

Sensors in Smart Grids



Dallas Konstantinos

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MSc in Information Systems
Athens University of Economics and
Business



Overview

This study provides an analysis of the:

- Usage
- Necessity
- Effects

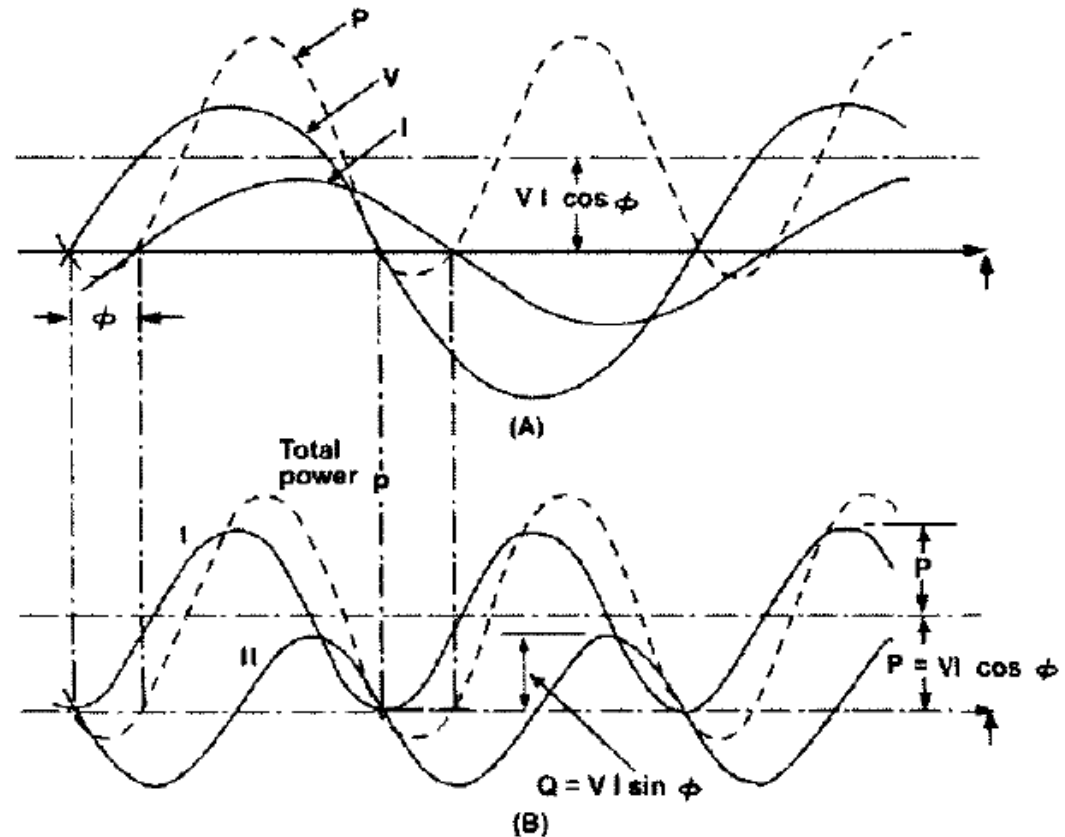
of sensors in electrical grids.

- Emphasis on Security issues.

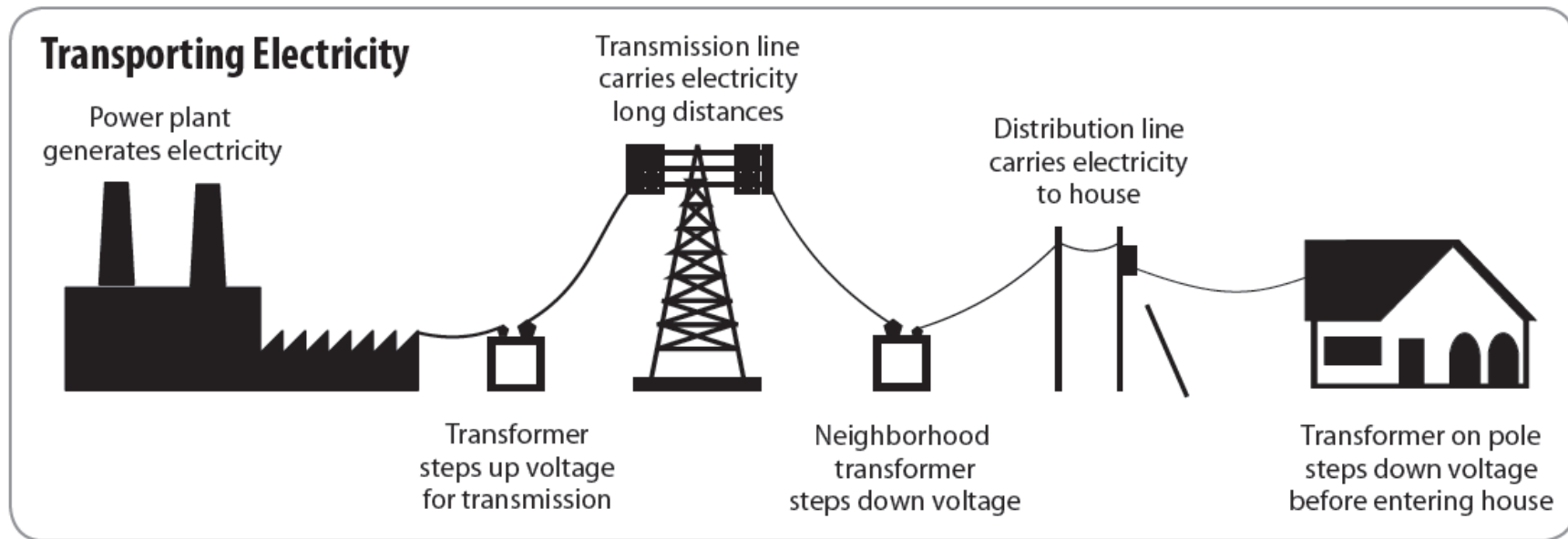


The most important characteristics of electricity

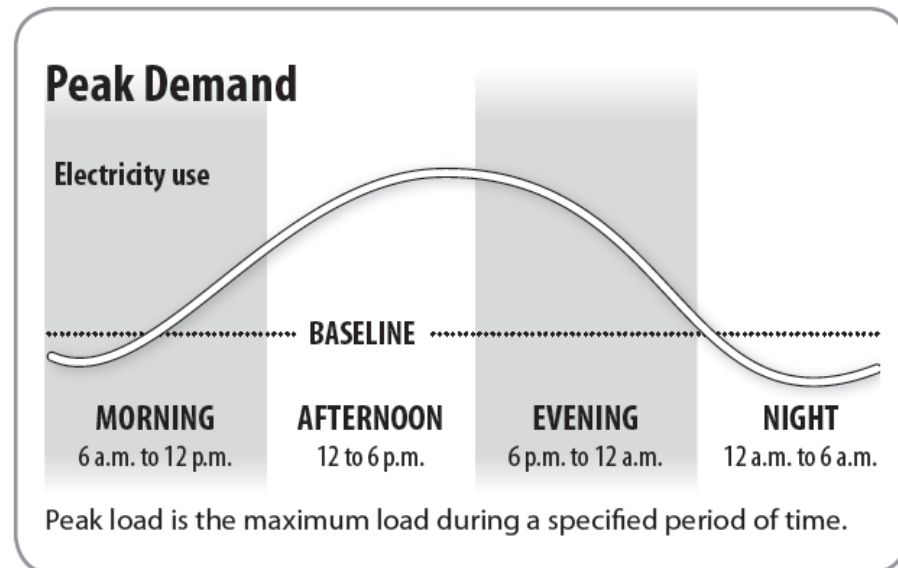
- Voltage V
- Current I
- Impedance Z
- Power :
 - active P
 - reactive Q
 - apparent (or complex) S
 - power factor $\cos\phi$



Classic power grids



- Generation
- Transmission
- Distribution
- Utilization



Current grid's problems and limitations

- Supply must always match the unpredictable, varying demand
- Difficult to store energy in large scale, effectively
- Generation far away from consumption: many losses during transport
- Systems tightly interconnected in national and international level and functioning near capacity limits
- Deregulation: many stakeholders control different parts of the grid – who has overview, responsibility?



The Smart Grid

- Many different definitions worldwide
- E.g. a Smart Grid will:
 - Link ICT with the existing power grid
 - Enable active participation by consumers
 - Accommodate all generation and storage options
 - Enable new products, services, and markets
 - Provide power quality for the digital economy
 - Optimize asset utilization and operate efficiently
 - Anticipate and respond to system disturbances
 - Operate resiliently against attack and natural disaster



Reasons to make measurements and deploy sensors

- Technical
- Environmental
- Economical



Technical and environmental reasons

- Resilience and reliability
- Security (physical and cyber)
- Efficiency
- Integration of emerging technologies and renewable resources



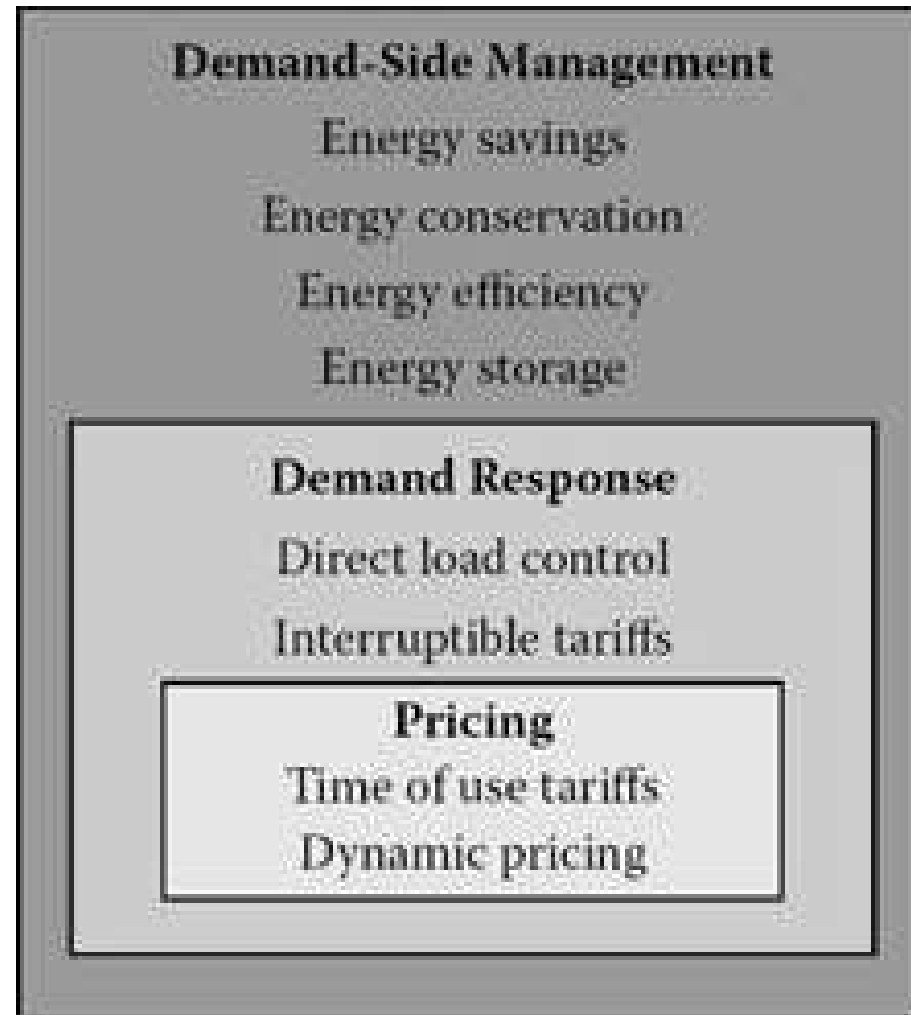
Economical reasons

- Overdimensioned grid – need for downsizing
- Demand Side Management (DSM) and Demand Response (DR) :

Advanced Metering Infrastructure (AMI) with smart meters and smart appliances

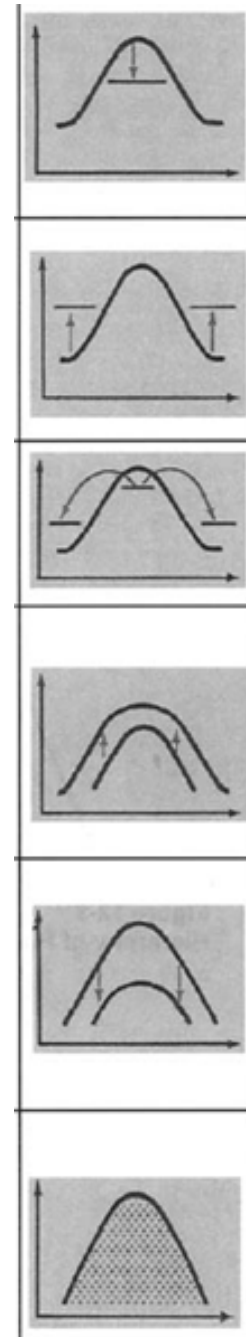
- Societal benefits: increase state income, improve citizens' welfare

Demand Side Management (DSM) and Demand Response (DR)



DSM objectives

- Peak clipping
- Valley filling
- Load shifting
- Energy efficiency
- New, efficient uses
- Demand Response

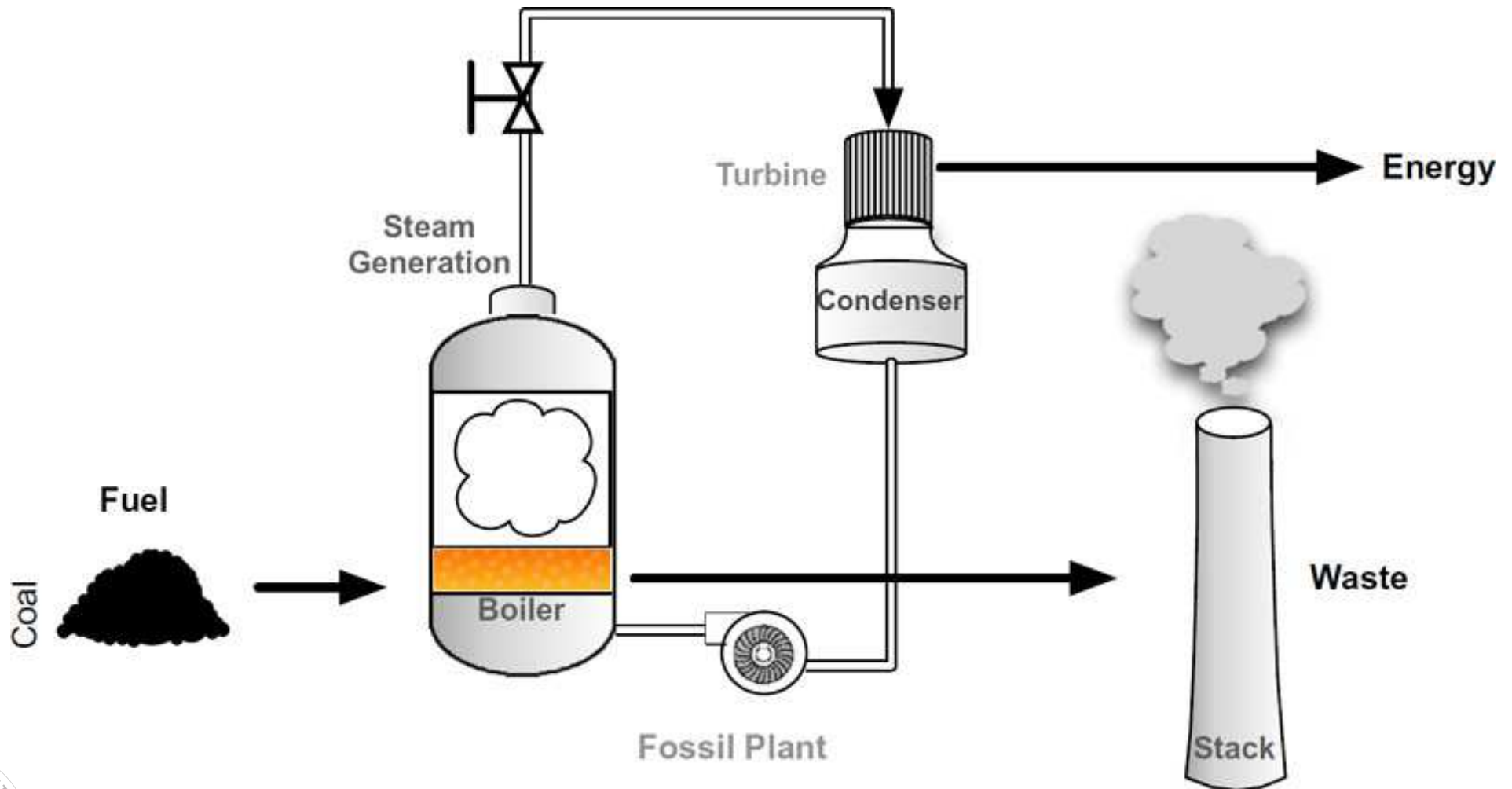


Sensors and their usage in Smart Grids

- Sensors: devices that measure a physical property by responding to a physical stimulus
- Sensor categorization:
 - by power source:
 - active
 - passive
 - by way of communicating:
 - Wireless and satellite
 - Wired
 - Optical fiber
 - Hybrid



Sensors in Generation

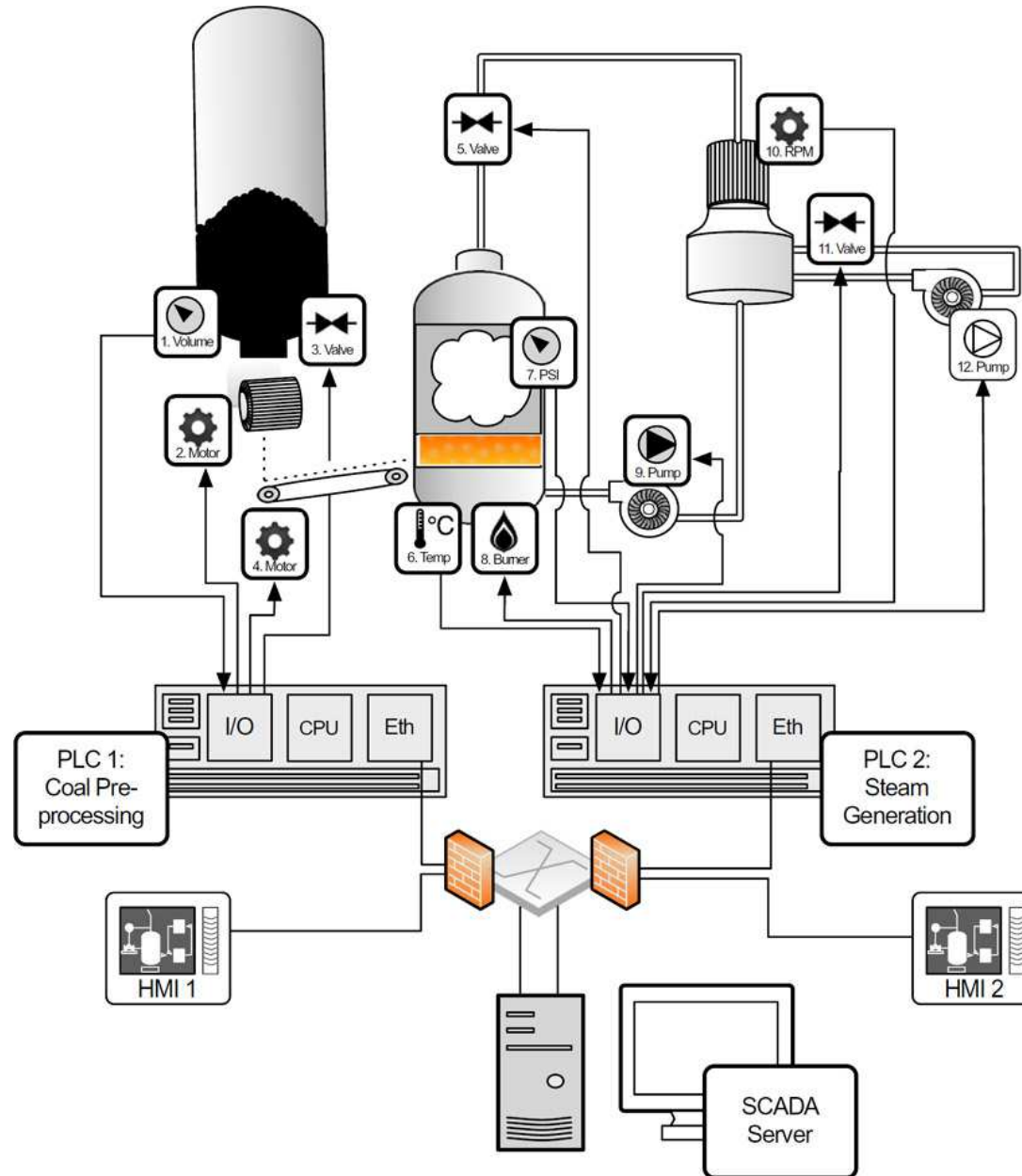


Sensors in Generation

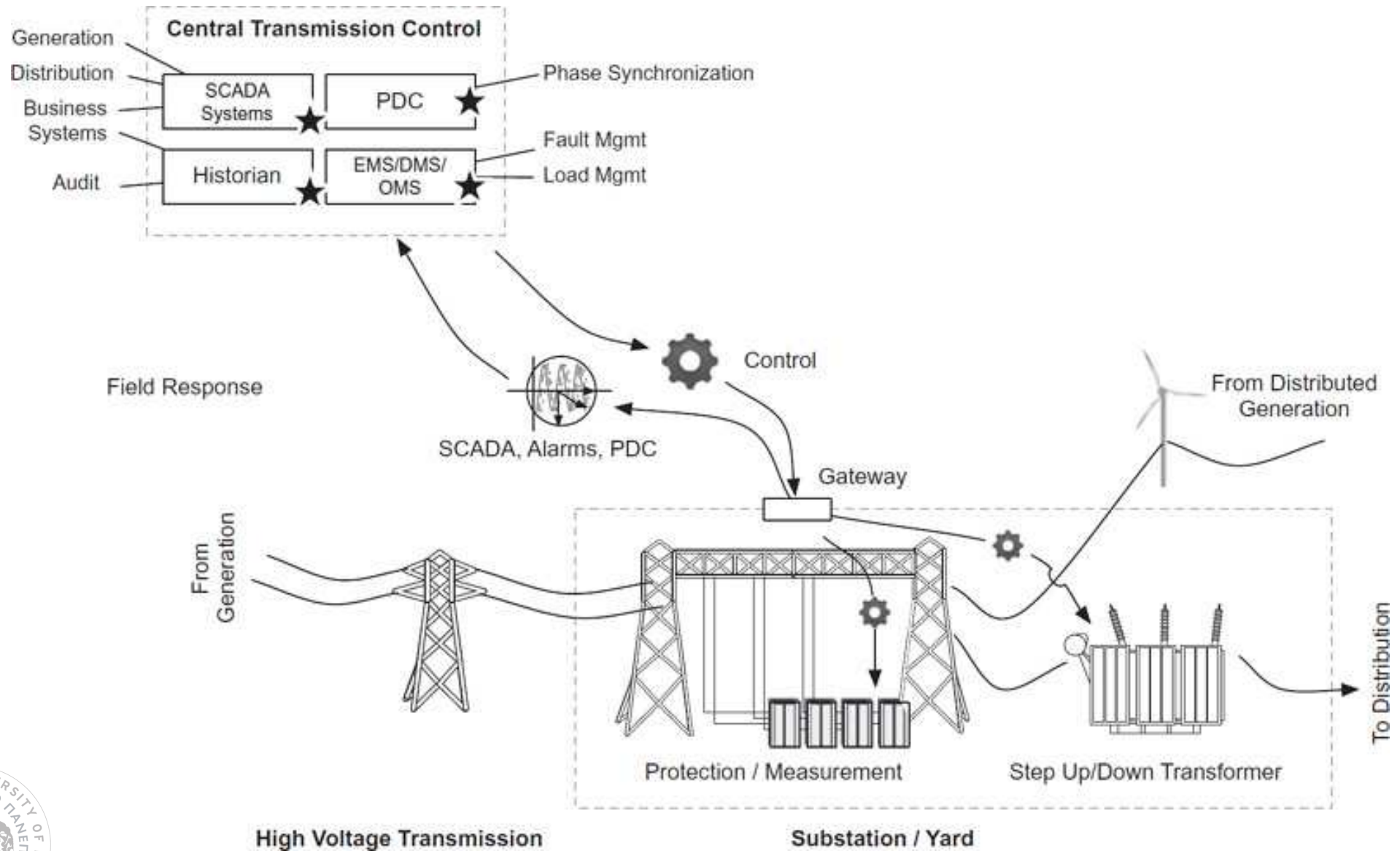
- Programmable Logic Controllers (PLCs)
- Generation Supervisory Control and Data Acquisition systems (G-SCADA)
- Human-Machine Interface (HMI)



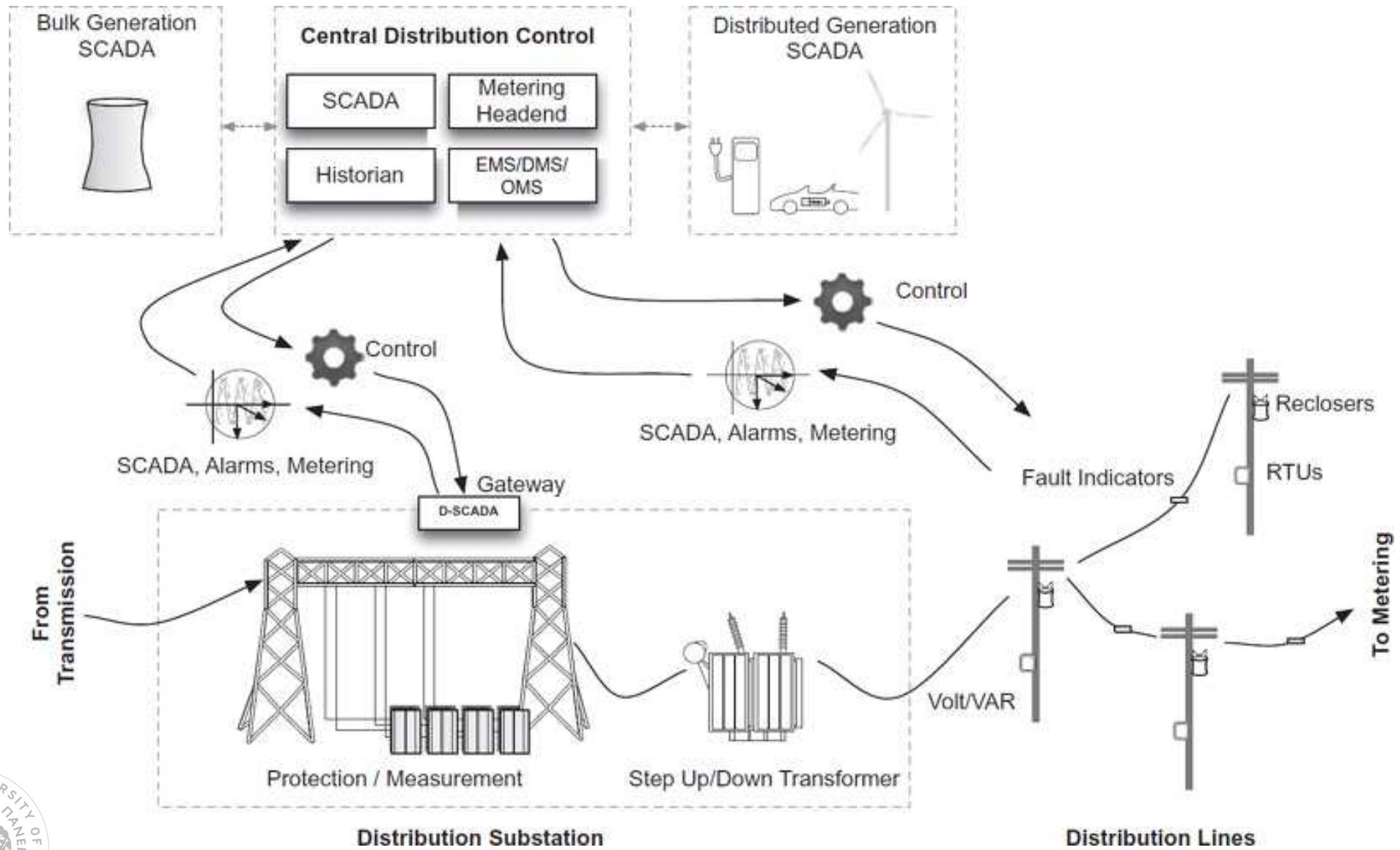
Sensors in Generation



Sensors in Transmission



Sensors in Distribution

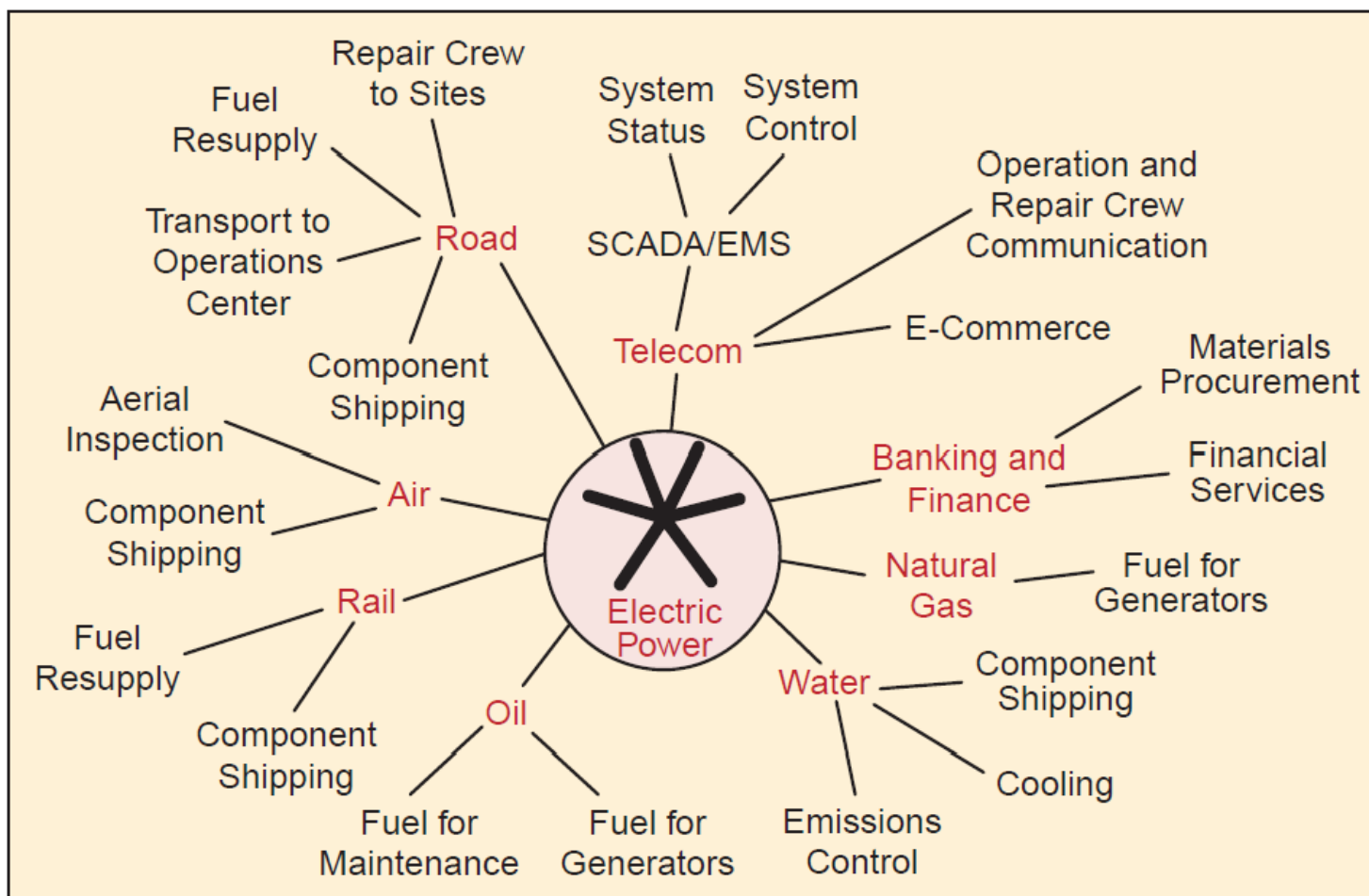


Characteristics of Smart Grid data

- Data collection is needed by many different actors: e.g. operator, government, 3rd parties,...
- Different Quality of Service (QoS) for different usage
- Increasing volume
- Security and privacy concerns



General issues of security in the Smart Grid



Interdependencies of electric power

General issues of security in the Smart Grid

Threats:

- Intentional (human originated, malicious)
- Unintentional :
 - human error
 - natural phenomena

General issues of security in the Smart Grid

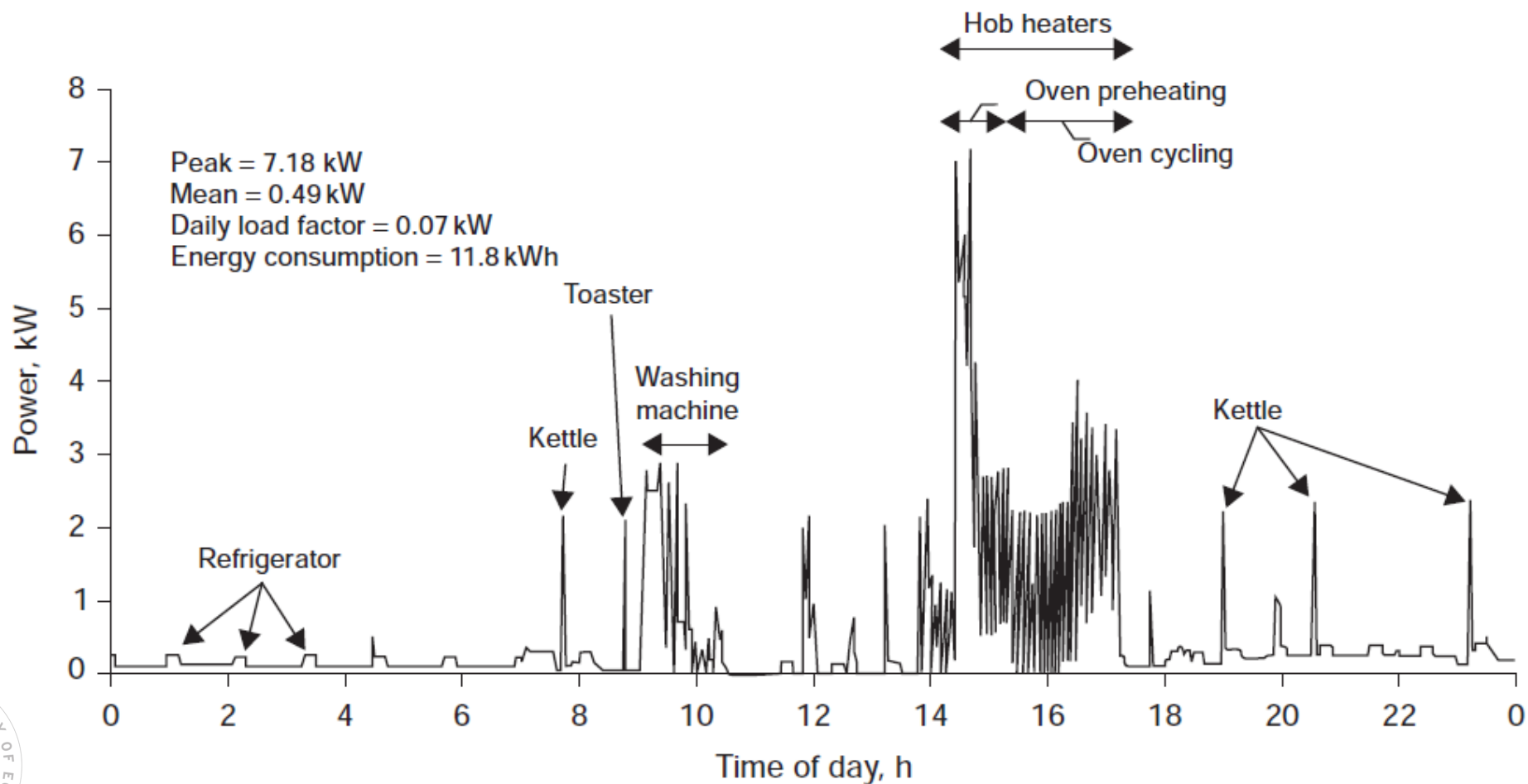
Motivation of cyber-attacks

- Curiosity
- Notoriety
- Revenge or extortion
- Financial gain
- Terrorism
- Spying and cyber electronic warfare



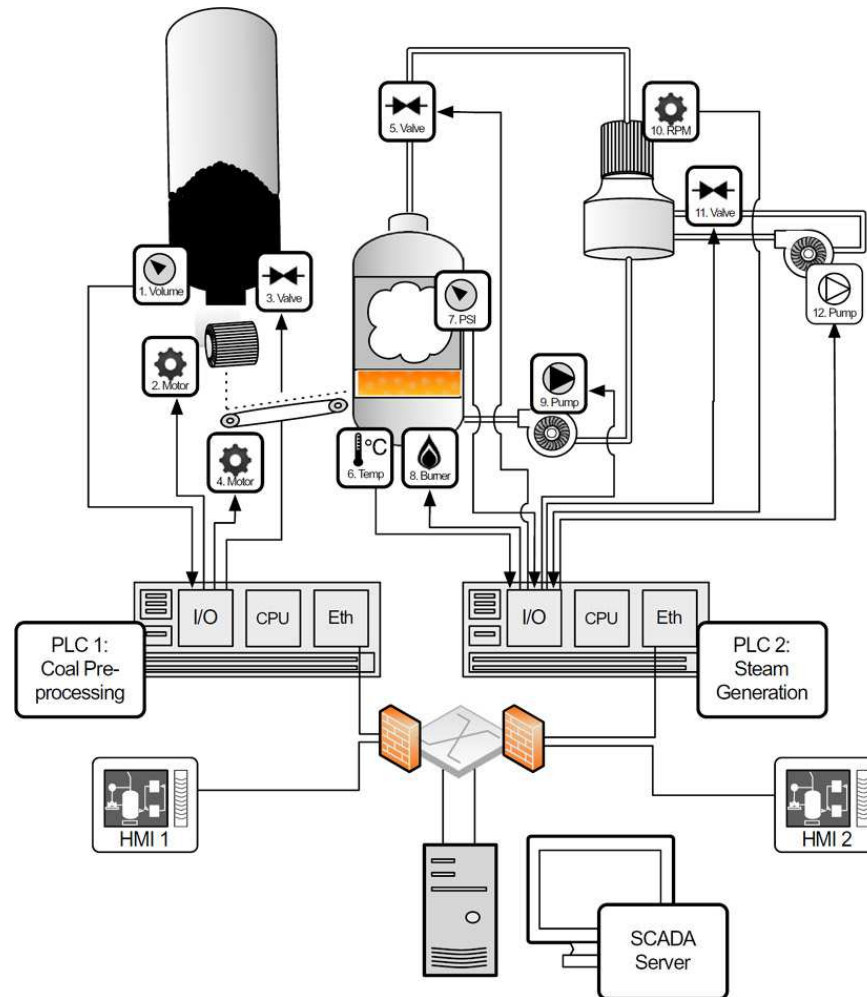
General issues of security in the Smart Grid

- Consumer privacy concerns



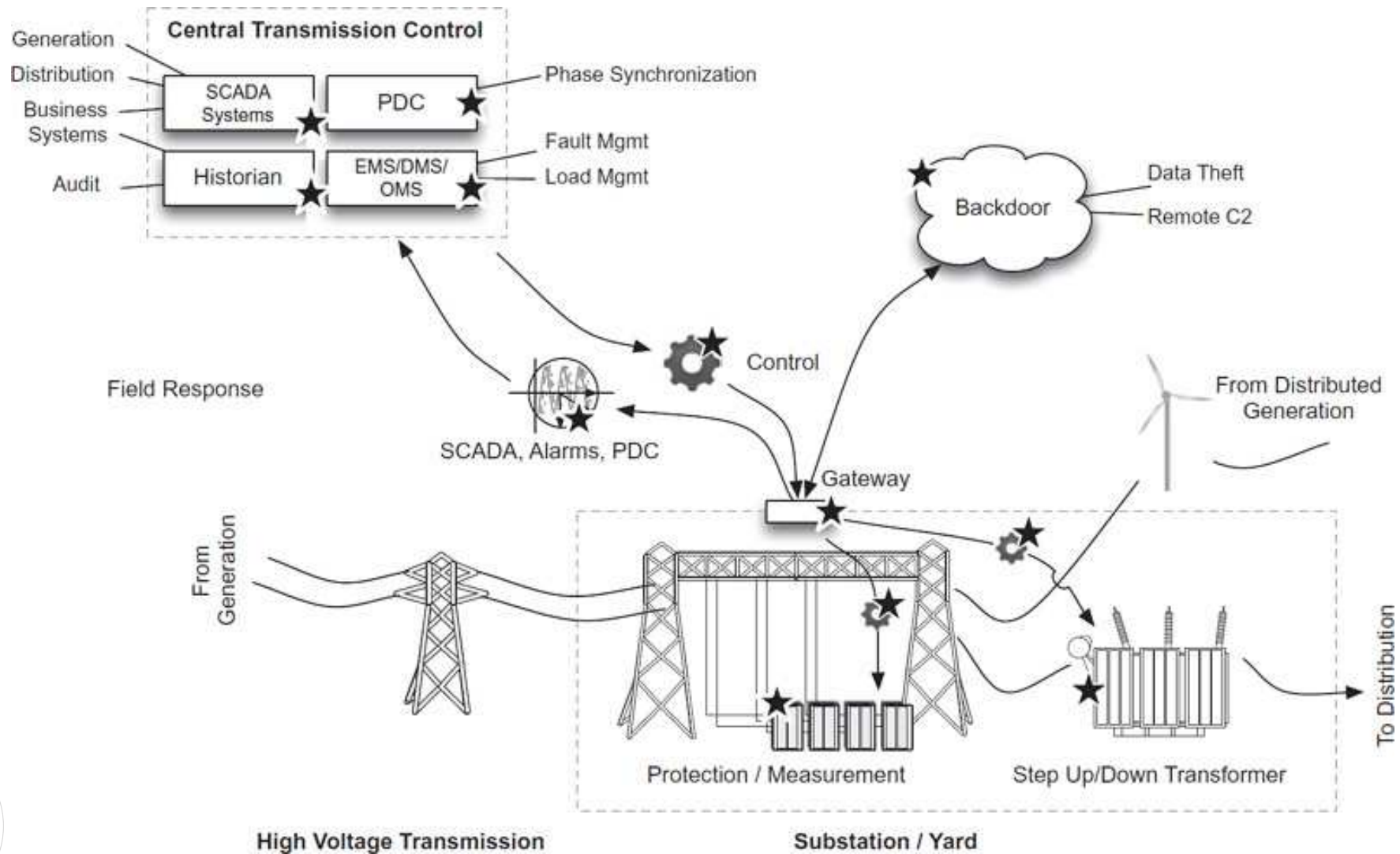
A bottom-up system security approach: identifying targets and consequences

- Attacking the Generation system



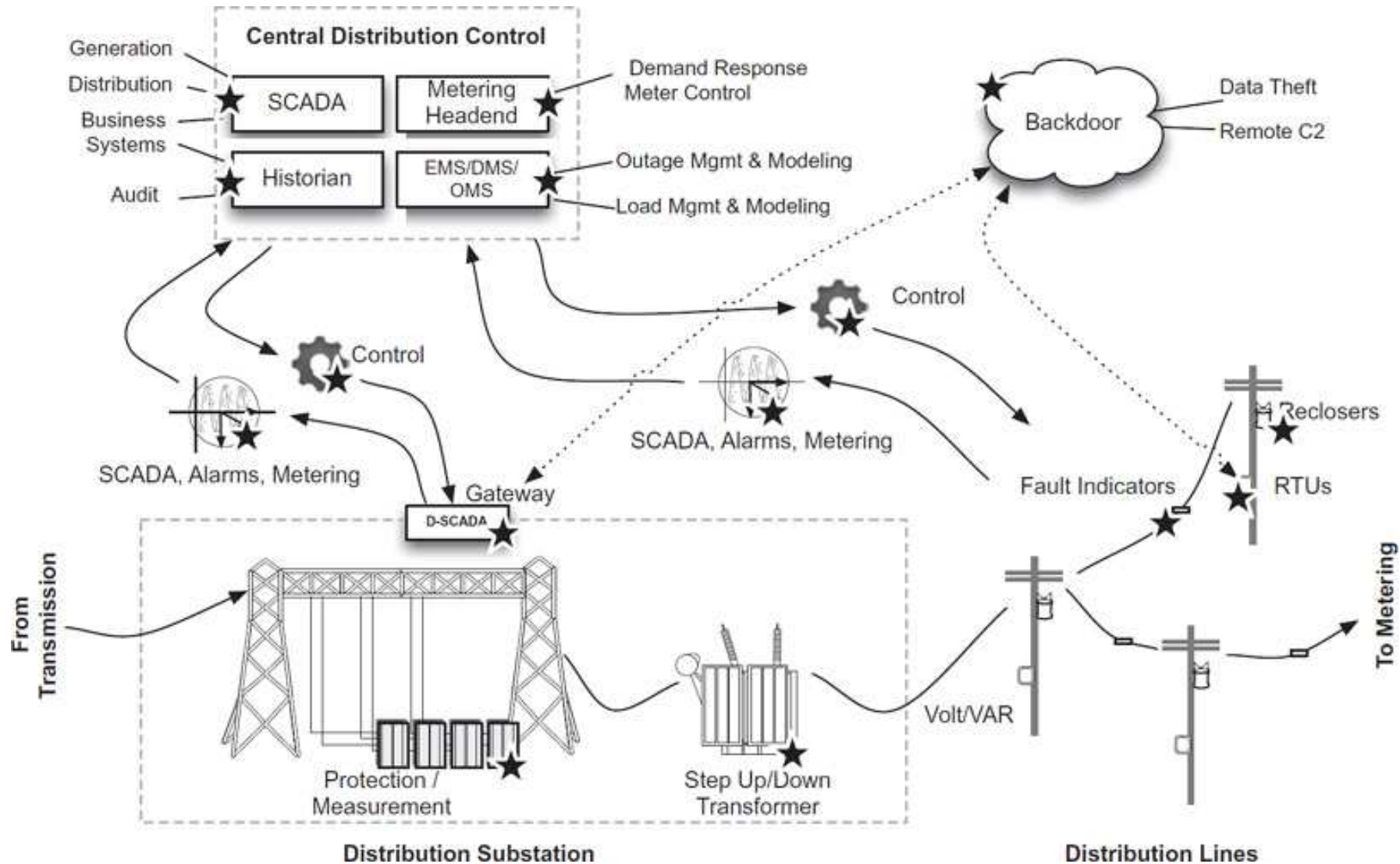
A bottom-up system security approach: identifying targets and consequences

- Attacking the Transmission system



A bottom-up system security approach: identifying targets and consequences

- Attacking the Distribution system



Security solutions and guidelines

- Objectives: Availability, Integrity, Confidentiality
- An organization needs overall security strategy – best practices:
ISO 27000 series, Information Security Forum of Good Practice (SoGP) or other international standard
- Practical solutions:
 - devices that have improved communication, encryption and update capabilities
 - the active participation and team work of all stakeholders
 - use of PKI and strong encryption protocols



Smart Grid implementations

- Slow and costly upgrades of the current grids' infrastructure
- Costs are enormous, governmental support is inevitable: USA issued 100 public grants worth \$3.4 billion
- Examples:
 - Italy, Enel – pioneer in 2001
 - Ontario Canada, HydroOne – 1,3 million smart meters in 2010



Conclusions

- Limitations and problems of the past will be resolved by a technological evolution of the grid into a Smart Grid.
- Measurements and sensors play an important role for Smart Grid operation, maintenance, monitoring and security
- Data produced and communicated have distinct characteristics and requirements and their volume is expected to increase dramatically in the following years.
- Security concerns about intentional and unintentional threats are justified.
- A combined effort of all involved stakeholders, private and government, is crucial for the achievement of a more secure Smart Grid.
- The deployment of Smart Grid technologies has already started in costly efforts across the globe, but there is still a long distance to be covered till the ideal Smart Grid is reached.



Thank you!

