



# The Smart Grid

2011 Fall Creek Falls Conference  
Sept 13-16<sup>th</sup> , 2011

## **A Smart Grid:**

- Empowers consumers**
- Improves efficiencies**
- Optimizes resources**
- Increases reliability**
- Reduces emissions**

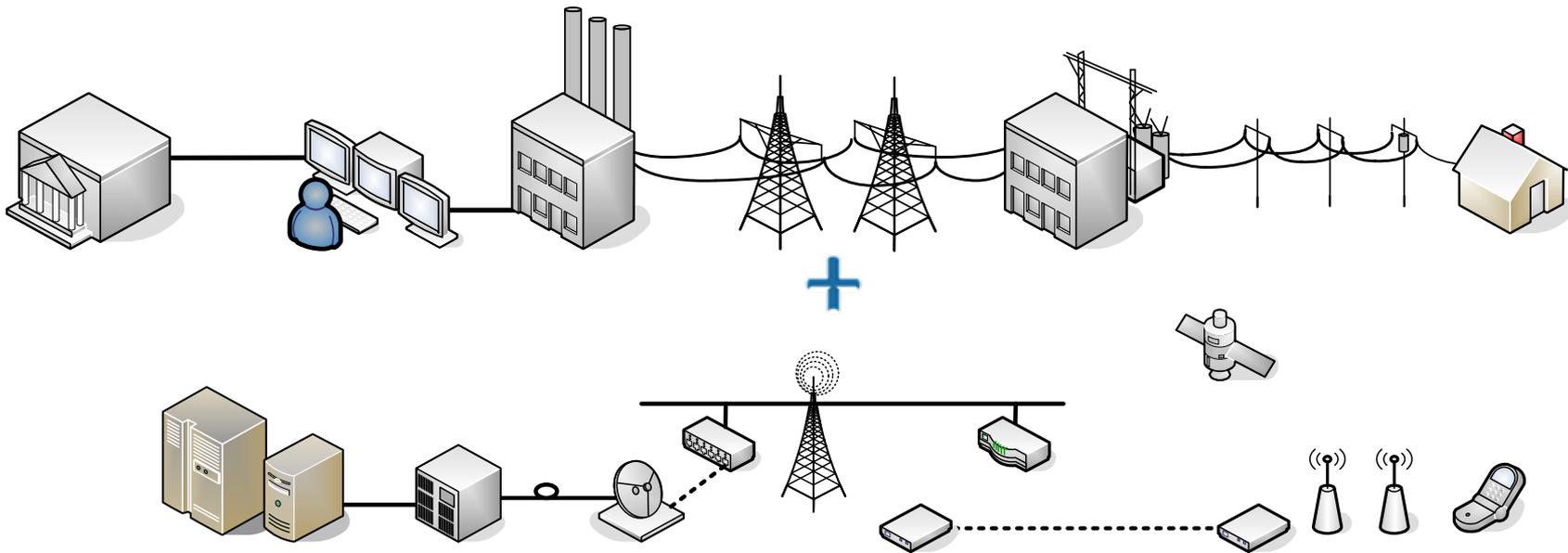
**A Smart Grid is  
comprised of various  
solutions focused on the  
integration of two  
infrastructures:**

**Electrical System**

**+**

**Information System**

# What Is The Smart Grid



A Smart Grid is not just adding an Information Technology architecture on top of an Electrotechnical architecture. It is building a system with subsystems that have at the same time a “body” and a “soul”.

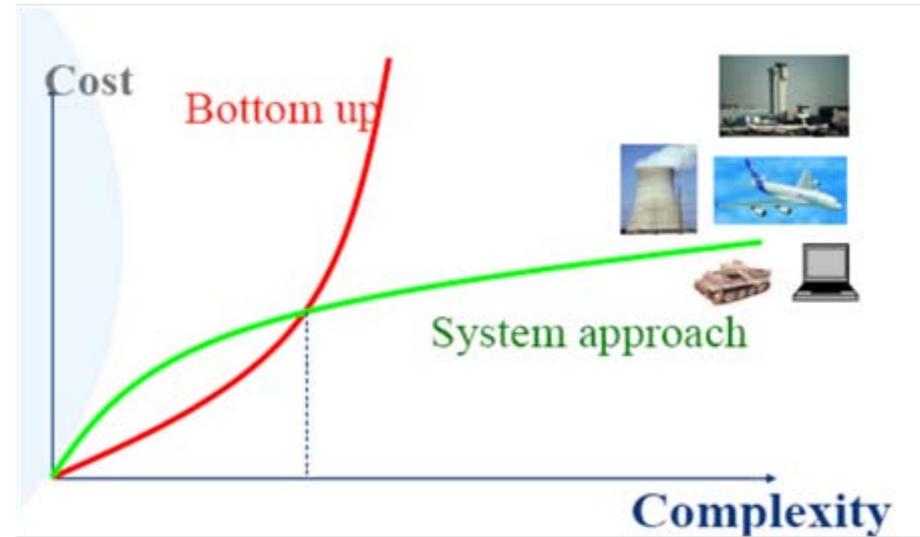
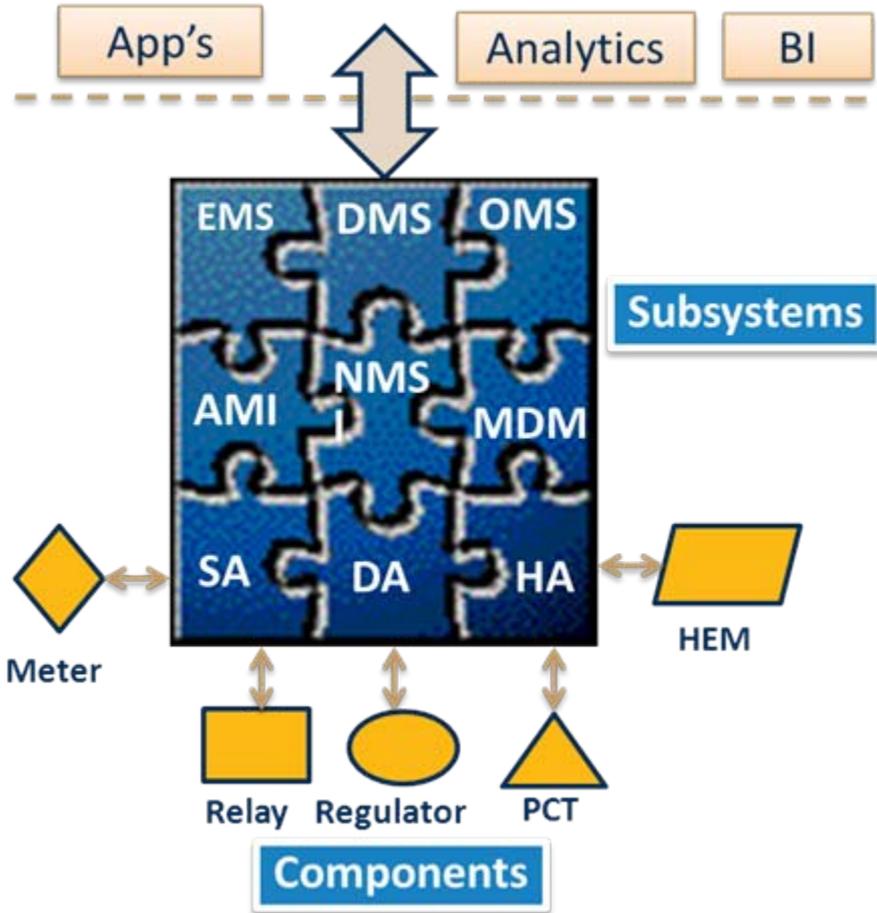
# Complex Systems

- **The Smart Grid is truly a “System of System”**
- **There are many hypothesis of how we can make the grid “smarter”**
- **Little is known of the impact of the introduction of new technologies**
- **The introduction of “Unintended Consequences”**
  - **Problem of voltage rise from renewables invertors**
  - **Renewables variability causes greater emissions levels per MW**
  - **Switch from coal to gas increases emissions**
- **Utilities reluctant to adopt**



# How Do We Make The Smart Grid Smarter

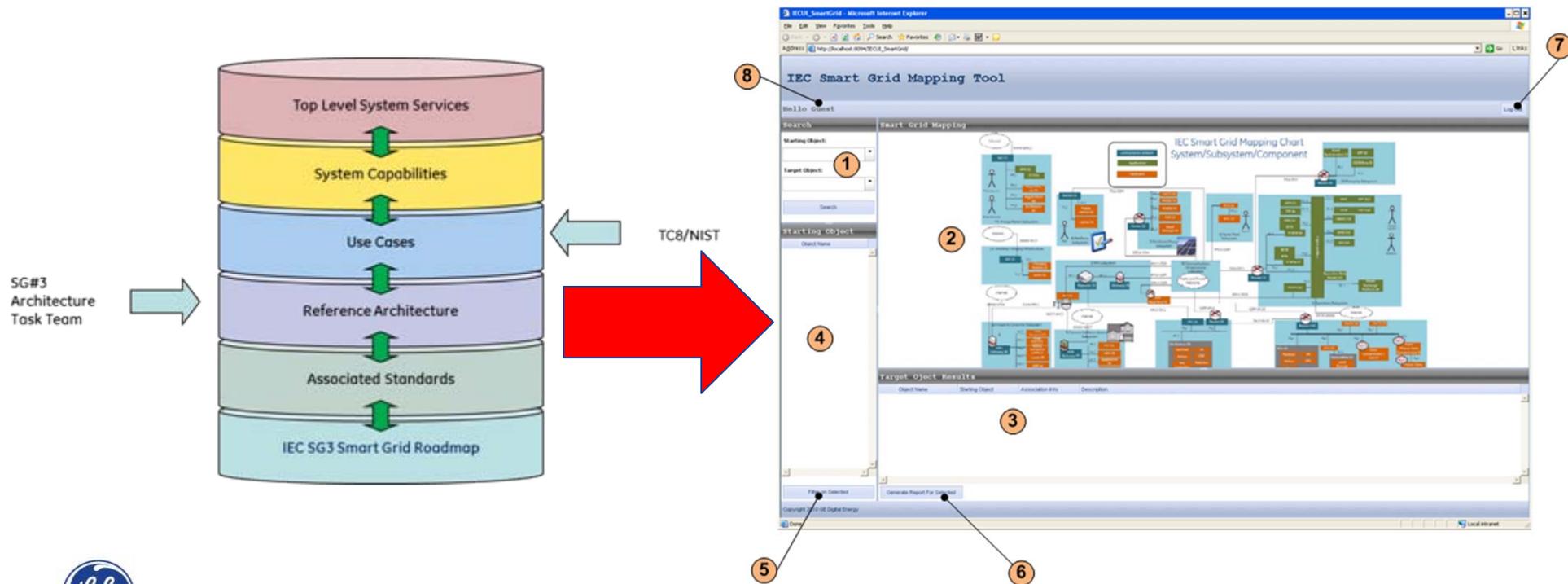
## Smart Grid "System of Systems"



Key is taking Systems Engineering Approach

# A System Engineering Approach

- Detailed requirements gathering
- Development of Use Cases
- UML ... associations, dependencies, etc



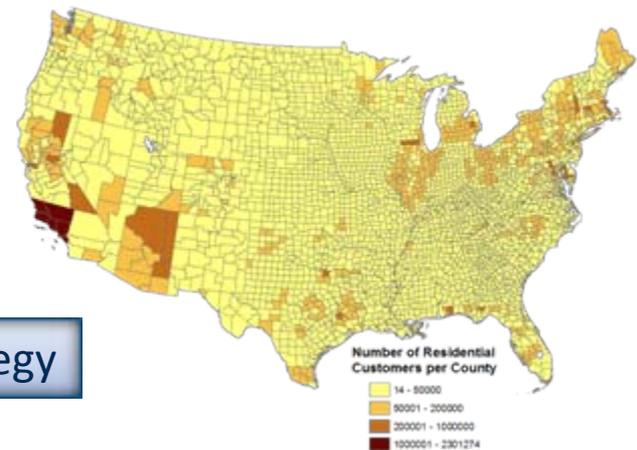
# Modeling & Simulation ... virtualizing the grid

- **Why we want to Model & Simulate the entire grid**
  - **Avoid endless round of “pilots”**
  - **Let utilities “drive before they buy” ... impact of new technologies**
  - **Expose “Unintended Consequences” they happen**



# Modeling & Simulation ... working with National Labs

- **PNNL – Grid Lab D ... distribution network M&S**
  - Impact of Renewables
  - Impact of EV's
- **ORNL – VERDE , CoNNECT – Visualization**
- **Battelle – Visualization & GIS Interface**



Encourage More Coordinated Strategy

# Next Steps

- **Focus on the larger energy cycle ... “Smart Communities”**
  - **Integrate electricity, oil & gas, water/waste water, transportation, etc.**
  - **Energy arbitrage**
  - **Impact of social media**
  - **Customer behavior**





# Virtualizing The Grid

Questions?