

Smart Meters And Their Application To Zero Energy Buildings

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Audience



Professionals and Electrical Engineering students with an interest in

- Energy Management
- Real life applications of the smart grids
- Global Technology trends.

Learning Objectives

After this presentation, the attendants should be capable of:

- **1. D**efining the term smart meter.
- 2. Analyzing the technical aspects of a smart meter.
- **3.** Applying smart meter concepts to a zero energy building.
- 4. Evaluating economical impacts of smart meters.



Did you know?

By the end of 2022, there will be almost as many Smart Meters as cars worldwide? How many? **1.1** Billion Smart Meters

1.15 Billion cars

Forecast by Navigan Research Institute:

https://www.navigantresearch.com/newsroom/the-installed-base-of-smart-meters-will-surpass-1-billion-by-2022

Background: What is a smart meter?

- 1. Records customer consumption (Two way AMI = Automatic Metering Infrastructure)
- 2. Provides frequent transmittal of measurements over a communication network to a central collection point.
- Competitive time-of-use tariffs = cheaper prices for off-peak use.



Further Reading: <u>https://www.ferc.gov/legal/staff-reports/12-08-demand-response.pdf</u> https://www.uswitch.com/gas-electricity/guides/smart-meters-explained/



Important Fact

Over 16 countries utilize Smart Meters



Further Reading:

https://www.bchydro.com/news/conservation/2011/smart_meter_facts.html

Features and Components of Smart Meter

Typical features of a smart meter

- Measurement of parameters
- Daily energy and maximum demand profile
- Harmonic Analyzer
- Non-Volatile Event and Data Recording
- Demonstrate multifaceted communication facilities
- Firmware based interface

Source: <u>http://www.edn.com/design/power-</u> management/4368353/What-s-inside-a-smart-meter-iFixittears-it-down



- 1. Input power terminals.
- 2. SOC (System on Chip) with microprocessor, realtime clock, flash memory and an LCD Driver.
- 3. Operational Amplifier Circuit.
- 4. RFMD Amplifier.
- 5. Additional SOC with microcontroller.

Smart Meter Communication System

Radio Frequency (RF) Mesh Network

- The smart meters talk to each other to form a LAN cloud to a collector using a relatively low power radio
- Constructing multiple routes between a concentrator and a smart meter can secure communication quality.



Wireless Star Network

- High-power radio allows collection of smart meter data at wide area.
- Telecommunications carrier's service can be used, by considering its service quality, continuity and communication fee.

Power Line Communication (PLC)

- Data can be transmitted across the utility power lines from the meter to a collection point
- A concentrator is installed for each transformer to ensure the communication quality considering transmission loss passing through transformer.





Concept for Communication System Selection

System	Evaluation	Adaptation in
RF Mesh	 Certain user density is required for communication network construction. Low power consumption due to low-power radio. 	Common residential areas etc.
PLC	 There is no need to set up new communication lines by using power lines. Applicable even where wireless transmission is difficult. 	High-rise buildings etc.
Wireless Star	 Applying a carrier service is a precondition because constructing dedicated high-power base stations is difficult. Applicable area is limited to the carrier service area. 	Sparse areas such as mountainous areas etc.

Standards

With strong criticism faced by smart meters in the recent past, it is obligatory for the manufacturers to comply to various standards for proper operation of the smart meter.

IEC 61000 (Part 2, 3, 4, 5 & 6)

FCC (Federal Communications Commission) Class B

IEC 62052 (Part 11)

IEC 60688 and ANSI C12.20

Local Technical Codes and Standards

Utility specific and consumer beneficial compliances

For Further Reading: http://www.echelon.com/assets/bltc1e4347bb1a04c1c/Smart-Meter-MTR-3000-IEC-Poly-Phase-datasheet.pdf

Interaction of Smart Meters with the Grid



Smart Meter's interaction with the power grid is a gateway for many prospects:

- Time Based Rates (TOU, critical peak pricing, variable peak pricing, real-time pricing)
- Load Shedding (With Incentive)
- Economic Dispatch

In the province of Ontario, Canada, in September 2006, there was a short period of time when the prices were negative for some category of users, and they had to be paid a rebate.

Source: Green Energy: Technology, Economics and Policy, CRC Press

Issues with Smart Meters

Radio Frequency Exposure

- Typically smart meters work by transmitting information wirelessly.
- Two types of potential effects of RF emissions:
 - Non-Thermal (lower level of RF exposure)
 - Thermal (Heating up of biological body tissues)





Meter Accuracy

 Most changes in meter usage are usually caused by differences produced by load additions, longer billing periods or extraordinary weather occurring simultaneously with meter upgrades. This is a MISCONCEPTION among consumers leading to blame the accuracy.

Security

- The use of utility backhaul communications and increase usage of public wireless networks has increased the exposure to potential security intrusions.
- Higher end cryptographic techniques along with protocols like SSL (Secure Socket Layer), SSH (Secure Shell) and IPSec (Internet Protocol Security) shall be employed.



Zero-Energy Buildings

- Also known as Zero net energy Building (ZNE).
- 2. Total amount of energy used annually is approximately equal to the amount of energy generated in the building mostly by renewable.
- 3. Contribute less overall greenhouse gases.
- 4. Different from Energy-plus buildings and near-zero energy buildings.



Mosaic Centre: Canada's Biggest Net Zero Building

Edmonton, Alberta.





Smart Meters in Zero-energy Buildings

Benefits

Benefits for DISCO	Benefits for the user:
 Reduce metering costs Improved asset / network planning Less reserve capacities necessary Lower redispatch costs Prepay possible Time of Use pricing → wholesale passing-on 	 Identify poor-performance appliances Abnormal consumption notification Home displays: approx. 4% energy saving (DECC) Lower electricity price (ref[4]: EuParl-studies)

Further Reading: Ernst and Young, "Cost-benefit analysis for the comprehensive use of smart metering," 2013 [3]

Costs

	Great Britain Electricity and gas	France		Germany	
Sector (Scenario)		Electricity	Gas	Electricity (EU scenario)	Electricity (Roll-out Plus scenario)
CBA modelling period	2012 - 2030	2011 - 2038	2013 - 2032	2012 - 2032	2012 - 2032
Time frame for deployment	2014 - 2019	2013 - 2018	2011 - 2022	2012 - 2022	2012 - 2022
Number of meters (Min)	49	35	11	38.5	32.6
Overall cost (€ Bin)	14.4	3.8	1.2	20.8	13.7
Roll - Out Investment costs (€ billion)	8.3	3.8	1.0	8.5	7
Operating costs (€ billion)	6.2		0.2	12.3	6.7
Investment costs per meter (€)	168.5	108.6	94.8	220.8	214.7
Expected benefits (€ billion)	22.3	3.9	1.28	20.7	15.2
Lower customer care costs (€ billion)	13.2	3.9	0.5	5	9
Energy conservation (€ billion)	7.7	(2)	0.2		3
Others (€ billion)	1.4		0.54	. *	ан Эн
Net Present Value (€ billion)	7.9	0.1	0.07	-0.1	1.5

CERRE/DECC: Regulating Smart Metering in Europe [9]

Market potential

Source: US International Trade Commission, "Global Market for Smart Electricity Meters: Government Policies Driving Strong Growth", 2014 [10]

FIGURE 7 Growth in European Smart Grid Spending: Average annual growth forecast for 2012–16 22 percent







Regional Breakdown Of Smart Meter Installed Base

SMART METERS

Millio

Future Directions



Installed base of smart gas meters (EU28+2 2015–2022) and installed base of smart electricity meters (EU28+2 2015–2022)

- Mandatory roll-out discussed in many countries
- Include gas/water roll-out?
- Open standards? → interaction with other devices
- Privacy concerns \rightarrow governmental regulation, personal use
- Billions of market potential \rightarrow worldwide growth

Summary

Defining the term smart meter.	 Records power consumption Provides the measured data to DSO, PSC and/or consumer 	
Analyzing the technical aspects of a smart meter.	 Analyzing the Communication System Options Conformance to various IEC, FCC and ANSI standards 3 – tier layer interaction with the grid with many prospects for optimized pricing, generation & consumption of energy 	
Applying smart meter concepts to a zero energy building.	 Smart Meters can control the (net) energy flow Influence the load pattern 	
Evaluating economical impacts of smart meters.	 Distinguish the highest cost part: often roll-out Net Present Value (mainly) positive Evaluate the worldwide potential (Asia, Europe) 	

Refereces:

Further Reading and Links:

http://hme.ca/reports/Design_and_Optimisation_of_Net_Zero_Energy_S olar_Homes.pdf

Energy management systems: state of the art and emerging trends

http://ieeexplore.ieee.org/document/6400447/?arnumber=6400447&tag =1

http://www.sciencedirect.com/science/article/pii/S0378778812000497

Interesting Patents:

https://www.google.com/patents/US3842208

https://www.google.com/patents/US4241237

https://www.google.com/patents/US4455453

http://www.eei.org/issuesandpolicy/gridenhancements/documents/smartmeters.pdf

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- [7] J. (Irec) Salom, J. Widén, J. a Candanedo, I. Sartori, K. Voss, and A. J. Marszal, "Understanding Net Zero Energy Buildings: Evaluation of load matching and grid interaction indicators," *Proc. Build. Simul. 2011*, vol. 6, pp. 14–16, 2011.
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 [11] The Table Commission ("Data Strong Growth")
- The Tokyo Electric Power Company, "Basic Specifications for Smart Meter Communications", March 2012
 [12]
 - A. Barenghi, G.M. Bertoni, L. Breveglieri, M.G. Fugini and G. Pelosi, "Smart metering in power grids: Application scenarios and security", 2011 IEEE PES
 Innovative Smart Grid Technologies, Perth, WA, 2011
- [13] The Electric Power Research Institute, INC (EPRI), "Accuracy of Digital Electricity Meters", May 2010