

Incentive-based
- Direct Load Control
- Emergency demand response program
- Capacity market programs
- Interruptible/curtailable rates
- Demand bidding program
- Ancillary-Service market programs

Time-based
- Time-of-use (TOU)
- Real time pricing (RTP)
- Critical peak pricing (CPP)
Different DR Programs

- Time-based demand response = changes in usage by customers in response to changes in the prices they pay
  - Real-time pricing
  - Critical-peak pricing
  - Time-of-use rates

- Incentive-based demand response = giving customers load reduction incentives to preserve reliability or decrease electricity prices
  - Direct Load Control
  - Emergency demand response program
  - Capacity market programs
  - Interruptible/curtailable rates
  - Demand bidding program
  - Ancillary-Service market programs
Load-shape Objectives Of DR Programs

Power industry

Peak Clipping

Load Shifting

Valley Filling
The effect of DR plans on price of electricity market

Determination of Optimum Strategy of Large Consumers Presence in Electricity Markets Using IGDT

Price without DR

Generation curve

Price

Demand curve

Price with DR

Demand with DR

Demand without DR

Quantity
Motivations to drive smart grid

33,000,000 Customers
276 TWh
# FAHAM Environment Benefits

<table>
<thead>
<tr>
<th>DR program</th>
<th>Reduction of energy consumption (%)</th>
<th>Reduced energy consumption (MWh)</th>
<th>Reduction of CO2 production (ton)</th>
<th>Reduction of NOx production (ton)</th>
<th>Reduction of SO2 production (ton)</th>
<th>Reduction of environmental costs ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepayment + TOU</td>
<td>3.5%</td>
<td>84000</td>
<td>60,060</td>
<td>243</td>
<td>327</td>
<td>$4,200,000</td>
</tr>
<tr>
<td>Operational reserve</td>
<td>14%</td>
<td>336000</td>
<td>240,240</td>
<td>972</td>
<td>1,306</td>
<td>$16,800,000</td>
</tr>
<tr>
<td>Summer vacation and repair</td>
<td>0.03%</td>
<td>25911</td>
<td>18,526</td>
<td>75</td>
<td>101</td>
<td>$1,295,550</td>
</tr>
<tr>
<td></td>
<td>0.68%</td>
<td>508000</td>
<td>363,220</td>
<td>1,470</td>
<td>1,975</td>
<td>$25,400,000</td>
</tr>
</tbody>
</table>
## FAHAM Environment Benefits

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<thead>
<tr>
<th>DR program</th>
<th>Reduction of energy consumption (%)</th>
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<th>Reduction of SO2 production (ton)</th>
<th>Reduction of environmental costs ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-of-use, Critical peak pricing</td>
<td>0.2%</td>
<td>15963</td>
<td>11,414</td>
<td>115</td>
<td>155</td>
<td>$1,995,373</td>
</tr>
<tr>
<td></td>
<td>0.5%</td>
<td>26938</td>
<td>19,260</td>
<td>156</td>
<td>210</td>
<td>$4,489,590</td>
</tr>
<tr>
<td>Real time pricing</td>
<td>1.2%</td>
<td>8957</td>
<td>6,405</td>
<td>83</td>
<td>112</td>
<td>$1,440,000</td>
</tr>
<tr>
<td></td>
<td>1.5%</td>
<td>11197</td>
<td>8,006</td>
<td>104</td>
<td>140</td>
<td>$1,800,000</td>
</tr>
<tr>
<td>Direct load Control</td>
<td>0.1%</td>
<td>251</td>
<td>1,796</td>
<td>7</td>
<td>10</td>
<td>$125,604</td>
</tr>
<tr>
<td></td>
<td>0.6%</td>
<td>1507</td>
<td>10,777</td>
<td>44</td>
<td>59</td>
<td>$753,625</td>
</tr>
</tbody>
</table>
The ongoing activities and the future plans

- Demand response programs
- Diversify to electricity tariff
- Codifying regulation electricity prepayment

- Planning for National smart grid Operator
- Codification and modeling of application system
- Plan of providing electricity for electrical vehicles
- Unifying data model in all information & communications layers (interoperability)
- Founding a center for monitoring renewable resources by FAHAM
Electric vehicles supply management in smart grid of Iran

Faham and support the idea of EVs

- Faham in charge of the EVs, will provide load management.
- With increased number of EVs, the system development of communication and control will execute.

The implementation of this model will be similar to communication system of smart fuel carts.

<table>
<thead>
<tr>
<th>Des.</th>
<th>title</th>
</tr>
</thead>
<tbody>
<tr>
<td>6000 MW</td>
<td>Electric load for 3 million EVs</td>
</tr>
<tr>
<td>100%</td>
<td>Power consumption for charging EVs Simultaneous with network peak</td>
</tr>
<tr>
<td>$ 9 billion</td>
<td>The cost of network expansion to supply this amount of load</td>
</tr>
<tr>
<td>$ 0 billion</td>
<td>The cost of implementing smart grid</td>
</tr>
<tr>
<td>$ 9 billion</td>
<td>Estimated total investment cost</td>
</tr>
</tbody>
</table>

Smart grid, solution for EVs management

- Planning for changing a threat to opportunity
- Network threat by electric vehicles
- The need to manage the network connection of EVs

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<tbody>
<tr>
<td>6000 MW</td>
<td>Electric load for 3 million EVs</td>
</tr>
<tr>
<td>30%</td>
<td>Power consumption for charging EVs Simultaneous with network peak</td>
</tr>
<tr>
<td>$ 2.7 billion</td>
<td>The cost of network expansion to supply this amount of load</td>
</tr>
<tr>
<td>$ 0.45 billion</td>
<td>The cost of implementing smart grid</td>
</tr>
<tr>
<td>$ 3.25 billion</td>
<td>Estimated total investment cost</td>
</tr>
</tbody>
</table>

Power supply without the development of smart grid

Power supply with the development of smart grid

Economic advantage

WWW.SABA.ORG.IR
WWW.IRANSNG.COM
FAHAM Distribution Management System

Network
Communication
Central Access
System

Distribution
Network

GPRS

Gather Raw meter reading
Validation, Estimation and Editing of meter reading
Storage, management, and maintenance of Processed data

Communicate with the meters
Store raw data
Smart meters configuration & settings

Application System Software

Demand Response Management System
Network Estimation System
Billing System
Network Planning System
Customer Information System

Enterprise Service Bus (ESB)

Outage Management System
Geographical Information System (GIS)
Maintenance Management System
Volt/VAR Control System
Electric Vehicle Management System

Distribution System Operator
Performance monitoring of application system
Final Decision and Orders
Renewable Energy Monitoring Center by using FAHAM

- Measurement and monitoring of electrical energy generated by renewables
- Forecasts of renewables energy for the day-ahead horizon
- The calculation and billing of generated energy through monitoring center
- Capability to define incentive programs for implementing photovoltaic systems
- Real-time identification of renewable units faults or disconnection from the network
- Efficiency Measurement of renewable units during their life cycle
- View the forecasted and actual amount of renewable energy divided by region
"Building, Operating and Maintaining an Ecosystem comprising:

1. Communication systems
2. Cloud based computation and Data Centers
3. Frontend and backend Smart Grid software as well as Web-based Portals, Mobile Apps to provide appropriate data to consumers, prosumers and other stakeholders.

NSO is going to satisfy all ICT needs of today and future Smart Grid project in Iran (mostly known as FAHAM in Persian) through a robust/reliable/secure ICT backbone. The RoI (Return on Investment) to be achieved by developing Strategic Partnership and creating Value Chain thanks to viable and agile business model based on revenue sharing with Tavanir as well as selling basic and added value services to the stakeholders.”
National Smart Operator (NSO)
Boarders and Relation with Stakeholders

- Distribution Generation & Renewable Energies
- Management & Investment
- Communication Infrastructure
- Server Farms/Data Center/Cloud/Big Data
- Backend/Frontend Software/Mobile Apps
- Other Utilities (Water/Gas)
- Consumers/Prosumers
- Server Farms/Data Center/Cloud/Big Data
- Electrical Operators/Retailers
- Government
- Tavanir
- Utilities
NSO Ecosystem

Utilities/
Electricity Operators/
Electricity Retailers
(Energy Suppliers)

Telecom Operators
(Enablers)

Consumers

Mobile Application
Startup Companies
(Innovation)

Smart Grid
Hardware/software
(Solutions Providers)
1. **Automation**: Meter Management, Billing, CRM, Distribution Automation, Asset Management etc.

2. **Energy Efficiency**: Fraud and Tamper detection, Conservation Voltage Reduction, Demand Side Management, Demand Response, Reactive, Volt/VAR Optimization etc.

**National Smart Grid Operator (NSGO)**

Smart Grid Operator covers all functions defined for NSO plus owning meters, sensors and other devices in a Smart Grid network

<table>
<thead>
<tr>
<th>Role and Responsibilities</th>
<th>Description</th>
<th>Risk</th>
<th>Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Communication Pipe</td>
<td>To provide End to End Communication “pipe”</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>2  NSO</td>
<td>To Provide all ICT services as per Smart Grid (FAHAM) needs and spec</td>
<td>Moderate to High</td>
<td>Moderate to High</td>
</tr>
<tr>
<td>3  NSGO</td>
<td>NSO plus Meter and Sensor hardware</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>
32 Millions electricity meters
17 million gas meters
15 million water meters
2.7 millions new meters to be installed annually (all 3 types)
Electricity loss in transmission and distribution network is between 13 to 15% (debated) from which 3% is transmission network loss
580K smart meters needed for electricity market (revenue meters to be installed on feeders)
An investor has already submitted a proposal to replace 360K 3Phase demand meters with smart meters. The project is supposed to monitor almost 25% of national power consumption.
✓ **CAPEX**: 32 Millions electricity meters needs USD 4.8 billion investment to go Smart (USD 150 in average per meter) if Tavanir invests on meters and builds and operates his own ICT network

✓ **OPEX**: USD 2.00 per meters per month, but this to be reduced to below USD 85 cents per meter within three years as mass deployment is commenced. Hence OPEX will exceed USD 326 millions annually.

✓ **Total revenue** to be generated by FAHAM is estimated USD 982 millions annually, so gross profit is (982-326)=**USD 656 million per year**
✓ NSO needs USD 960 millions investment to satisfy smart grid ICT technical requirements as CAPEX, and USD 2.00 per meters as monthly OPEX, but this to be reduced to below USD 50 cent per meter within three years as mass deployment is commenced. Hence OPEX should be as low as USD 192 millions annually.

✓ Revenue to be generated by NSO is estimated USD 352 millions annually, so gross profit is (352-192)=USD 160 million per year
NSGO needs USD 3360 millions investment to build and operate national wide smart grid network including ICT backbone as well as meters and other devices as CAPEX, and USD 2.3 per meters as monthly OPEX, but this be reduced to below USD 60 cent per meter within three years as mass deployment is commenced. Hence OPEX should be as low as USD 230 millions annually.

Revenue to be generated by NSGO is estimated USD 765 millions annually, so gross profit can be (765-230)=USD 535 million per year
## Facts and Figures, Cost Breakdown

<table>
<thead>
<tr>
<th>Cost break down cost per item (CAPEX)</th>
<th>Total cost</th>
<th>NSO</th>
<th>NSGO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meters including communication module</td>
<td>35%</td>
<td>0%</td>
<td>35%</td>
</tr>
<tr>
<td>Communication</td>
<td>20%</td>
<td>2.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td>System integration and security</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>IT cost including backend and frontend software, data center (or Cloud)</td>
<td>15%</td>
<td>7.5%</td>
<td>7.5%</td>
</tr>
<tr>
<td>Installation and rollout</td>
<td>20%</td>
<td>2.5%</td>
<td>17.5%</td>
</tr>
<tr>
<td>Mobile Apps, portal etc</td>
<td>5%</td>
<td>2.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>20%</strong></td>
<td><strong>70%</strong></td>
</tr>
</tbody>
</table>
# Facts and Figures, Revenue share model

<table>
<thead>
<tr>
<th>Item</th>
<th>Revenue Source</th>
<th>Revenue Forecast (USD Millions)</th>
<th>NSO Revenue (USD Millions)</th>
<th>NGSO Revenue (USD Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Distribution grid loss reduction including non technical losses (tampers) and fraud management</td>
<td>406</td>
<td>126</td>
<td>357</td>
</tr>
<tr>
<td>2</td>
<td>Billing and revenue assurance</td>
<td>52</td>
<td>41.5</td>
<td>41.5</td>
</tr>
<tr>
<td>3</td>
<td>Demand Side Management</td>
<td>204</td>
<td>51.5</td>
<td>127.5</td>
</tr>
<tr>
<td>4</td>
<td>Demand Response</td>
<td>98</td>
<td>35.5</td>
<td>70</td>
</tr>
<tr>
<td>5</td>
<td>Blackout management</td>
<td>64</td>
<td>18.5</td>
<td>58.5</td>
</tr>
<tr>
<td>6</td>
<td>Reducing maintenance due to nature of mechanical meters</td>
<td>59</td>
<td>27</td>
<td>45.5</td>
</tr>
<tr>
<td>7</td>
<td>Value Added Services (VAS) and CRM</td>
<td>17</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>Other services to Tavanir (Renewable energies and DG integration, Streetlight management, asset management, etc)</td>
<td>23</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>Other services to government (CO2 reduction, Electrical Vehicle electricity management, electricity subsidizing management, oil and natural gas export opportunity due to consumption reduction etc)</td>
<td>29</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>ICT services to Water and Gas utilities</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>
Thanks for your kind attention

www.saba.org.ir
www.IranSG.com