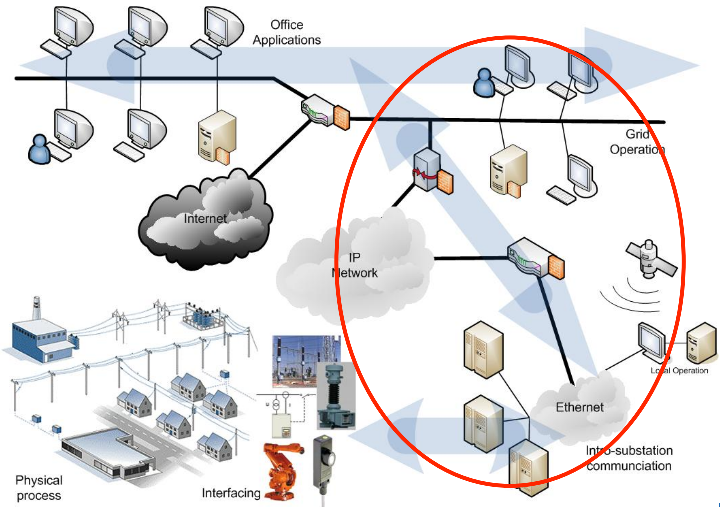
Systems Architecture

The Smartgrid Architecture Model

Lecture 8 EH2741 2015-10-15

Course Map



Outline of the lecture

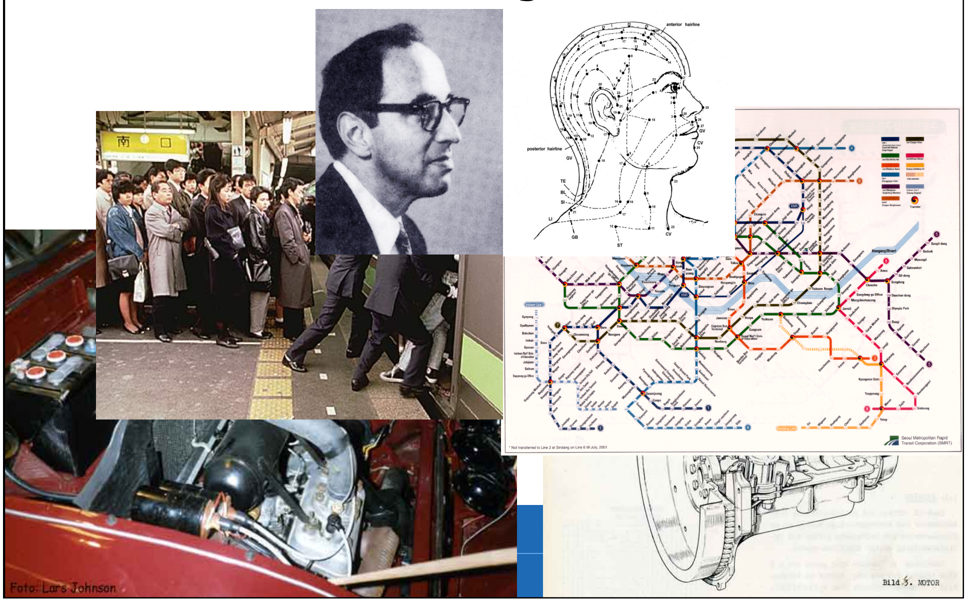
System Architecture – introduction

- Architecture Models – why?
- Architecture Models – what?
- SGAM - Smartgrid Reference Architecture Model

Smartgrid Architecture Example

- IEC 61850 Substation Architecture

How to make things understandable



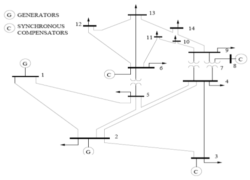
Power System Decisionmaking

Power system analysis, control and operation is dependent on models

Using the models, analytical and numerical analysis provides decision support for e.g.

- Security
- Stability
- Optimal power flow
- Contingency analysis
- Expansion planning
- Market clearing

$$0 = -P_i + \sum_{k=1}^{N} |V_i||V_k|(G_{ik}\cos\theta_{ik} + B_{ik}\sin\theta_{ik})$$
$$0 = -Q_i + \sum_{k=1}^{N} |V_i||V_k|(G_{ik}\sin\theta_{ik} - B_{ik}\cos\theta_{ik})$$



Smartgrids Decisionmaking

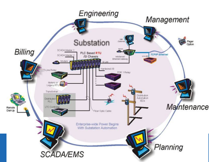
Smartgrids will be power systems integrated with ICT systems

Decisionmakers want to make informed decisions about:

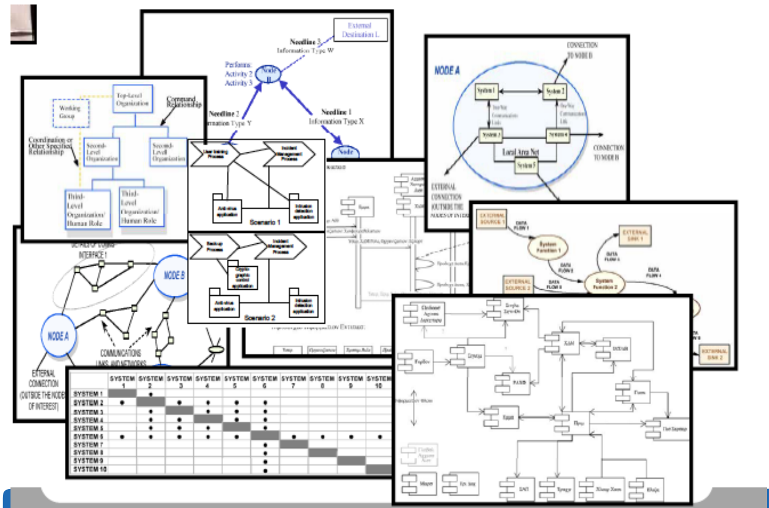
- Functionality
- Security
- Stability
- Reliability
- Performance
- Interoperability
- Usability

Analysis tools?

Models?



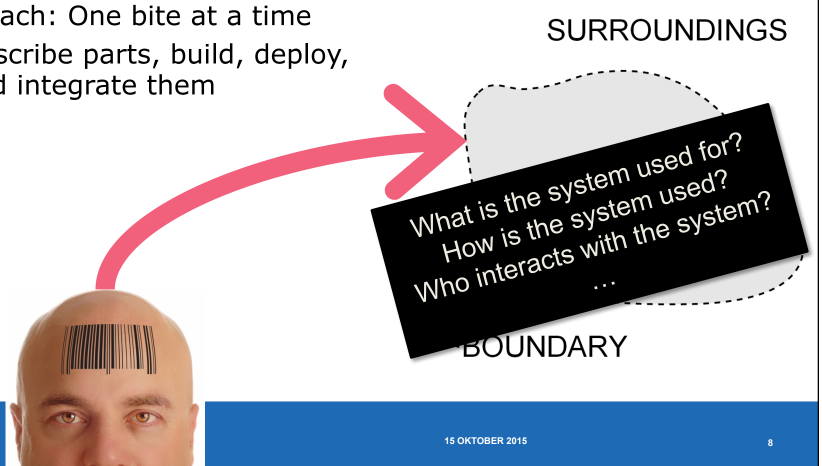
When and why to use which model?



What is an architecture

Approach: One bite at a time

- Describe parts, build, deploy, and integrate them



What is a reference architecture?

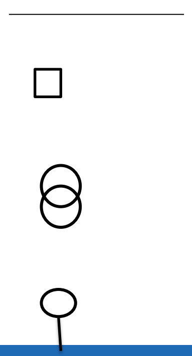
A Reference *Architecture* describes the *structure* of a system with its element types and their structures, as well as their *interaction* types, among each other and with their environment. Describing this, a Reference Architecture defines restrictions for an instantiation (concrete architecture). Through abstraction from individual details, a Reference Architecture is universally valid within a specific domain. Further architectures with the same functional requirements can be constructed based on the reference architecture. Along with *reference* architectures comes a *recommendation*, based on experiences from existing developments as well as from a wide acceptance and recognition by its users or per definition. [ISO/IEC42010]

In short: it is the specification of which language you should use to describe the system you are describing.

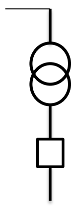
Example:
Reference architecture for for Power systems

One line diagram (just one possible form of description)

A set of symbols



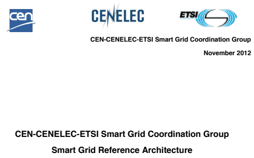
Rules on how you can combine them



Sort of similar for ICT systems

Standard for "Smartgrid Architecture"

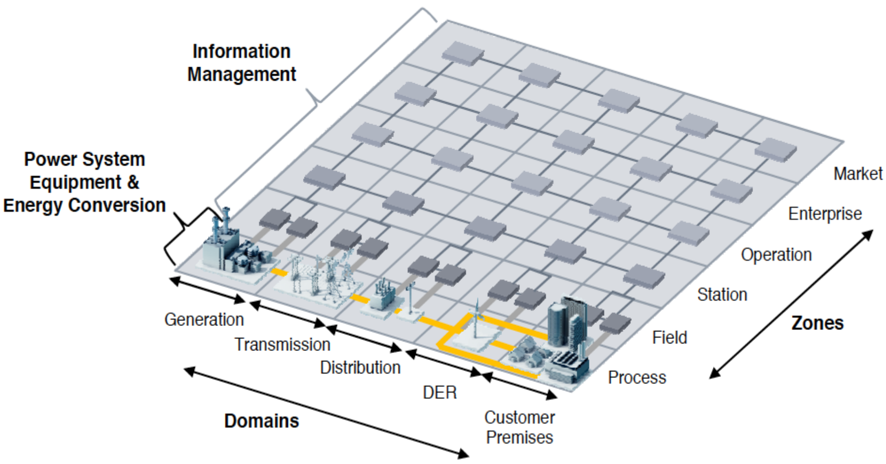
To create rules for design and analysis of Smartgrid solutions the European Commission ordered the standardsorgansiations to develop a refernece architecture



SGAM

Smartgrids Architecture Reference Model

The context– the Smartgrid Plane



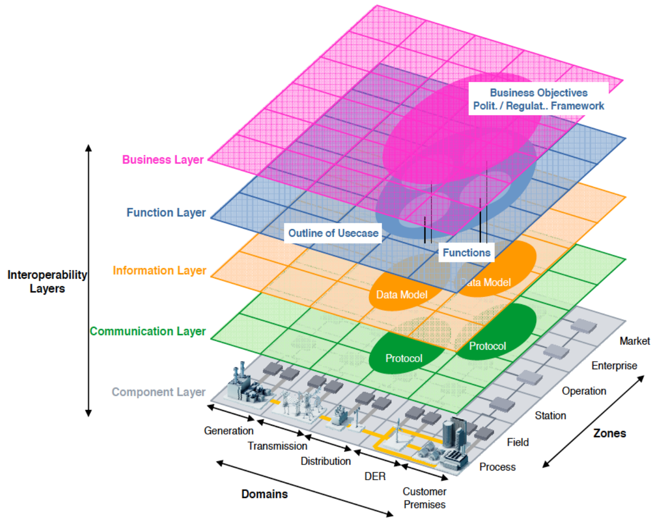
Architecture Domains

Domain	Description
Bulk Generation	Representing generation of electrical energy in bulk quantities, such as by fossil, nuclear and hydro power plants, off-shore wind farms, large scale photovoltaic (PV) power– typically connected to the transmission system
Transmission	Representing the infrastructure and organization which transports electricity over long distances
Distribution	Representing the infrastructure and organization which distributes electricity to customers
DER	Representing distributed electrical resources, directly connected to the public distribution grid, applying small-scale power generation technologies (typically in the range of 3 kW to 10.000 kW). These distributed electrical resources can be directly controlled by DSO
Customer Premises	Hosting both - end users of electricity, also producers of electricity. The premises include industrial, commercial and home facilities (e.g. chemical plants, airports, harbors, shopping centers, homes). Also generation in form of e.g. photovoltaic generation, electric vehicles storage, batteries, micro turbines… are hosted

Architecture Zones

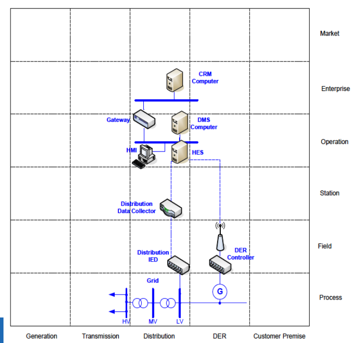
Zone	Description
Process	Including both - primary equipment of the power system (e.g. generators, transformers, circuit breakers, overhead lines, cables, electrical loads …) - as well as physical energy conversion (electricity, solar, heat, water, wind …).
Station	Representing the aggregation level for fields, e.g. for data concentration, substation automation…
Operation	Hosting power system control operation in the respective domain, e.g. distribution management systems (DMS), energy management systems (EMS) in generation and transmission systems, microgrid management systems, virtual power plant management systems (aggregating several DER), electric vehicle (EV) fleet charging management systems.
Enterprise	Includes commercial and organizational processes, services and infrastructures for enterprises (utilities, service providers, energy traders …), e.g. asset management, staff training, customer relation management, billing and procurement.
Market	Reflecting the market operations possible along the energy conversion chain, e.g. energy trading, mass market, retail market...

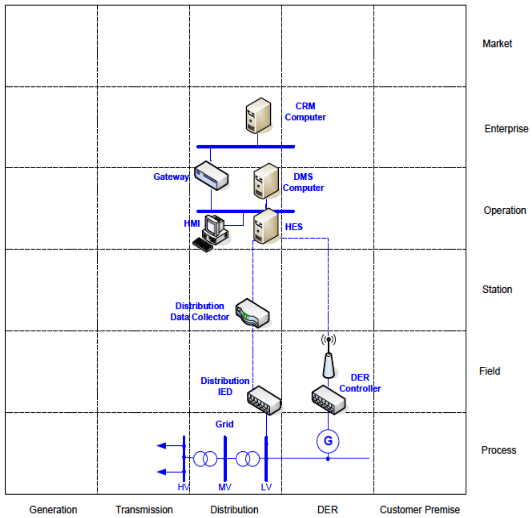
Complete Reference architecture



Component Layer

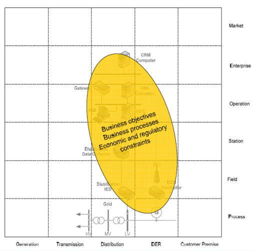
The emphasis of the component layer is the physical distribution of all participating components in the smart grid context. This includes actors, applications, power system equipment (typically located at process and field level), protection and tele-control devices, network infrastructure (wired / wireless communication connections, routers, switches, servers) and any kind of computers.





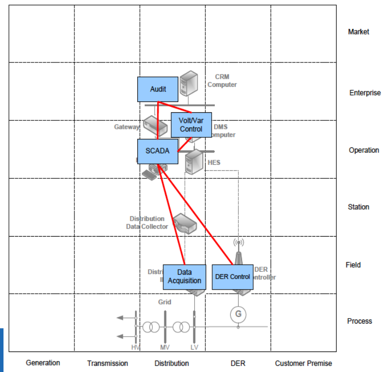
Business Layer

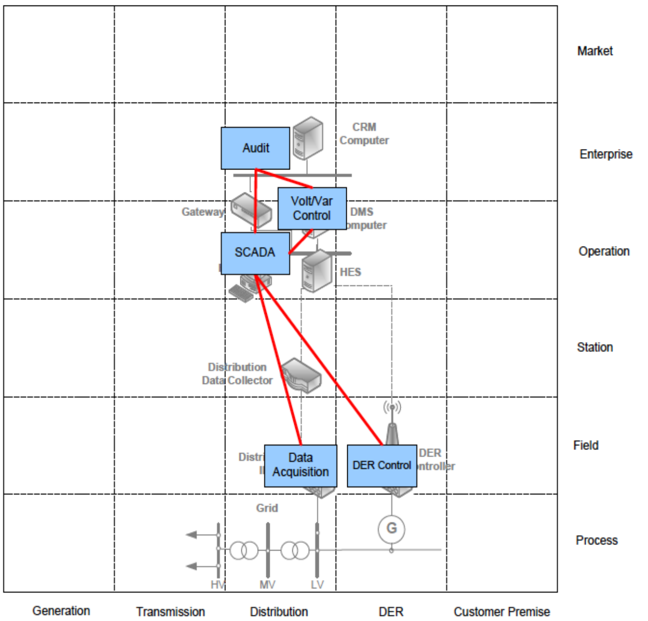
The business layer represents the business view on the information exchange related to smart grids. SGAM can be used to map regulatory and economic (market) structures and policies, business models, business portfolios (products & services) of market parties involved. Also business capabilities and business processes can be represented in this layer. In this way it supports business executives in decision making related to (new) business models and specific business projects (business case) as well as regulators in defining new market models. The Business layer is addressed in more detail in paragraph 6.1.



Function layer

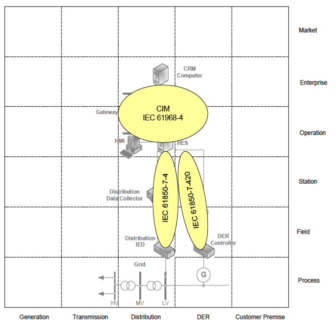
The function layer describes functions and services including their relationships from an architectural viewpoint. The functions are represented independent from actors and physical implementations in applications, systems and components. The functions are derived by extracting the use case functionality which is independent from actors.

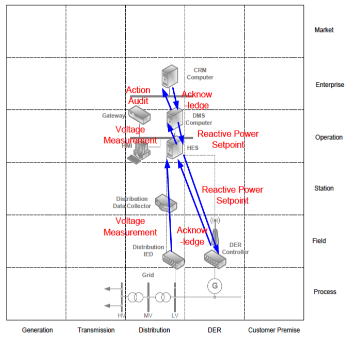


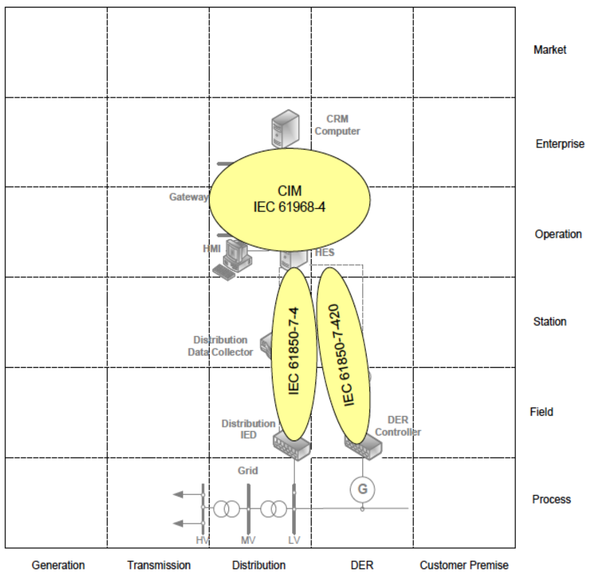


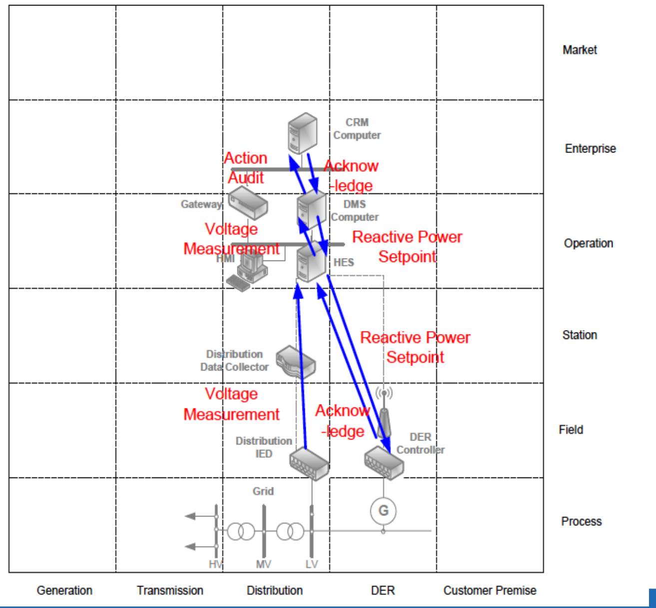
Information Layer

The information layer describes the information that is being used and exchanged between functions, services and components. It contains information objects and the underlying canonical data models. These information objects and canonical data models represent the common semantics for functions and services in order to allow an interoperable information exchange via communication means.



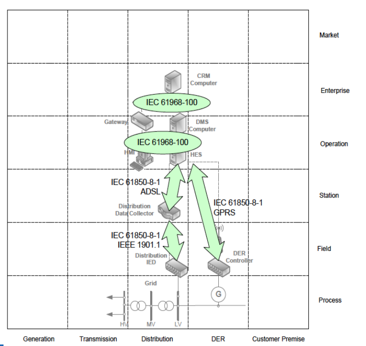


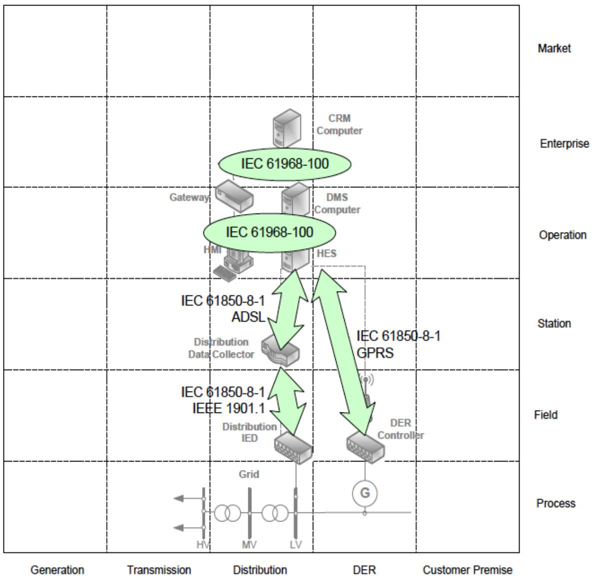




Communication Layer

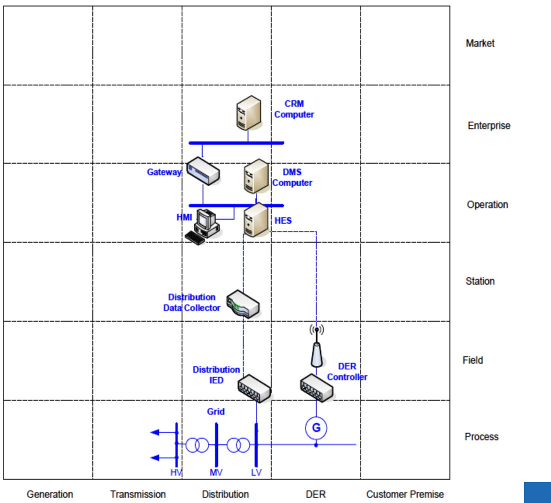
The emphasis of the communication layer is to describe protocols and mechanisms for the interoperable exchange of information between components in the context of the underlying use case, function or service and related information objects or data models.





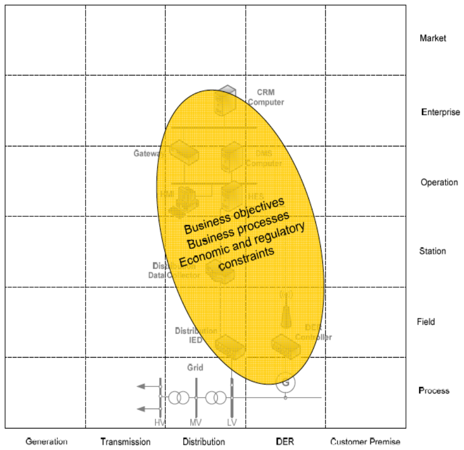
Step 1 – Develop Physical setup

Describe the components from the Use Case Diagram as tangible objects



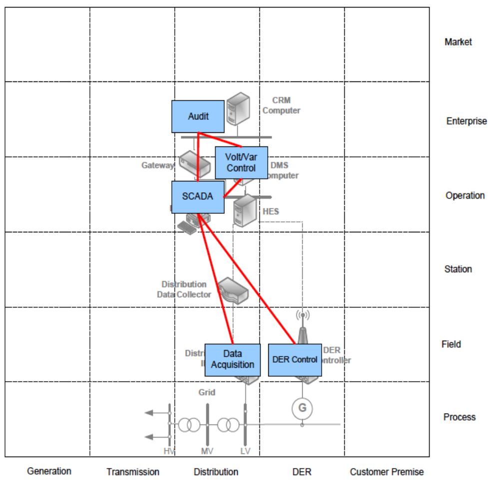
Step 2 – Develop Business layer

Useful to de-lineate the scope of the use case



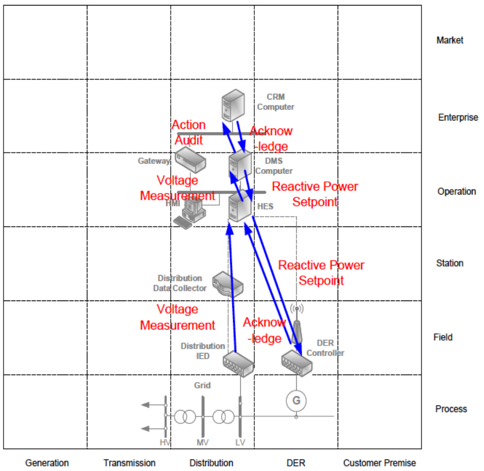
Step 3 – Develop the functional layer

Assign the functions to the components. Not necessarily one-to-one.



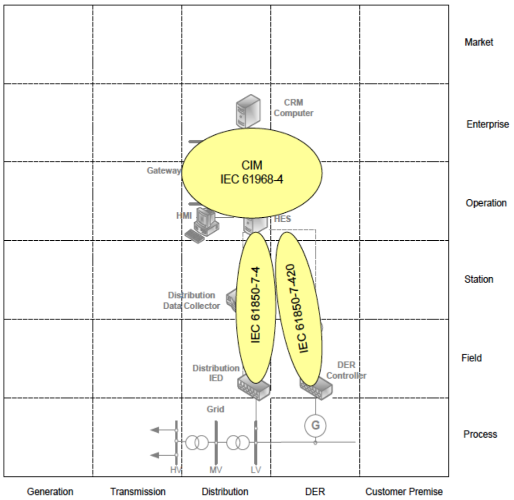
Step 4 – Develop the Information layer

Identify (from the Use case description) which data is to be exchanged between which components & function.



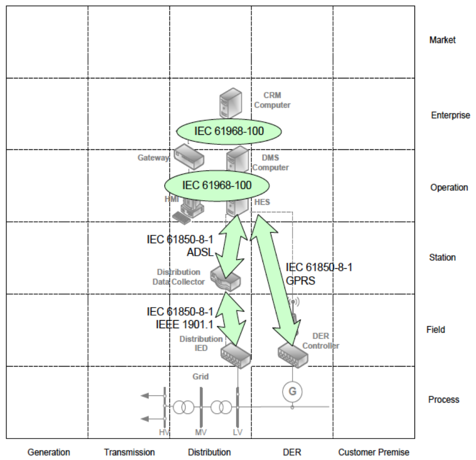
Step 5 – determine datamodels to use

Based on type of information exchanged, determine suitable standardised datamodel



Step 6 – Determine communication protocols to use.

Define standard for communication protocol, including physical and link layer protocols to use



The end

After following the process we should have:

A total of 5 architecture ”drawings” that present different views of the System

Why all this?

The Smart Grid Architecture Model is being used in several European R&D projects to design the solutions being tested.