Distributed Sensors & Connectivity as the answer to future grid requirements

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Innovation & Program Management

AIT Industry Day – September 11th, 2015
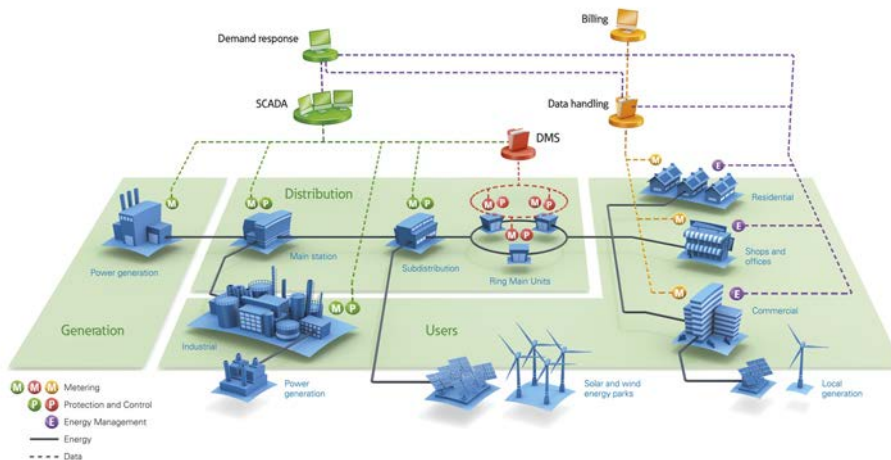
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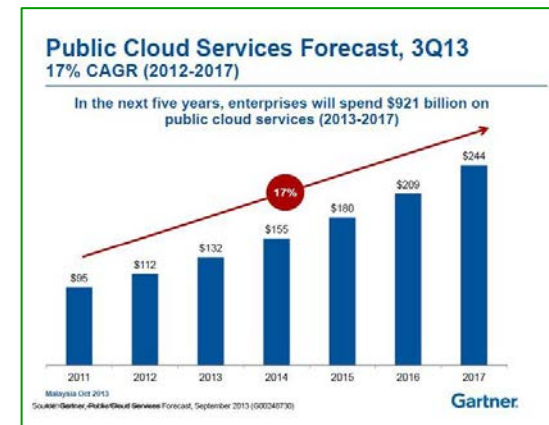
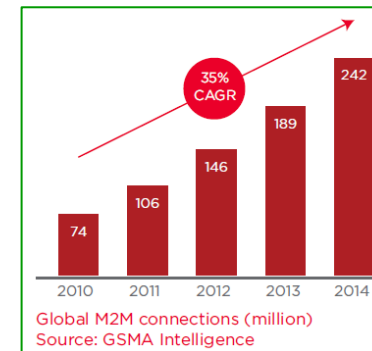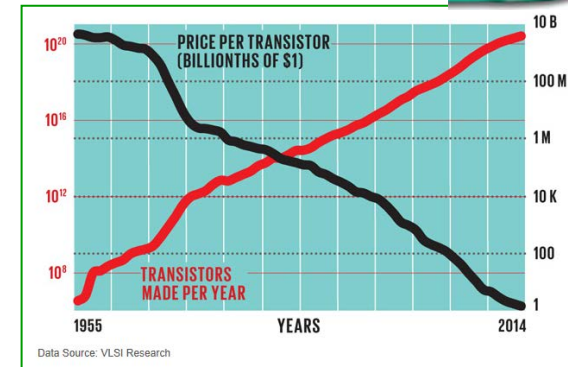# Power business – status quo

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- **Consumer – Prosumer transformation requests new system approaches**
  - ➢ Virtual power plants
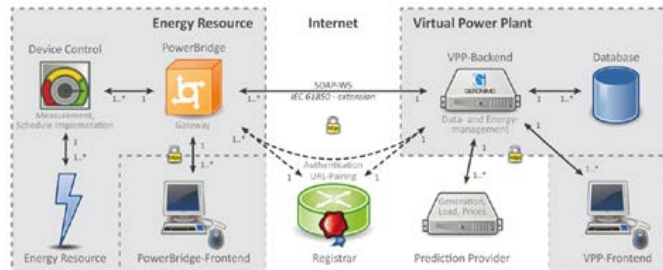
Technology trends are lowering the hurdles to develop and connect more intelligent devices

- Semiconductor component costs continue to decline

- Functionality and power management performance improving

- Pervasiveness of communications increasing

- Cloud services and development tools are being used more and more…and their costs are dropping dramatically with scale

PRICE PER TRANSISTOR (BILLIONTHS OF $1)

TRANSISTORS MADE PER YEAR

1955 — YEARS — 2014

Data Source: VLSI Research

35% CAGR

| 2010 | 2011 | 2012 | 2013 | 2014 |
| 74 | 106 | 146 | 189 | 242 |

Global M2M connections (million)
Source: GSMA Intelligence

Public Cloud Services Forecast, 3Q13
17% CAGR (2012-2017)

In the next five years, enterprises will spend $921 billion on public cloud services (2013-2017)

17%

$95 — 2011
$112 — 2012
$132 — 2013
$155 — 2014
$180 — 2015
$209 — 2016
$244 — 2017

Source: Gartner, Public Cloud Services Forecast, September 2013 (G00248730)

Gartner.

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Future challenges

World Energy Consumption by fuel type, 1990-2040 - *Source : EIA (2013)*
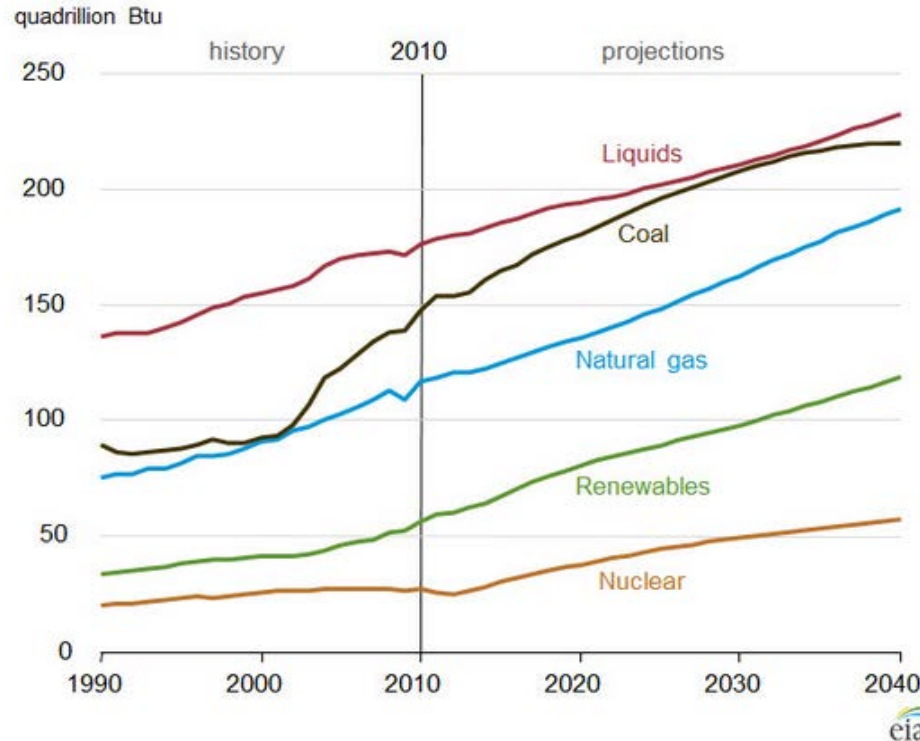
Future challenges

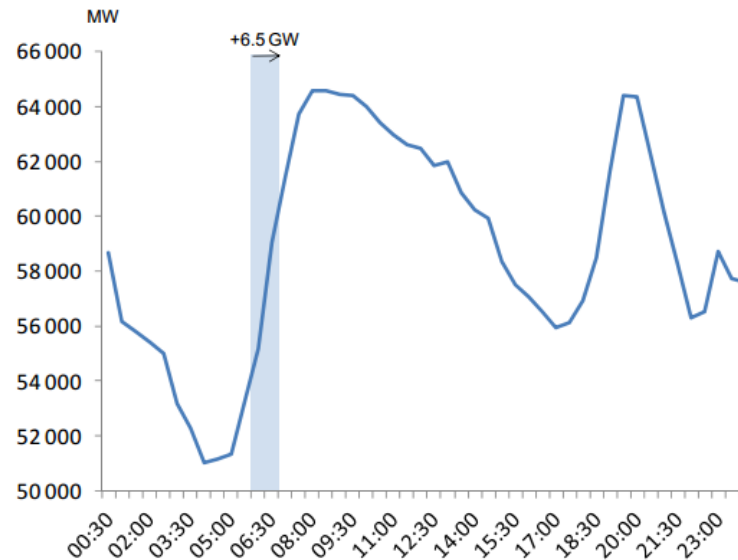| 1. Growing Electricity Demand & Ageing Infrastruture	2. Electricity Peak Management	3. Increasing Variable Energy Generation	4. Increasing Integration of Electric Vehicle

Chong Qing (Central China), one of the world fastest growing cities
Source : Forges

Example of one-day electricity consumption in France on March 22nd 2012 - *Source : IEA (2012)*
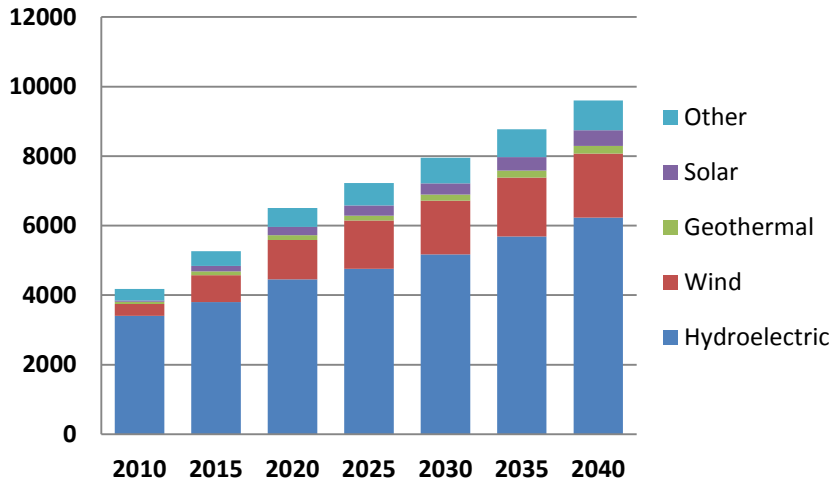
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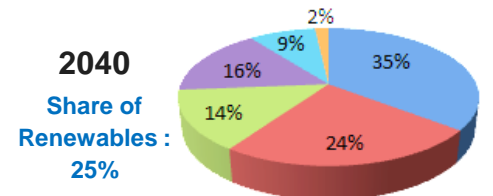| 1. Growing Electricity Demand & Ageing Infrastruture	2. Electricity Peak Management	**3. Increasing Variable Energy Generation**	4. Increasing Integration of Electric Vehicle

World net renewable electricity generation by energy source in TWh 2010-2040 - *Source: EIA (2013)*

Middelgrunden Wind Farm, (Denmark)

Solar ship in Freiburg (Germany)
Source: Clean Technica

- Coal
- Natural gas
- Nuclear
- Hydropower
- Nonhydropower renewables
- Liquids

2010 Share of Renewables : 21%

2040 Share of Renewables : 25%
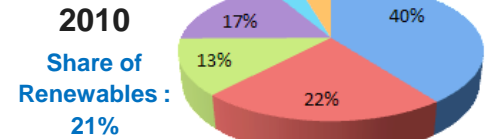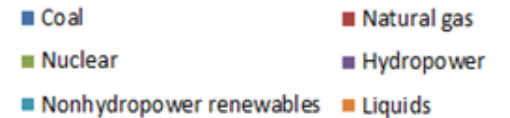
World net electricity generation by energy source comparison between 2010 and 2040 outlooks - *Source :* EIA (2013)

Future challenges

Source: EVI. Note: A 20% compound annual growth rate is assumed for countries without a specific sales target (i.e., only a stock target) or with targets that end before 2020.
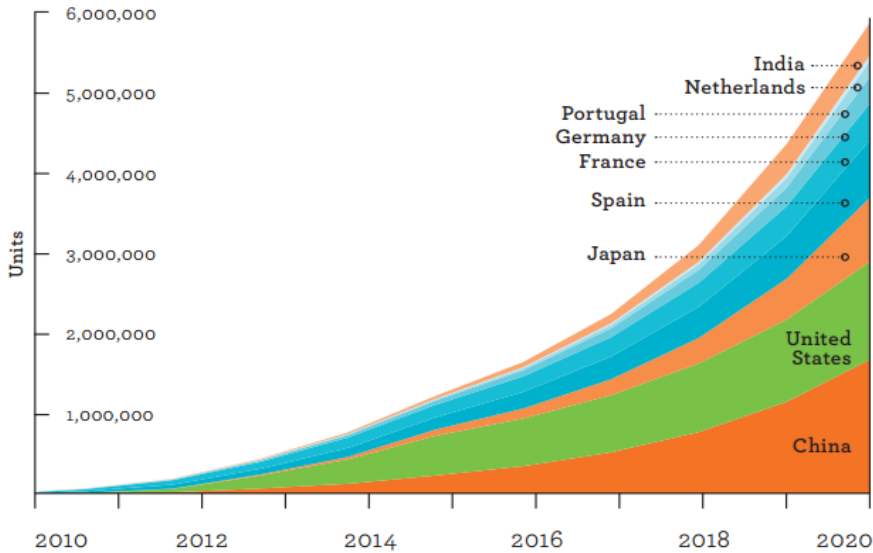
RWE Electric Car Pilot Project (Germany)

EV sales target (in 9 out of 14 selected EVI member countries)

Source : IEA (2013)

EVI = Electric Vehicle initiative

Economical aspect of power outages

- Based on an US market risk analysis from the Allianz insurance group the following figures have been reported:

  - A **30-minute power cut** results in an average loss of **US$ 15,709** for medium and large industrial clients

  - An average loss of **US$ 94,000** for an **eight-hour interruption**

  - Even **short blackouts** – which **occur several times a year in the US** – add up to an annual estimated economic loss of between **US$ 104** and **US$ 164 billion**

- The president of the Ankara Chamber of Commerce (ASO) said if the electricity is out for **eight hours**, the incident costs **Turkey** an **estimated US$ 800 million** in lost productivity.

- An economic assessment of a four-hour outage in Austria done by **APOSTEL (Austrian Power Outage Simulation Tool)** turns out an **estimated total loss of US$ 80 Mio. per hour**.

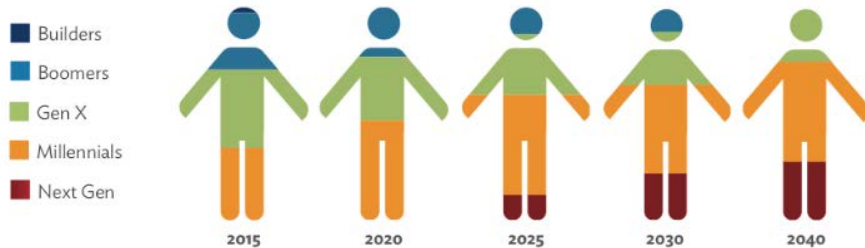**F·T·N**
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Aging workforce being backfilled by millennials who take connectivity for granted

Aging workforce being backfilled by millennials

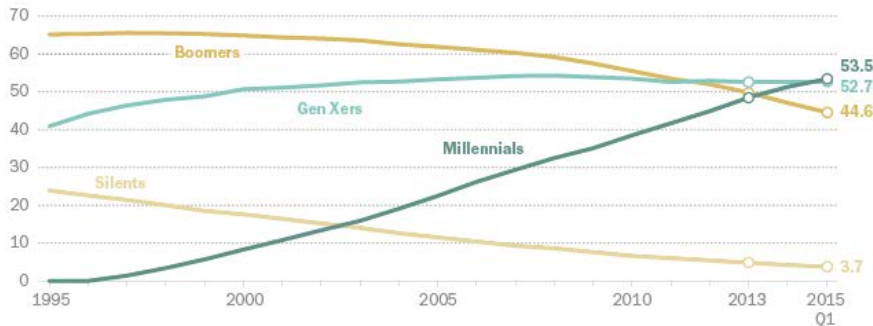### World Population by Generation

Worldwide and in the U.S., Millennials are the largest generation yet – some 2.3 billion strong. (U.S. Census Bureau)

- Builders
- Boomers
- Gen X
- Millennials
- Next Gen

2015 2020 2025 2030 2040

U.S. Labor Force by Generation, 1995-2015

In millions

Boomers — 53.5
Gen Xers — 52.7
Millennials
Silents
44.6
3.7

1995 2000 2005 2010 2013 2015 Q1

Note: Annual averages plotted 1995-2014. For 2015 the first quarter average of 2015 is shown. Due to data limitations, Silent generation is overestimated from 2008-2015.
Source: Pew Research Center tabulations of monthly 1995-2015 Current Population Surveys, Integrated Public Use Microdata Series (IPUMS)

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Consumer experiences shaping expectations for other segments

Key traits of the millennial customer

- Millennials expect technology to simply work, so you'd better make sure that it does…and mobile is the technology closest to their hearts

- Millennials are a social generation – and they socialize while consuming (and deciding to consume) your products and services

- They collaborate and cooperate – with each other and, when possible, with brands

- They're passionate about values – including the values of companies they do business with

Forbes, Micah Solomon, 12/29/14

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Customer's Needs

Our customers want:

- Safety: remote monitoring and control to minimize employee exposure
- Reliability: systems that predict failure or respond more quickly to bring power back online
- Efficiency: better algorithms and coordination between devices to reduce consumption and improve asset utilization and personnel productivity
- Lower costs and new features, quickly
- High levels of service from their vendors
- Products that are easy to use, which are backwards and forwards compatible

But there are numerous challenges

- Increasing complexity of systems
- Selecting the right technologies
- Security – physical and cyber
- All of the data and what to do with it
- Need to support legacy and new systems – standards or lack thereof – **protocol proliferation**

Hundreds of protocols on the market

- Many go back decades; legacy installed base is too large to ignore
- Interoperability between protocols must be addressed in devices, gateways and/or in the Cloud
- Many more vendor-proprietary and legacy protocols exist…

Industrial Automation Protocols
- AS-i – Actuator-sensor interface
- BSAP – Bristol Standard Asynchronous Protocol
- CC-Link Industrial Networks
- CIP (Common Industrial Protocol)
- CompoNet
- ControlNet
- EtherNet/IP
- Controller Area Network
- CANopen
- ControlNet
- DeviceNet
- DF-1
- DirectNet
- EtherCAT
- Ethernet Global Data (EGD)
- EtherNet/IP – IP stands for "Industrial Protocol"
- Ethernet Powerlink
- FINS
- FOUNDATION fieldbus – H1 & HSE
- HART
- HostLink.
- Incom - Eaton
- Interbus
- PROFINET IO
- MACRO Fieldbus
- MECHATROLINK
- MelsecNet,
- Modbus PEMEX
- Modbus Plus

- Modbus R
- MTConnect
- OPC
- OPC UA
- TU or ASCII or TCP
- OSGP – The Open Smart Grid Protocol, ISO/IEC 14908.1
- Optomux
- PieP
- Profibus.
- PROFINET IO
- RAPIEnet
- SmartWire DT
- SERCOS III
- SERCOS interface
- GE SRTP
- Sinec H1
- SynqNet
- TTEthernet

Building Automation Protocols
- 1-Wire
- BACnet
- C-Bus
- CC-Link
- DALI
- DSI
- Dynet
- Ego-n
- EnOcean
- iNels
- LON, LonTalk
- KNX
- Modbus RTU or ASCII or TCP

- Nikobus
- oBIX
- OpenTherm
- HDL-Bus-
- VSCP
- xAP
- xComfort
- X10
- Z-Wave
- ZigBee
- INSTEON

Utility Automation Protocols
- DNP3
- ICCP
- IEC 60870-5
- IEC 61850
- IEC 62351 – Security
- ANSI C12.18
- DLMS/IEC 62056
- IEC 61107
- M-Bus
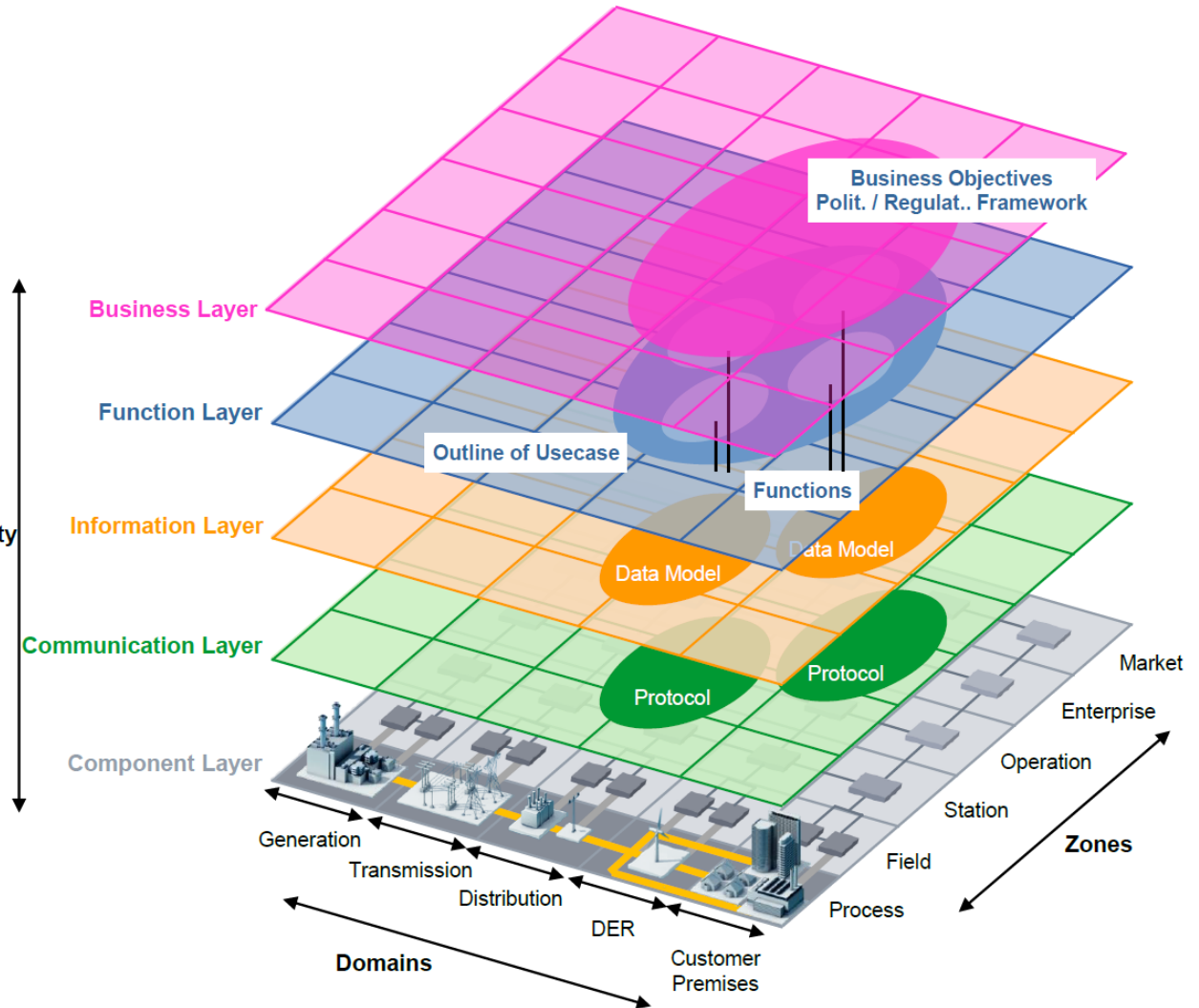- ZigBee Smart Energy 2.0
- Modbus
- ANSI C12.21
- ANSI C12.22

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Asset management

Future interactions (HMI)

Big data management

Interoperability Layers

Business Layer

Function Layer

Information Layer

Communication Layer

Component Layer

Business Objectives
Polit. / Regulat.. Framework

Outline of Usecase

Functions

Data Model

Data Model

Protocol

Protocol

Generation

Transmission

Distribution

DER

Customer
Premises

Domains

Market

Enterprise

Operation

Station

Field

Process

Zones

Safe Energy from Eaton

Power Plants

Transport

Infrastructure

Distribution & Transmission

Commercial buildings

Main feeder stations

Transformer stations

Process Industry

Smart Home

Smart Factory

Green Energy

MOELLER B-LINE HOLEC
AEROQUIP BEGEROW BOSTON
SANTAK JEIL MEM AIRFLEX CHAR-LYNN
POWERWARE CUTLER-HAMMER
INTERNORMEN SELCOOPER B-LINE
FULLER CARTER SYNFLEX VICKERS
SANTAK HOLEC MEM AEROQUIP
HOLEC SANTAK BOSTON
BUSSMANN ARGO-TECH HOLEC
WEATHERHEAD CROUSE-HINDS
ARGO-TECH B-LINE SEL AIRFLEX
BOSTON BEGEROW ARGO-TECH
HOLEC SEL CUTLER-HAMMER
B-LINE CHAR-LYNN SANTAK
WEATHERHEAD HYDRO-LINE
HOLEC BUSSMANN