Endesa´s approach to IEC61850

IEC 61850 Europe 2017

Endesa´s approach to IEC61850

Contents

The Enel Group

Enel today[1]

Global and diversified operator

~**40** €bn Regulated Asset Base
~**62** mn distribution end users

#1 in Italy, Spain, Chile, Peru
#2 in Argentina, Colombia

~**18.3** mn free retail customers

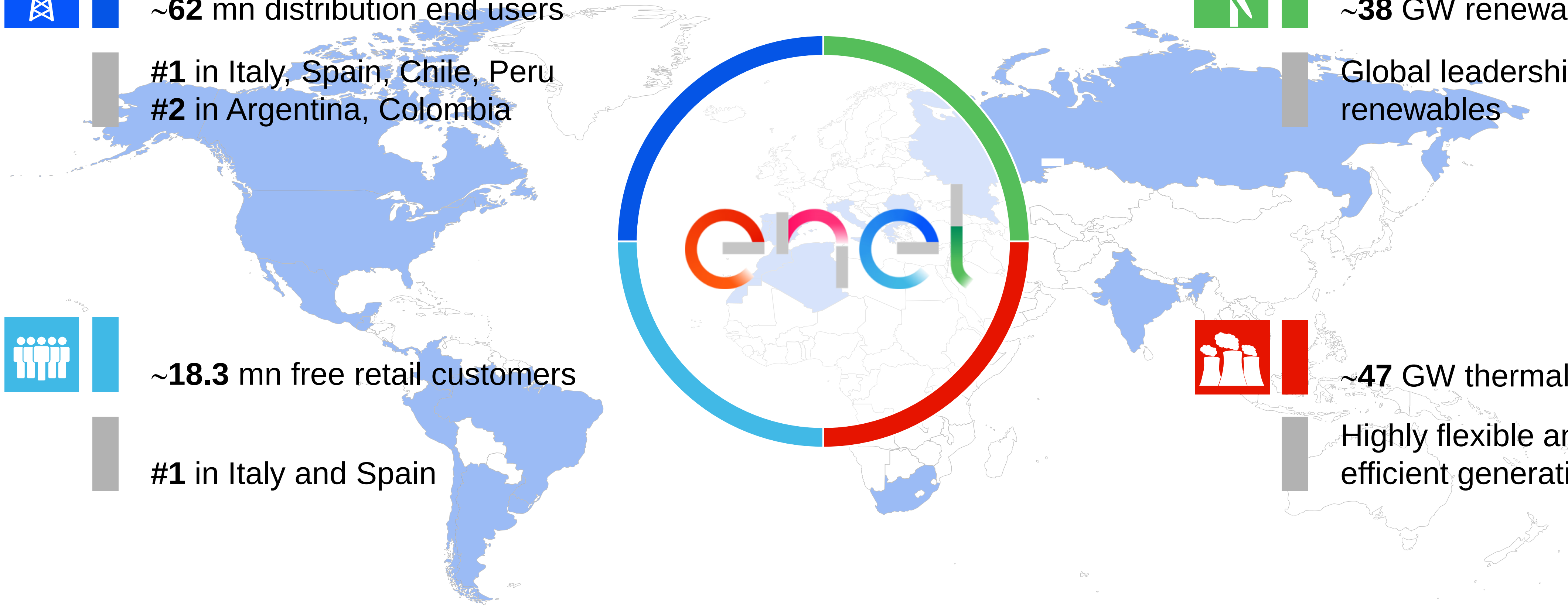
#1 in Italy and Spain

~**38** GW renewable capacity[2]

Global leadership in renewables

~**47** GW thermal capacity

Highly flexible and efficient generation fleet



1. *As of 2016*
2. *Consolidated (35.9 GW) and managed (1.9 GW) capacity including 24.9 GW of large hydro.*
3. *Presence with operating assets*

Operational data

Leadership along the various segments of the value chain

Key indicators[1]

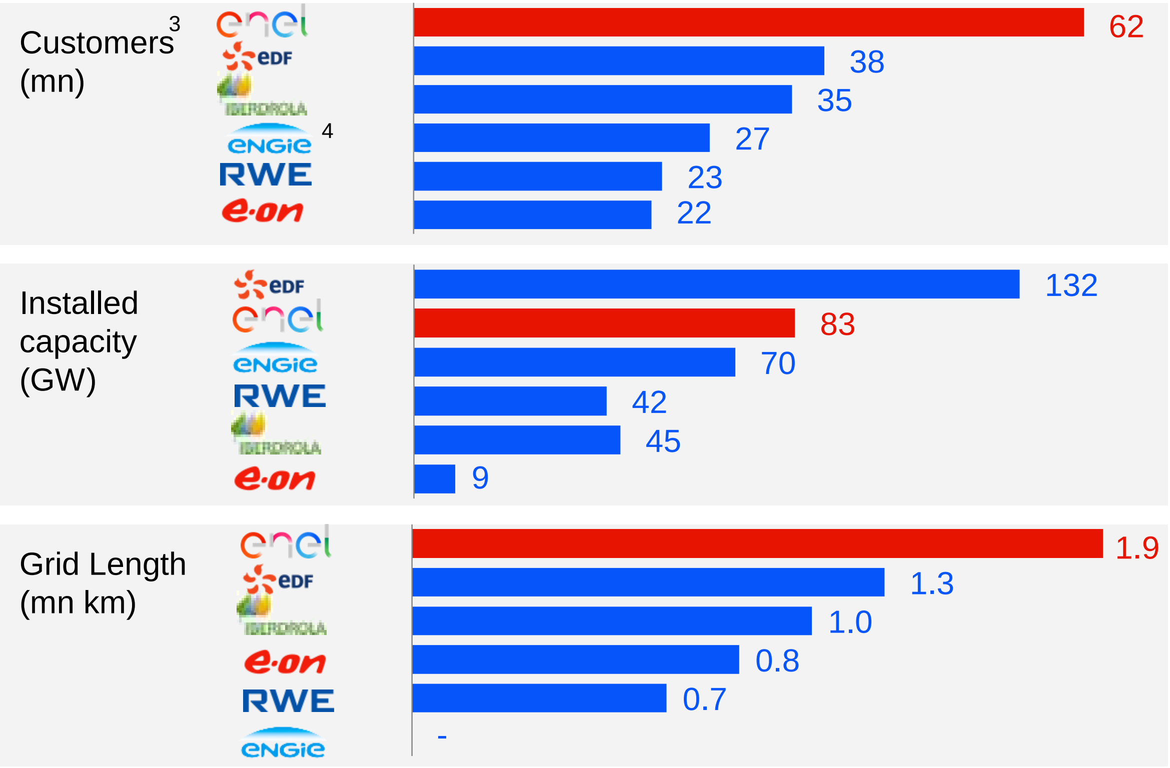
Infrastructure & Networks
- 62 mn end users
- 41.2 mn smart meters
- 1.9 mn km grids

Retail
- 56.4 mn power customers
- 5.5 mn gas customers

Renewables generation
- 35.9 GW of installed capacity[5]

Thermal generation
- 46.8 GW of installed capacity

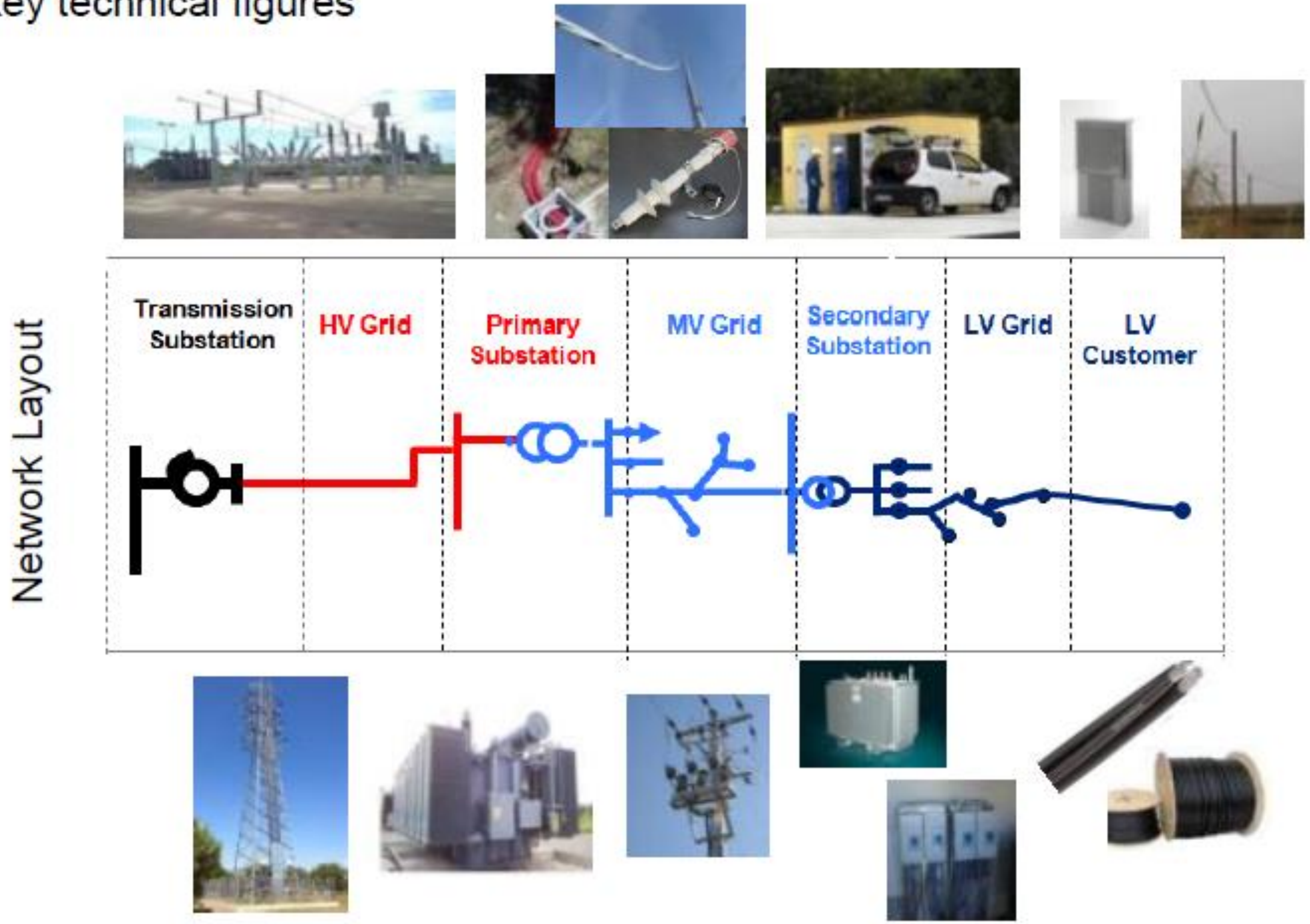
Enel and European peers[2]



1. Data as of December 31st 2016; 2. Data as of December 31st 2016; 3. Retail Customer: Free + Regulated; *4. Figure refers to the European perimeter (Engie does not disclosure total number of customers); 5. It doesn't include 1.9 GW of managed capacity*

Enel Global Infrastructure & Networks

Key technical figures



More than 30,000 different types of components

Enel Group Grid

HV Lines: 36,500 km

Primary Substations: 4,192

Secondary Substations: 1,065,000

MV Lines: 658,000 km

LV Lines: 1,203,000 km

HV/MV Transformers: 6.900

190,000 MVA

MV/LV Transformers: 890.000

160,000 MVA

Enel Global Infrastructure and Networks

Colombia 2° DSO (22%)

14 TWh distributed energy

3.0M customers

Peru 2° DSO (20%)

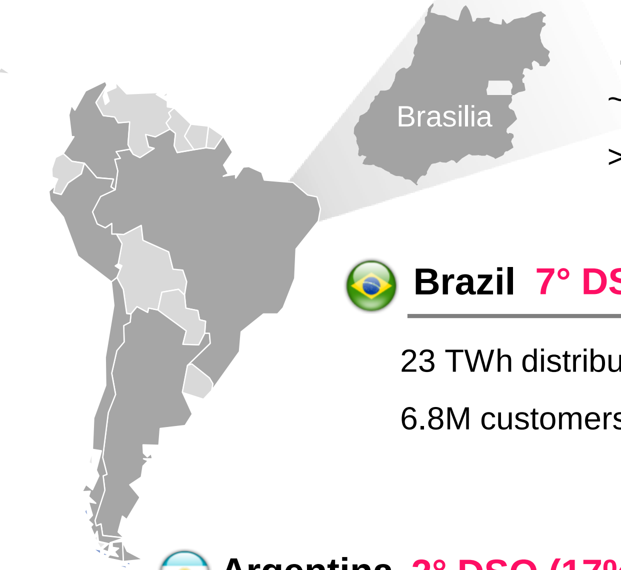
8 TWh distributed energy

1.4M customers

Chile 2° DSO (33%)

16 TWh distributed energy

1.8M customers



2° DSO with CELG

~13.1 TWh distributed energy

>2.9M customers

Brazil 7° DSO (8%)

23 TWh distributed energy

6.8M customers

Argentina 2° DSO (17%)

19 TWh distributed energy

2.5M customers

Spain 1° DSO (42%)

109 TWh distributed energy

12M customers

Italy 1° DSO (85%)

223 TWh distributed energy

31.6M customers

Key figures	2016
Distributed energy (TWh)	426
Costumers (M)	62

2016 positioning: a global leadership

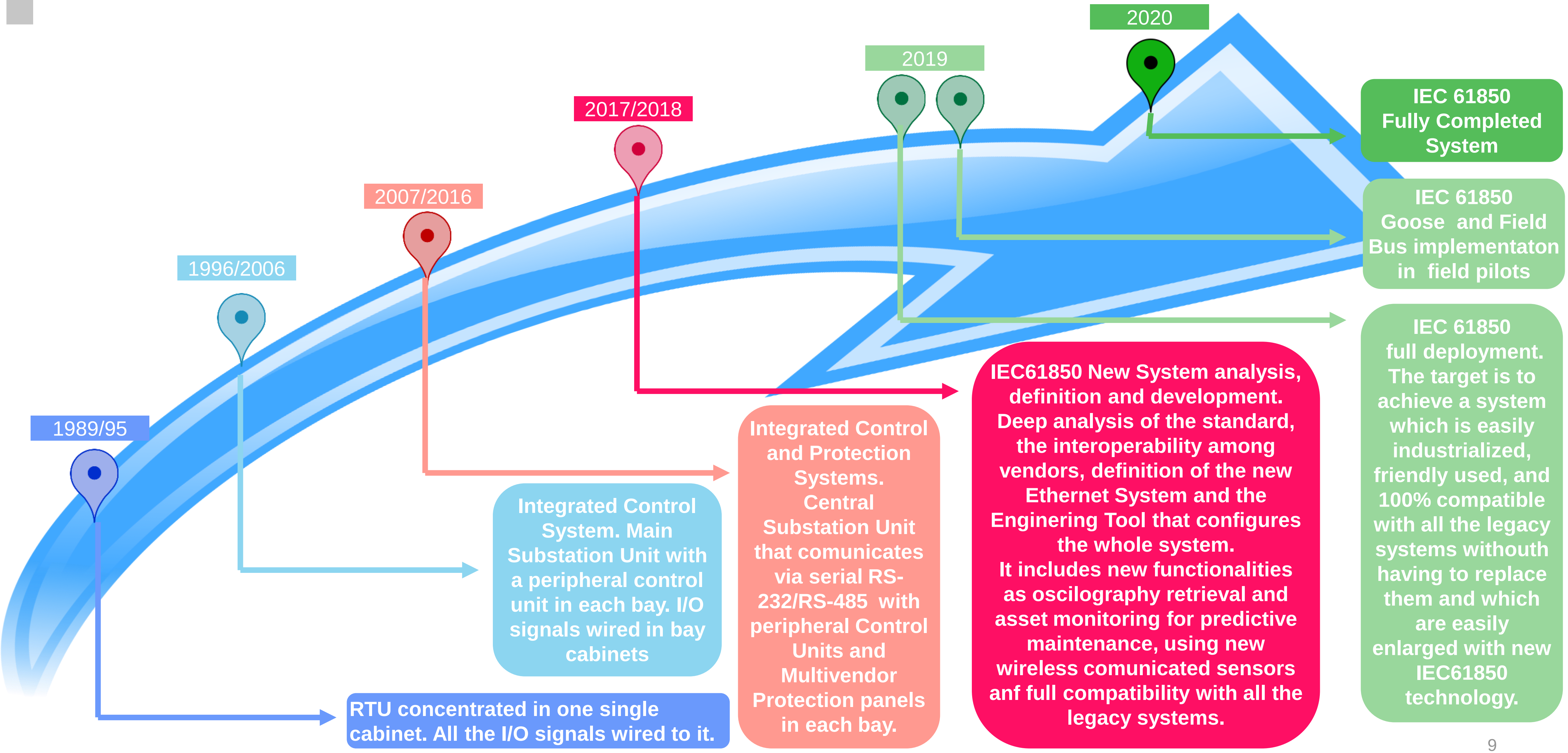
Romania 2° DSO (36%)

15 TWh distributed energy

2.9M customers

Primary Substation Digitalization Roadmap

Primary Substation Digitalization Roadmap



How to reach the IEC61850 goal

How to reach the goal

Funded projects

- Complete design of a **multi-vendor IEC 61850 substation** fully aligned with **Endesa current systems and operations**.

  Addressing interoperability challenges with **Endesa leadership.**

  Making the system definition from DOWN to TOP; instead of doing it in the traditional way.

- Automatic and easy to use Engineering System Configuration Tool **Tesla+**, that accomplishes mixed substations.

  Foresees integration of new challenges as wireless communication, connection to IoT platforms , cybersecurity, use of high precision synchronization protocols (IEEE 1588)

Subvencionado por el CDTI y apoyado por el Ministerio de Economía y Competitividad

The IdEAS project

Interoperability of Substation Automation Devices

Funded by the 2016 R&D call of the spanish Ministry of Economy and Competitiveness

Timeline: **2016 – 2018**

Endesa Network Technology Iberia

- Consortium leader.
- Coordination of the scope and objectives
- Functional requirements.
- Integration of IEC 61850 in O&M activities.
- Design validation.
- Demo site in a real substation in Spain
- Added-value services definition.
- Cost-benefit analysis

CIRCE

- Research and innovation center in Zaragoza, Spain
- Technical coordinator
- Functional specifications and design:
  - Data models, service profiles, interoperability applications, etc.
- Adaption of engineering projects.
- Laboratory tests and validation
- New IEC 61850 software tools
- Integration of the station bus with telecontrol systems and tools

International vendors:

- Three market leaders
- IEDs supply, configuration and adaption
- Technical support and feedback with IdEAS definitions
- New engineering tools
- Validation of new services for SAS

Budget	1 M€
Duration	Sep 2016- Dec 2018

GOBIERNO DE ESPAÑA MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD SECRETARÍA DE ESTADO DE INVESTIGACIÓN, DESARROLLO E INNOVACIÓN

UNIÓN EUROPEA FONDO EUROPEO DE DESARROLLO REGIONAL "Una manera de hacer Europa"

3S-CS Project

General scope

3S-CS

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The project is **aligned with UE Frame Strategy in terms of efficiency and security improvement of electric network.**

Application of Smart grids solutions and technologies **to improve network** interoperability, monitoring, control and supervision **capabilities**.

In electric substation, **IEC61850 is a world referent standard,** enabling **integration of protection, control, measuring and supervision functions**, combining **Ethernet technology** with **high performance and security capabilities.**

Budget	2,28 M€
Duration	Nov 2016- Dec 2018

Main objective

***Development of an integral control system for electrical substation based on IEC61850**, **considering RTU** (Remote Terminal Unit) **as central element**, in a mixed communications environment (fiber optics, cable and wireless) with enhanced security features and connecting substation with IoT eco-system.*

IEC 61850

Standardization

- Frame of **IEC61850 standard**
- New **standardized IEC61850 communication profile** for protection and control signaling

Security

- **Cyber security improvement** as main requirement
- **Risk/threats analysis** of substation control system

Synchronization

- **RTU design upgraded to use high precision synchronization** protocols (IEEE 1588)

LoRa IoT Design WiFi ZigBee Bluetooth

Connected

- **Wireless communications** in substation environment used as **back-up network** suitable for IEC61850 traffic.
- **Substation connected to IoT platforms** (open-data)

Substation

- Developments will be **validated in a real installation**
- Engineering and maintenance **procedures updated in the context of mixed-substations**

The final result

IEC 61850 Smart substation

IDEAS — Results and conclusions

+

3S-CS — Results and conclusions

=

The IEC 61850 Primary Substation Automation System

Ideas project

Ideas main targets

Interoperability analysis

The whole picture of **Interoperability:**

- Not limited to a particular demo but **integrated in the company standards**
- Taking the opportunity of a multi-vendor R&D consortium to **take over the high effort required by design and validation phases**
- Application of international **methodologies** (*Smart Grid Coordination Group*)

Boosting the digital substation bus:

- **Non-operational** data and services
  - Fault records, predictive maintenance, etc.
- New software tools

Goals and approach

The whole picture of interoperability

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Integrated Interoperability:

- Far beyond the mere message exchange
- **Information model**
  - Divergence between vendors
  - Adaption to DSO specific signaling
- **Engineering**
  - Bunch of new processes and skill set
  - Each tool = own workflowns and formats

FIRST USE CASE:

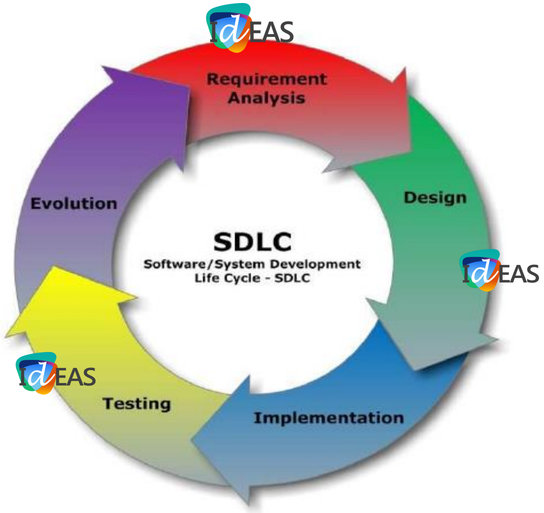
Information profiles from protection devices to control centre

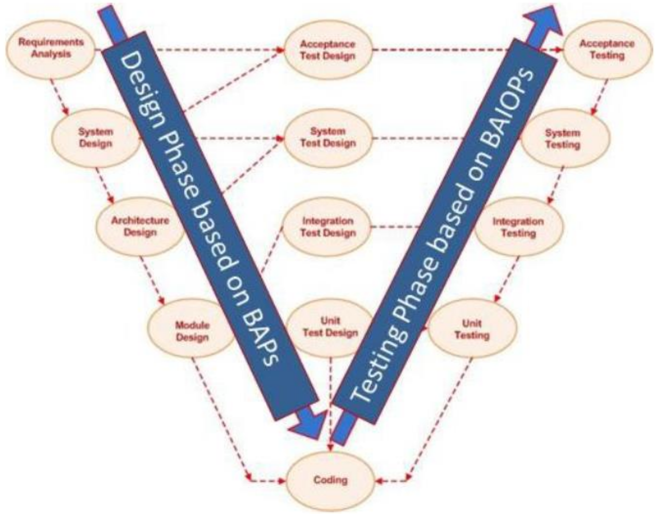
FIRST USE CASE:

Automated collection of disturbance records

How to approach them

Methodology





Smart Grid system interoperability through standardization, system design and testing

(CEN-CENELEC-ETSI SG Coordination Group)

- **Endesa** must define its requirements
- **Design and test phases account for 50% of IEC 61850 projects**
  - IDEAS: top-notch consortium to face that effort
- Use cases application & interoperability profiles and testing

Requirements, design and testing: **V Model**

Design: basic **application profiles** (BAP)
Mandatory requirements for a given function

Validation guidance: basic **application interoperability profiles** (BAIOP)
Device configuration and capabilities
Engineering framework

Complete tests
Unit test: device homologation
System test: application laboratory validation
User acceptance: SAT

Goals and approach

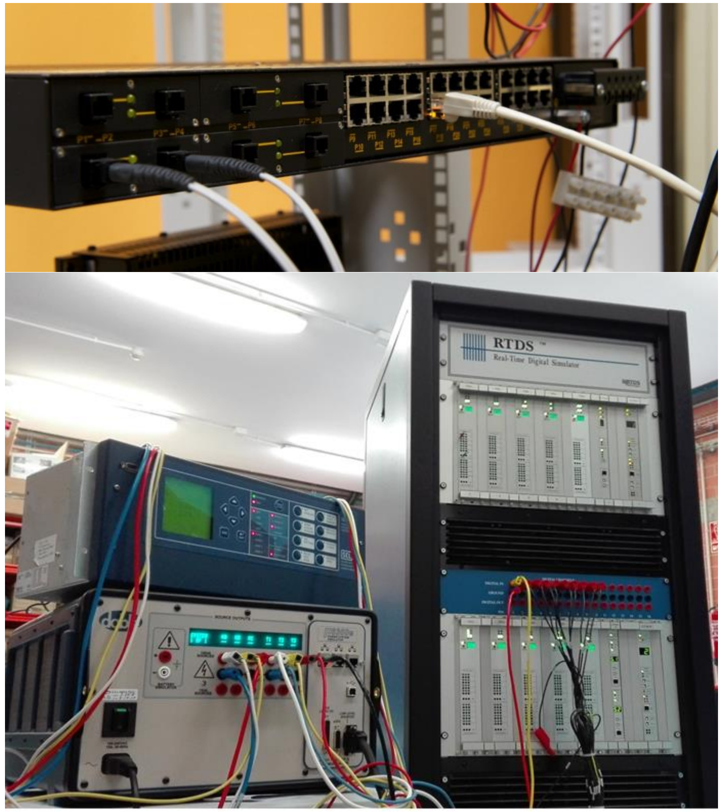
Methodology

Complete laboratory tests:

- More than 10 multi-vendor P&C IEDs
- Substation switches and redboxes
- RTDS and protection test sets
- Full IEC 61850 clients and substation managers
- Own GOOSE and MMS libraries
- IEC 61850 and legacy RTU

Living demo site:

- Upgrade of an existing Endesa HV-MV substation in Zaragoza, Spain



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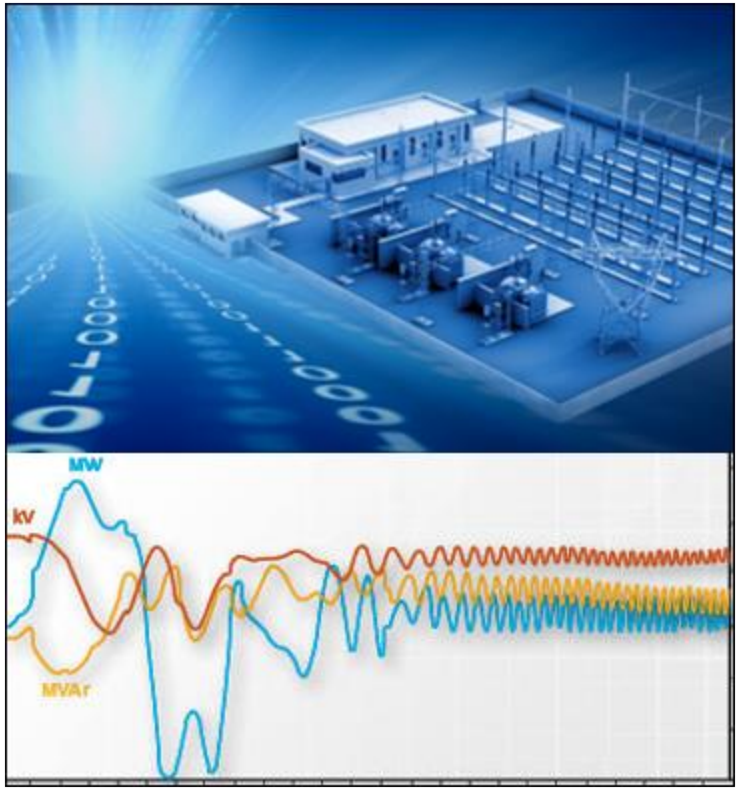
circe
CENTRO DE INVESTIGACIÓN
DE RECURSOS
Y CONSUMOS ENERGÉTICOS

Overview of ongoing use cases

Example 1:
Automated collection of disturbance records

Overview of ongoing use cases

Automated collection of disturbance recordings



Non-operational data:

- Substation digitalization paves the way for optimal data exchange leading to new services
  - Predictive maintenance
  - Fault analysis
  - Ad-hoc alarms

- Unexplored field
  - Ground for the re-introduction of vendor dependent solutions

Application of the project methodology to one of Endesa's prioritary non-operational services: **disturbance record collection**

Overview of ongoing use cases

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Automated collection of disturbance recordings

Implementation and validation phase:

- Analysis of suitable interfaces and their features for each project vendor
  - *File transfer service*
- Common agreement on needed configuration
- Selection of a market tool from one of the partners for the automated extraction of disturbance records
- Integration tests

- Quick first multi-vendor integration: CID, IED name, @IP
- Automated common file repository with remote access
- Complete software tool enabling additional functions

- Lack of application-specific tools
- Required staff adaption
- Performance difference amongst vendors

Overview of ongoing use cases

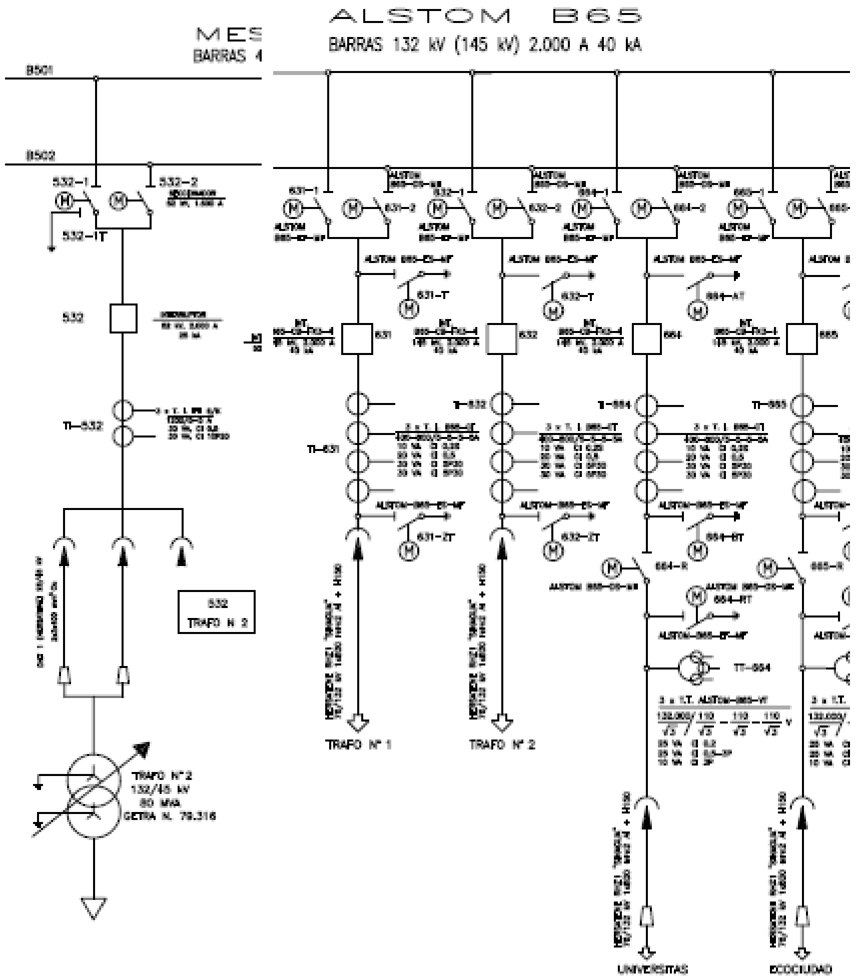
Living demo use case

Upgrade some by as of an existing Endesa Primary Substation in Zaragoza, Spain:

- 132/45 kV Transformer
- 45/10kV Transformer
- 132kV Bay Line

The demo case consists in use a market tool (installed in switch with an embedded computer) to collect using IEC61850 all the disturbance fault records from the new six protections installed in the substation (two from every of the three vendors).

And communicate this market tool with the Endesa Remote Maintenance Center (Voyager) in order to retrieve all the data also using IEC61850, and leave them to be consulted by any of the system users.



Example 2: Data profile between RTU and P&C devices

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Overview of ongoing use cases

Data profile between RTU and P&C devices

IED – RTU communication:

- MMS Report service
- Each P&C device must send to the RTU a fixed operational data list from its bay:
  - Legacy protocols: unreadable codes
  - IEC 61850: semantic data model
- Opportunity for seeking a common model for a given IED regardless of the vendor
- Relation with Endesa's control centre dictionary

Overview of ongoing use cases

Data profile between RTU and P&C devices

Analysis of each vendor’s data model flexibility

Results of different nature:

- **Vendor 1:** Predefined, **non-customizable** model
- **Vendor 2:** Customization of the model **only to a certain level**
  - Flexible data mapping of user variables
  - Fixed “standard objects”
- **Vendor 3: Full flexibility:** link between the SCL model and the internal variables

Overview of ongoing use cases

Data profile between RTU and P&C devices

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Lessons learned

Partial customization is similar to no customization in terms of achieving a complete model

Flexible models in the IEDs move the definition and configuration efforts to the grid owner or integrator

Data selection for proprietary attributes

Definition of new models

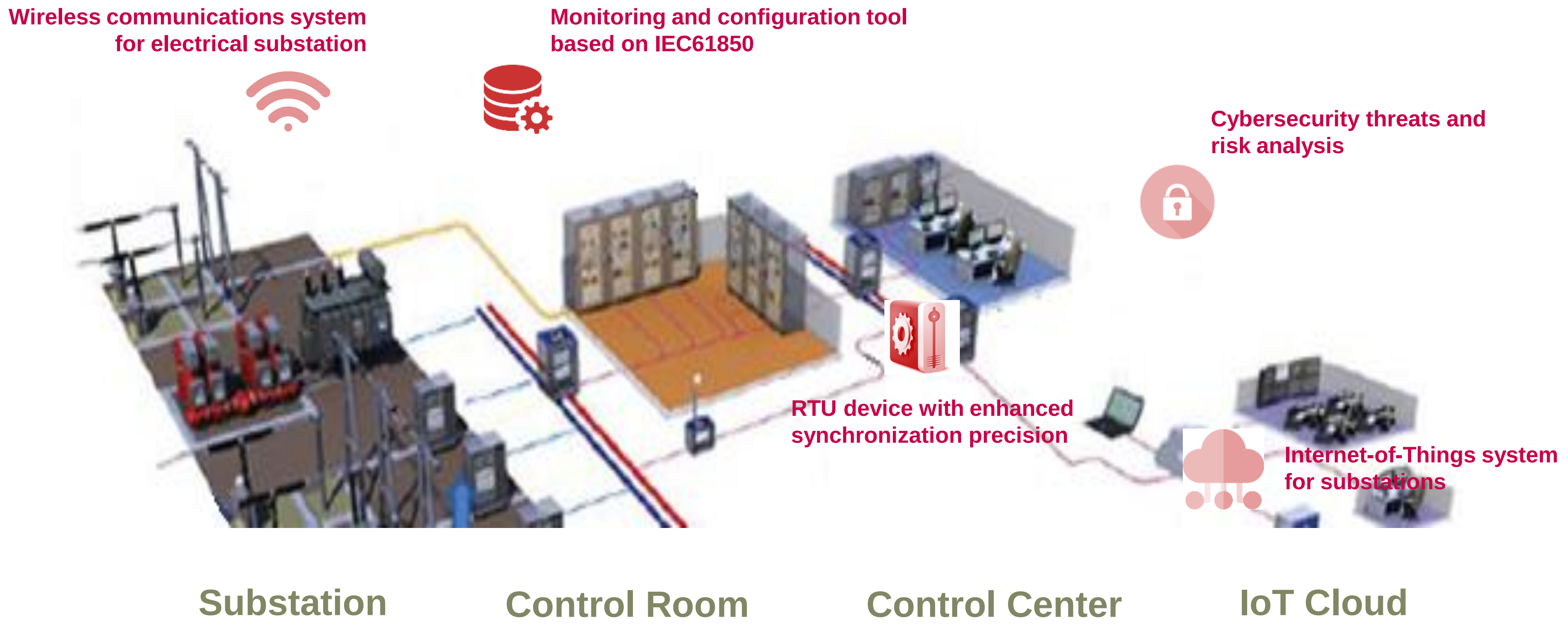
Previous analysis of IED implementation capabilities helps defining the proper strategy

Potential benefits of a centralization of the IEC 61850 data model in the RTU ➡ **3S-CS project**

3S-CS project

3S-CS Project

Main developments



For the first time at global level, the same pilot project will integrate cutting-edge technologies in mixed areas like **IEC61850**, **cybersecurity**, high precision **synchronization**, **wireless communication and IoT** connectivity **in a real substation**.

3S-CS Project

Monitoring and configuration tool for “mixed-substations” based on IEC61850

Updating current substation engineering process by means of a new configuration tool suitable both for:

- **Native IEC61850 substations**.
- **Mixed substations**, integrating serial protocol devices (DNP, IEC103, Modbus, ..) and native IEC61850 devices.

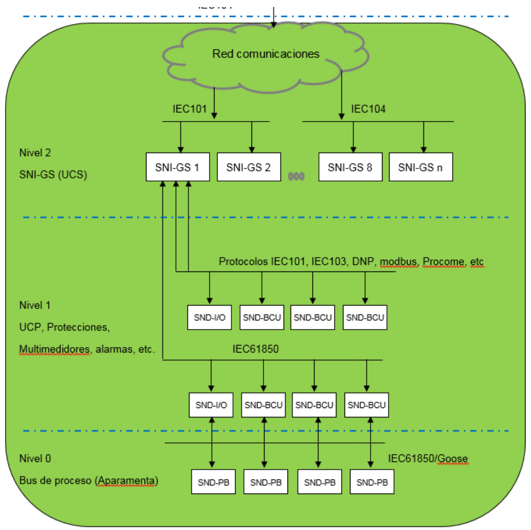
Tool will **integrate current configuration engineering**, and so, RTU will be configured by means of an **unique configuration file (.SCD).**

Tool also generates configuration files for native IEC61850 devices (.CID).

Two additional plug-ins will be developed:

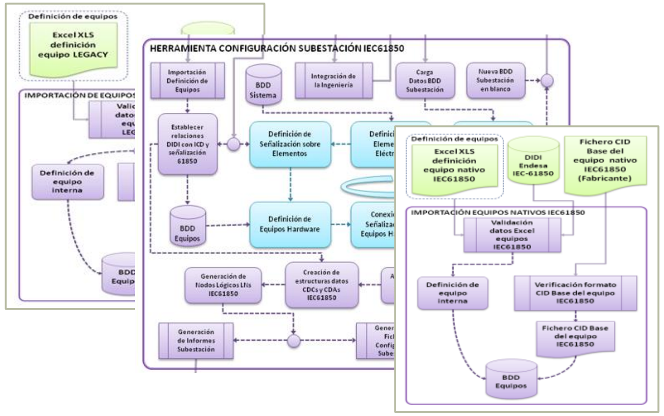
- **Graphical interface** to configure different logics in control system.
- **Web server embedded in RTU** to access main status information.

Signaling of **different protection and control devices to RTU is being normalized** and modelled in IEC61850 to provide an “**standardized IEC61850 communication profile**” for Endesa substations.

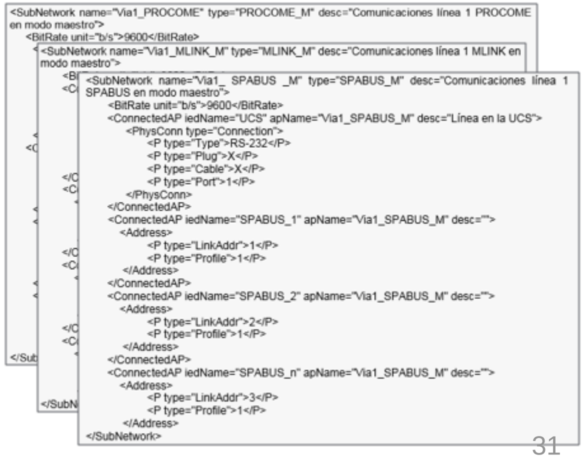


Mixed-substation concept

IEC61850 modelling of protection signaling profile



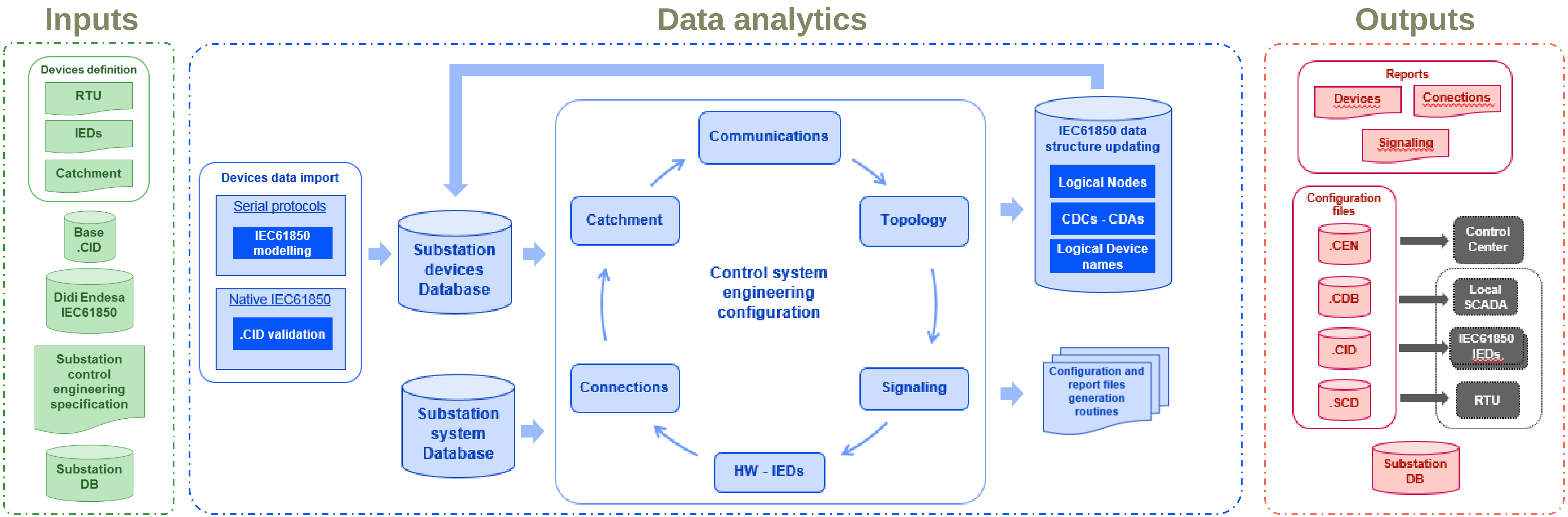
Some extracts of information management and logics implemented



Proposal of normalized IEC61850 engineering for legacy protocols integration in .SCD

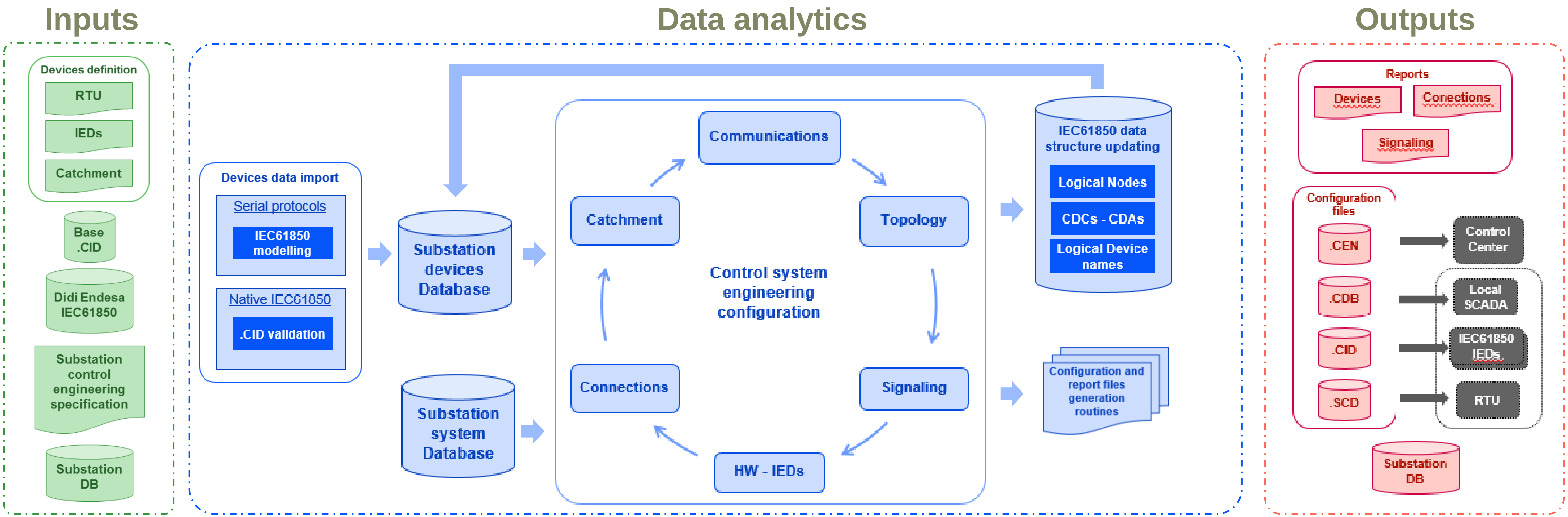
3S-CS Project

Engineering tool in a glance



3S-CS Project

Engineering tool in a glance

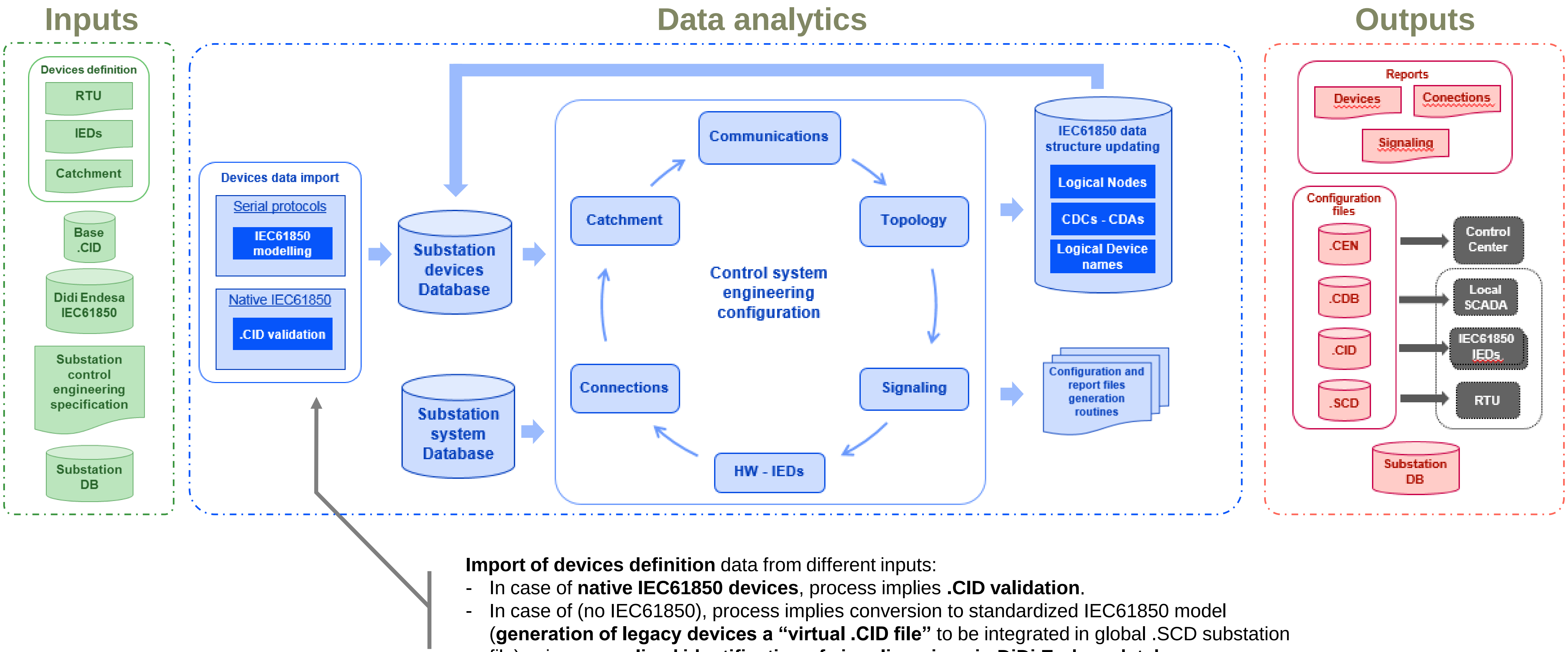


Several information **inputs** to engineering tool:

- **Definition of devices** according to Endesa **standardized profiles** (general features, signaling and terminal info).
- **Base .CID files** for native IEC61850 devices
- Database containing normalized electric elements and corresponding signaling (**DiDi Endesa**), also adapted to IEC61850 model.
- Excel file containing **definition of substation control project** (HW, connections, signaling, …).
- Database containing **current state of substation control system** (in case of upgrading/updating works).

3S-CS Project

Engineering tool in a glance

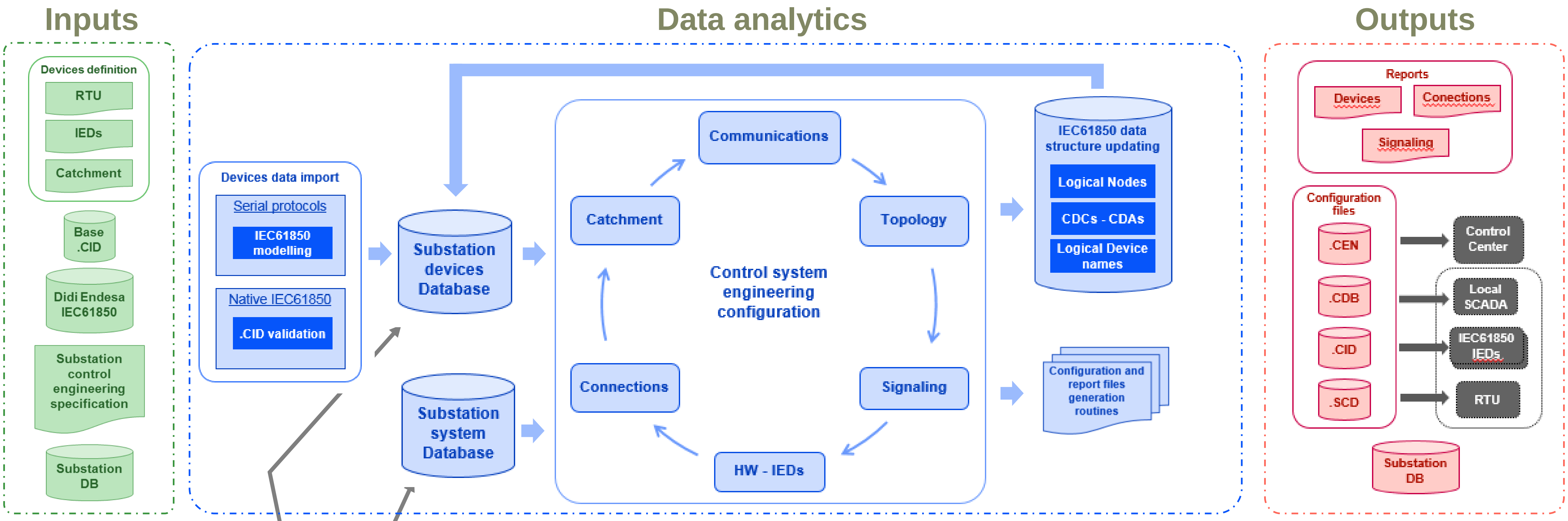


Import of devices definition data from different inputs:

- In case of **native IEC61850 devices**, process implies **.CID validation**.
- In case of (no IEC61850), process implies conversion to standardized IEC61850 model (**generation of legacy devices a "virtual .CID file"** to be integrated in global .SCD substation file) using **normalized identification of signaling given in DiDi Endesa database.**

3S-CS Project

Engineering tool in a glance

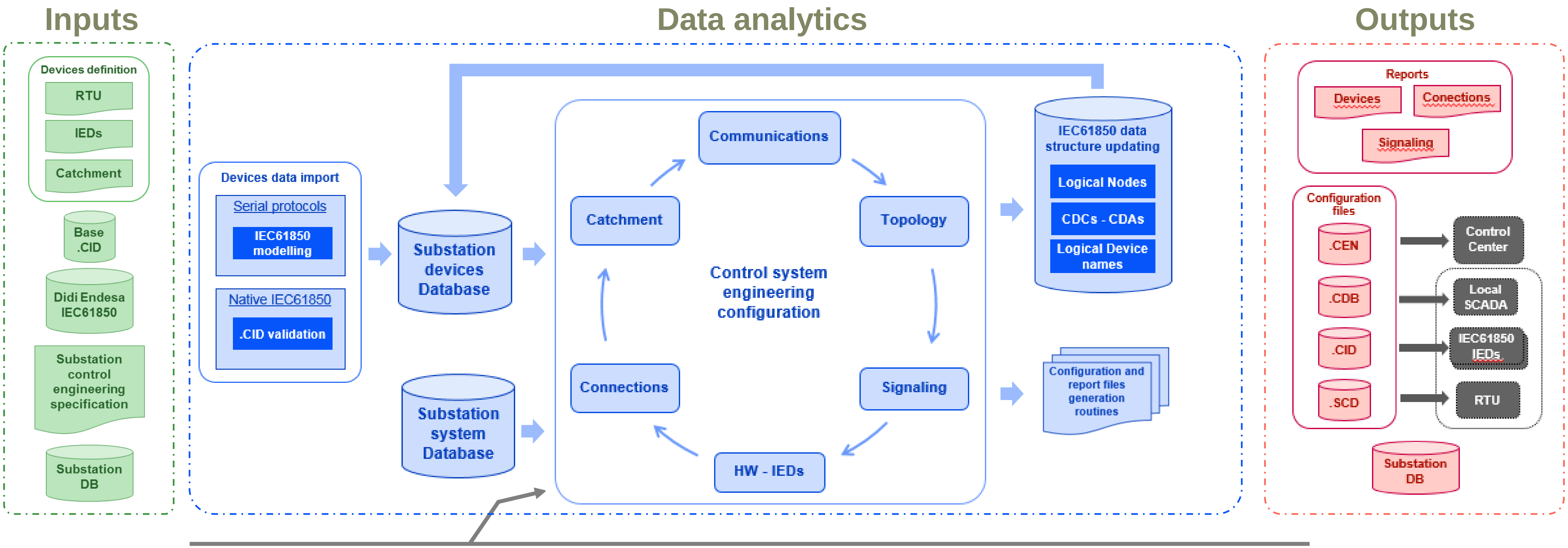


Internal database containing **general information** to be used in substation control system definition (control signaling types definition, electric element types and hierarchy, internal alarms definition for control system HW, …).

Internal database containing complete **information of devices** (homologated by Endesa) that can be used in substation control system definition (communication type, terminals list, signaling type, hierarchy, ...).

3S-CS Project

Engineering tool in a glance

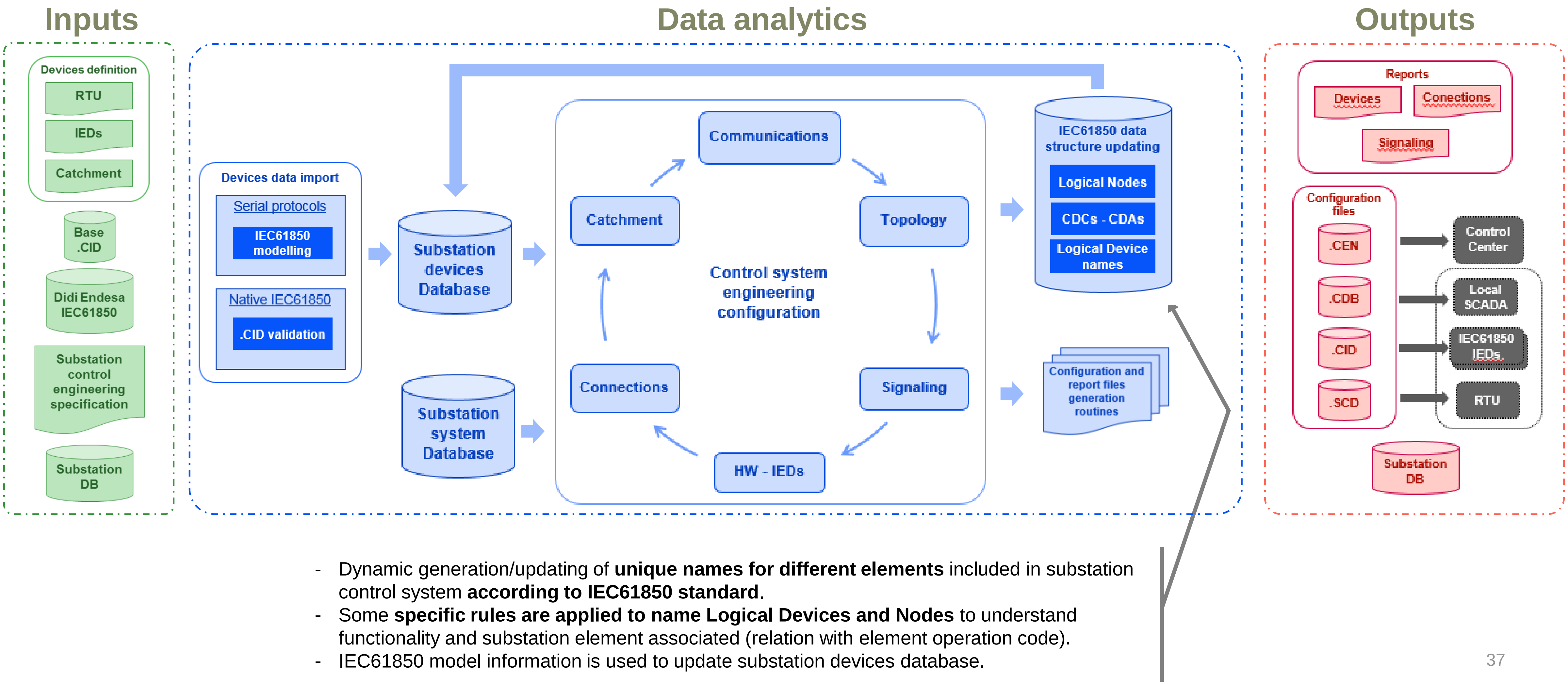


Step-by-step work cycle for complete definition and configuration of different features of control system:

- **Communication parameters** for RTU channels (according to corresponding protocol).
- Hierarchical structure of **electric elements in substation**, basic properties (operation code/name) and **signaling parameters**.
- Hierarchical structure of **normalized IEDs in substation control system**, basic properties/parameters (IP address, communication channel, …) and **wired signaling definition**.

3S-CS Project

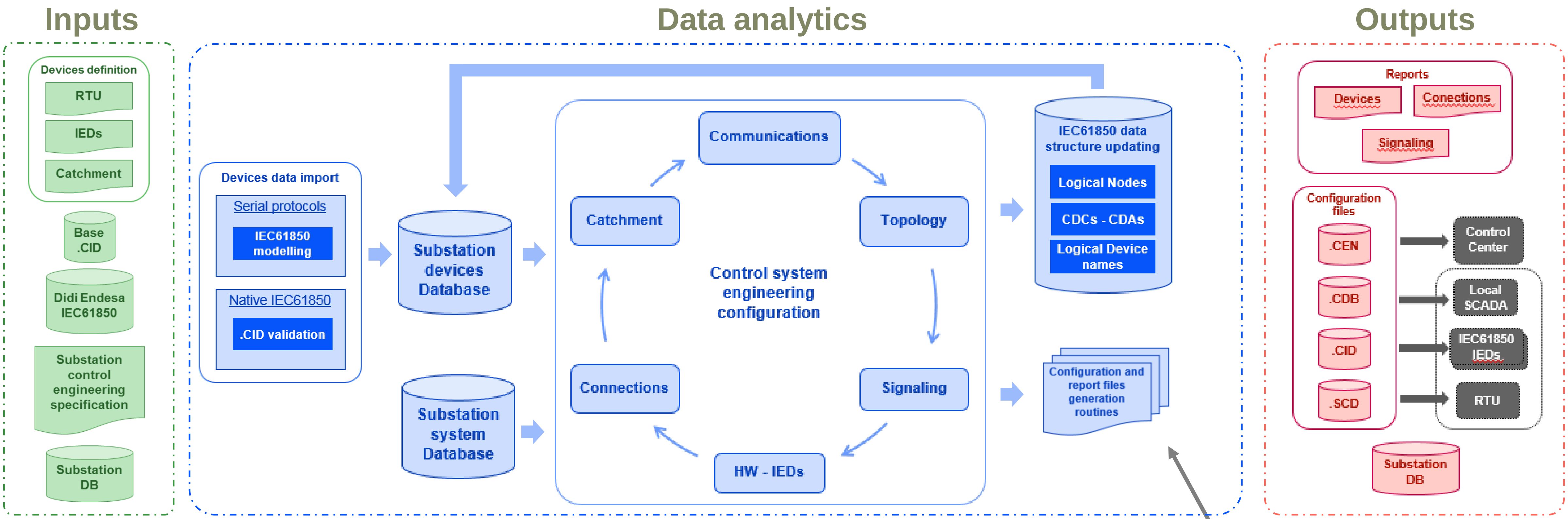
Engineering tool in a glance



- Dynamic generation/updating of **unique names for different elements** included in substation control system **according to IEC61850 standard**.
- Some **specific rules are applied to name Logical Devices and Nodes** to understand functionality and substation element associated (relation with element operation code).
- IEC61850 model information is used to update substation devices database.

3S-CS Project

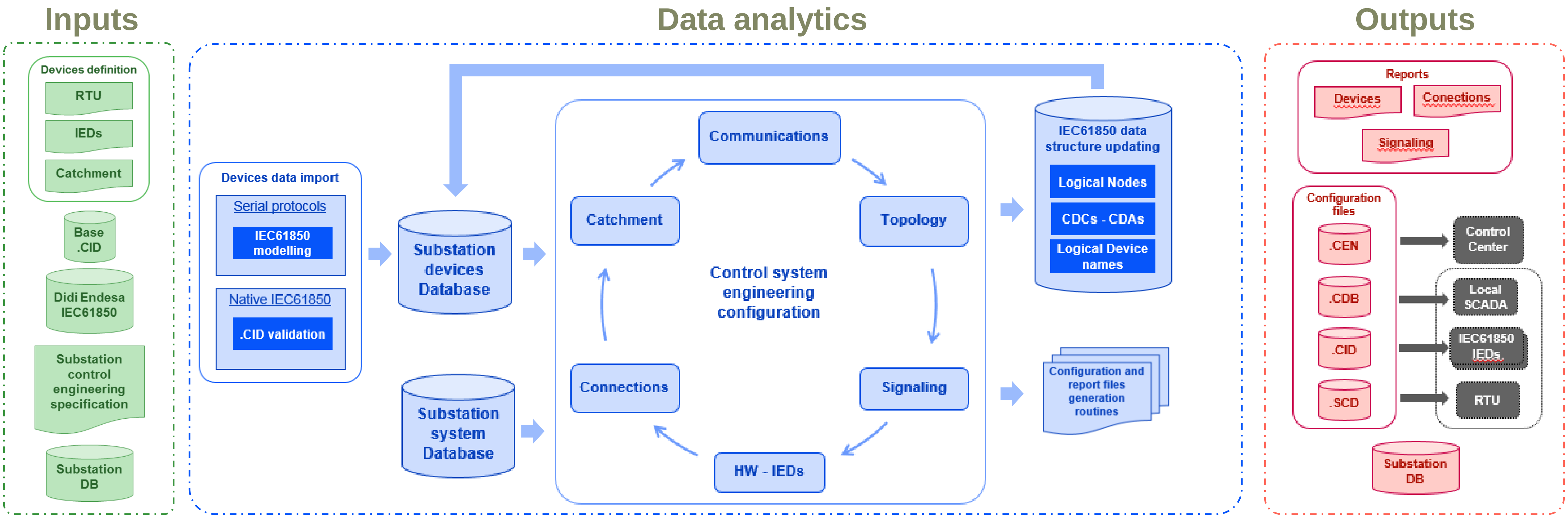
Engineering tool in a glance



Internal data structures containing information to be exported to reports and configuration files defined as outputs.

3S-CS Project

Engineering tool in a glance



Information **outputs** from engineering tool:

- **Preconfigured reports** to facilitate debugging and commissioning activities.
- Resulting **configuration files for different systems** and devices:
  - Remote control system
  - Local scada in substation
  - RTU and native IEC61850 IEDs.
- Database containing **resulting state of installation control system** (for later updating/modifications).

3S-CS Project

Normalized IEC61850 modelling

Legacy communication protocols devices profiles

ELEMENTOS					
ORDEN	Principal	Tipo	Descripción elemento	Barra	Padre
1	SI	4	Posición		
2	NO	7	Interruptor		1
3	NO	8	Seccionador Barras	B	1
4	NO	8	Seccionador PAT	PAT	1

ALARMAS INTERNAS								IEC103					RESTO			GBDU
Borna	Cod.Disco.	Tipo	Descripción	Elem.	Cod.Oper.	Subelem.	Info.	TYP	FUN	INF	Grp	Entry	Lec.Ini.	Start/End	Tip.Alar.	Activa
AI01	1756	SP	UCP no comunica con UCS										SI	S/E	device_error	SI
AI02	2508	SP	Detección incoherencia entre las BBDD de UCP y de UCS										SI	S/E	db_error	SI
AI03	2511	SP	Reset + inicialización										SI	S/E	eoi	SI

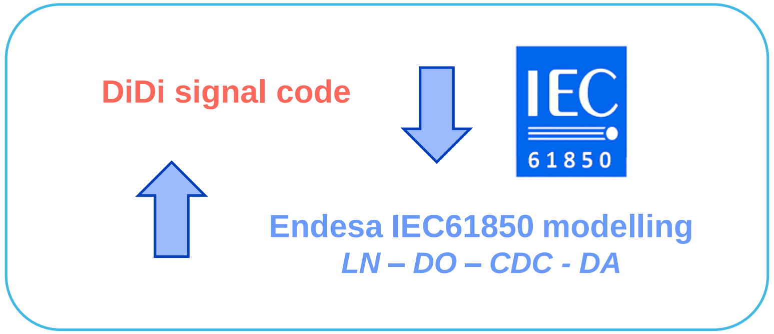
SEÑALES								IEC103					RESTO			
Borna	Cod.Disco.	Tipo	Descripción	Elem.	Cod.Oper.	Subelem.	Info.	TYP	FUN	INF	Grp	Entry	Lec.Ini.	Start/End	DP/DC	Log.Inv.
EDC001	349	DP	Posición abierto de interruptor	2				1	103	1			SI	S/E	OFF	NO
EDC002	349	DP	Posición cerrado de interruptor	2				1	103	1			SI	S/E	ON	NO
EDC003	477	DP	Posición abierto de seccionador de barras	3				1	240	163			SI	S/E	OFF	NO
EDC004	477	DP	Posición cerrado de seccionador de barras	3				1	240	163			SI	S/E	ON	NO
EDC005	477	DP	Posición abierto de seccionador de p.a.t.	4				1	240	164			SI	S/E	OFF	NO
EDC006	477	DP	Posición cerrado de seccionador de p.a.t.	4				1	240	164			SI	S/E	ON	NO
EDC007	256	DP	Posición en servicio de automatismo reenganchador					1	40	1			SI	S/E	ON	NO
EDC008	256	DP	Posición fuera servicio de automatismo reenganchador					1	40	2			SI	S/E	OFF	NO
EDC009	389	SP	Control mando local posicion	1				1	240	184			SI	S/E		NO
EDC010	1867	SP	Disparo neutro sensible	2				1	240	186			NO	S		NO
EDC011	785	SP	Fallo circuito disparo	2				1	170	55			SI	S/E		NO
EDC012	3019	SP	Disparo definitivo	2				2	240	181			NO	S		NO
EDC013	778	SP	Protec 75J622 local	1				1	101	85			SI	S/E		NO
EDC014	1866	SP	Disparo fase abierta	2				2	240	182			NO	S		NO
EDC015	2256	SP	Reenganche autobloqueado					1	40	85			SI	S/E		NO
EDC016	1441	SP	Orden de reenganche	2				1	160	128			NO	S		NO
EDC017	3018	SP	Ciclo reenganche en curso	2				1	160	37			SI	S/E		NO
EDC018	377	SP	Interruptor: Alarma baja presión gas	2				1	101	1			SI	S/E		NO

IEC 61850 profile

provided by *vendor*

SEÑAL IEC61850
SIP/CB1/XCBR1/Pos/stVal
SIP/CB1/XCBR1/Pos/stVal
SIP/Dc1/XSWI1/Pos/stVal
SIP/Dc1/XSWI1/Pos/stVal
SIP/Dc3/XSWI1/Pos/stVal
SIP/Dc3/XSWI1/Pos/stVal
SIP/CB1_79AutoReclosing/GEN_RREC1/On/stVal
SIP/CB1/USER1/APREON/stVal
SIP/CB1/USER1/MandoLoc/stVal
SIP/CB1/USER1/MandoLoc/stVal
SIP/CB1/USER1/AjEsp/stVal
SIP/CB1/USER1/F1Caido/stVal
SIP/CB1/USER1/MuellesDes/stVal
SIP/CB1/USER1/Antibombeo/stVal
SIP/CB1/USER1/SF652/stVal
SIP/CB1/USER1/BlqSF6/stVal
SIP/CB1/USER1/BlqSF6/stVal
SIP/CB1/USER1/BlqSF6/stVal
SIP/CB1/USER1/Q0OrdBlq/stVal
SIP/CB1/USER1/Q0BlqCTR/stVal
SIP/CB1/USER1/Q0NoAbre/stVal
SIP/CB1/USER1/Q0NoCierra/stVal

DiDi Endesa



Endesa normalized IEC61850 profile

DiDi	Señal	LN	DO	CDC	DA
352	posición cerrado de interruptor MT	XCBR	Pos	DPC	stVal
352	posición abierto de interruptor MT	XCBR	Pos	DPC	stVal
477	posición cerrado de seccionador de barras 1	XSWI	Pos	DPC	stVal
477	posición abierto de seccionador de barras 1	XSWI	Pos	DPC	stVal
477	posición cerrado de seccionador de p.a.t.	XSWI	Pos	DPC	stVal
477	posición abierto de seccionador de p.a.t.	XSWI	Pos	DPC	stVal
474	posición en servicio de automatismo reenganchador	RREC	AutoRecSt	ENS*/INS	stVal
819	posición en servicio de automatismo de cogenerador	ACGN	Mod	ENC*/INC	stVal
815	selector de mando en posición "manual"	XCBR	Loc*	SPS	stVal
389	selector de mando en posición "mando local"	XCBR	Lockey*/Loc	SPS	stVal
1429	selector ajustes en posición "ajustes especiales"	PTOC	SpSet	SPS	stVal

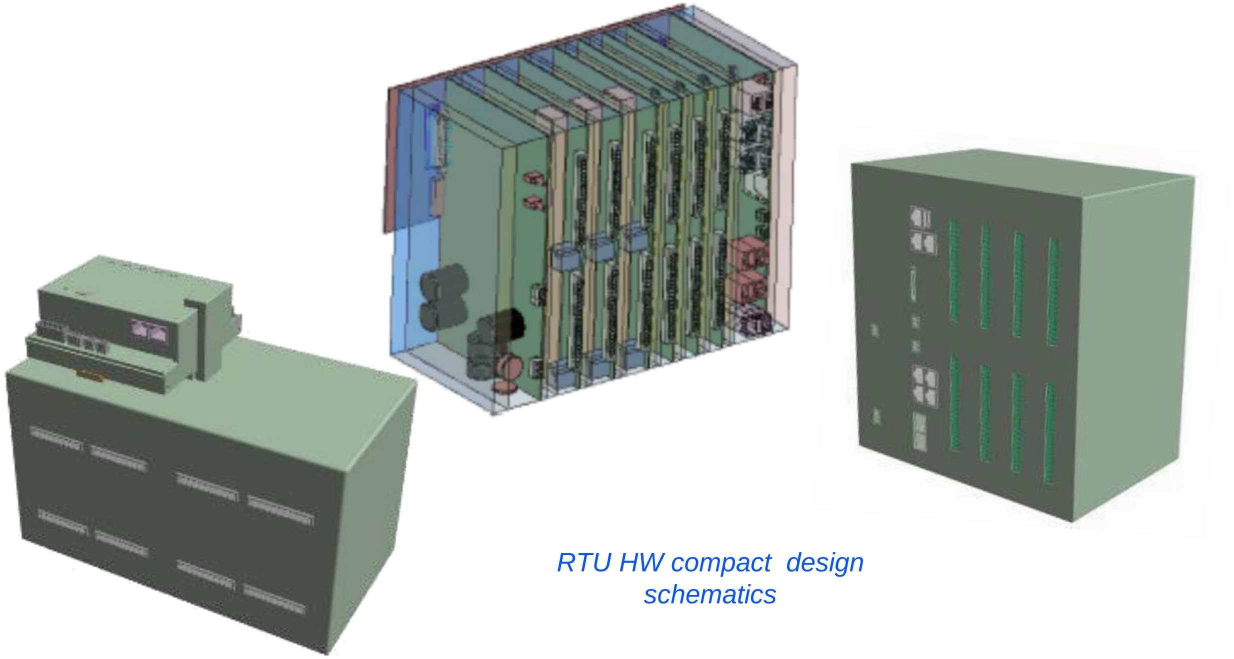
3S-CS Project

endesa

RTU device with enhanced synchronization precision

Improvement of HW/FW features of current RTU devices to **provide communication capabilities for IEC61850** services:

- Compact, modular and **extensible design**.
- **High-speed communication** based on peer-to-peer IEC61850 GOOSE service.
- **High precision synchronization using PTP protocols** (IEEE 1588).



RTU HW compact design schematics

NOMBRE	REQUISITO	HW/SW/GEN	TIPO
EDF.1	Entradas optoacopladas para valores de tensión en un rango 125-220Vcc	HW	Funcional
EDF.2	Capacidad nominal mínima del equipo de 50 entradas digitales	HW	Funcional
EDF.3	Diseño modular de entradas digitales, agrupando las entradas por módulos para dotar al sistema de flexibilidad y escalabilidad	HW	No Funcional
EDF.4	Los módulos de entradas digitales serán monitorizados individualmente para determinar su indisponibilidad	SW	Funcional
EDF.5	La frecuencia de la lectura de las entradas digitales será igual o superior a 1kHz	HW	Funcional
EDF.6	Los cambios de valor o bits de calidad de una entrada digital llevarán asociados una marca de tiempo de resolución de	SW	Funcional
EDF.7	Las entradas digital permanecen en el mism coincidencia de dos c de una entrada digital s menos		
EDF.8	Todos los eventos (cambio de estado y/ reg		

NOMBRE	REQUISITO	HW/SW/GEN	TIPO
SDF.1	Las salidas digitales serán de tipo relé y de libre potencial	HW	Funcional
SDF.2	Capacidad nominal mínima del equipo de 36 salidas digitales: 28 normalmente abiertas y 8 normalmente cerradas	HW	Funcional
SDF.3	Especificaciones eléctricas: Voltaje aplicable: 250Vac / 250Vcc Corriente nominal: 16A min / 125Vcc	HW	Funcional
	a	HW	Funcional
		HW	Funcional
	a	SW	Funcional

NOMBRE	REQUISITO	HW/SW/GEN	TIPO
SUP.1	El equipo cerrará un relé de salida ante pérdida de alimentación o anomalía	SW	Funcional
SUP.2	El equipo tendrá una función de supervisión (o watchdog) de cada uno de los módulos funcionales que lo componen	SW	Funcional
SUP.3	La RTU incorporará una función de autocomprobación continua de sus funciones y su estado, con el mayor alcance posible, y proporcionarán información detallada de las posibles anomalías que se detecten	SW	No Funcional
SUP.4	La información d remotamente		
SUP.5	Los equipos a su servicio, sin que pérdida del prop		

NOMBRE	REQUISITO	HW/SW/GEN	TIPO
COM.1	La RTU permitirá la recepción de mandos de control tipo sbo-witn-enhanced-security	SW	Funcional
COM.2	La RTU permitirá aplicar como mínimo las siguientes clases: - Controllable Single Point (SPC) - Controllable Double Point (DPC)	SW	Funcional
COM.3	Los mandos pondrán recibirse sobre MMS (IEC 61850-8-1) y sobre GOOSE	SW	Funcional

RTU requirements defined in different scopes (interfaces, coms, supervision, logics, …)

3S-CS Project

Wireless communications system for electrical substation

IEC61850 standard has been conceived for cable communications.

Migration to wireless communication implies both advantages (minimize roll-out cost/time, less maintenance efforts, more versatility, …) and risks (security, interferences, …).

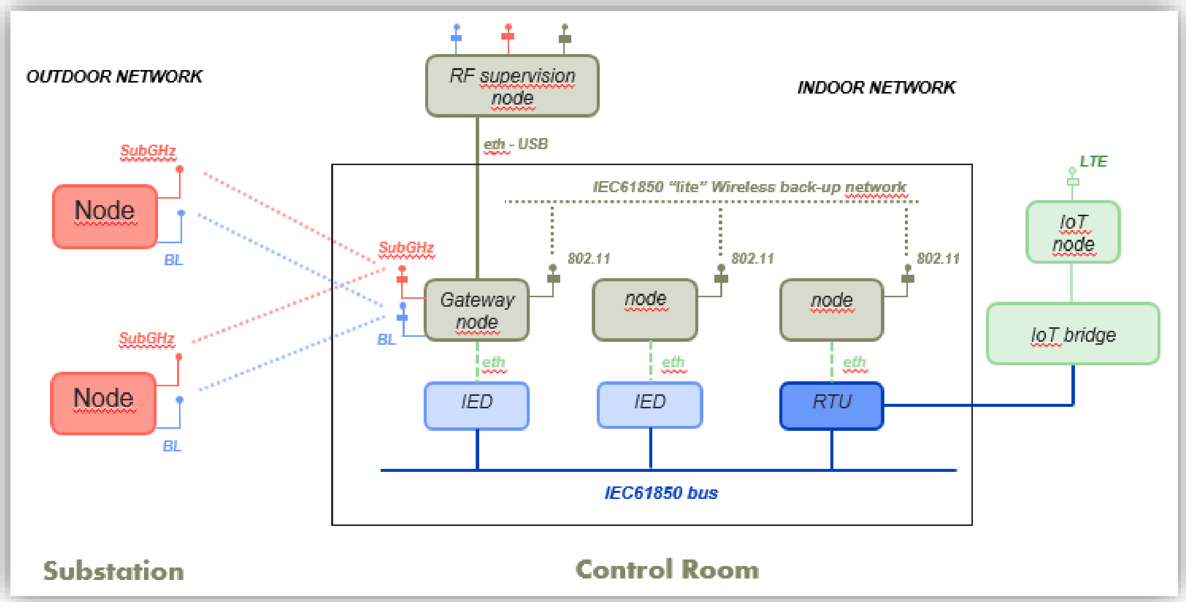
Previous analysis of existing wireless standards (WIFI, ZigBee, Bluetooth, Wireless Hart, ISA-100, optics communications) and possible topologies/configurations is required to obtain **real capabilities of wireless communications in electrical substation environment.**

Main objective is **upgrade current RTU communication features to provide wireless capability:**

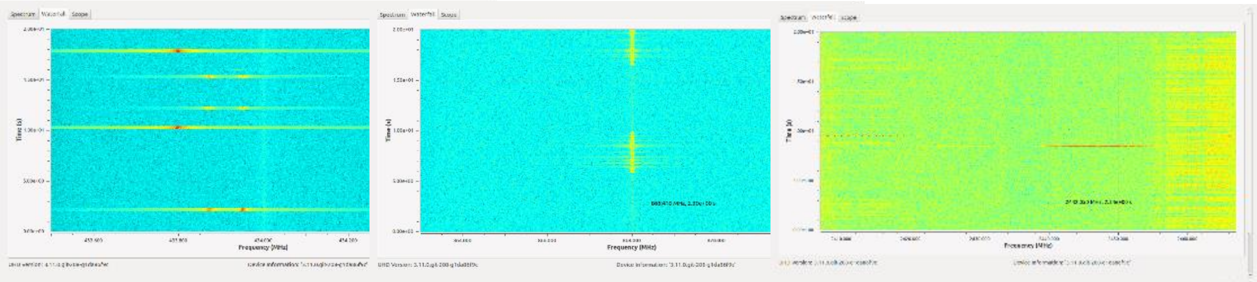
- **Redundant communication** (to cable communications) for IEC61850 traffic.
- **Satisfying IEC61850 requirements** (bandwidth, latency, BER, …).

Communication protocols stack is re-designed (both for wireless nodes and gateways) **to satisfy IEC61850 requirements** previously analyzed.

Wireless network will be supervised by means of an upgraded management tool implemented in the project.



General architecture of wireless communication proposal



EMI measurement in substation environment (control room, field, …)

3S-CS Project

Internet-of-Things system for substations

Design and development of an architecture based on a new "**IoT substation gateway**" **which provide connectivity to "IoT eco-system"**:

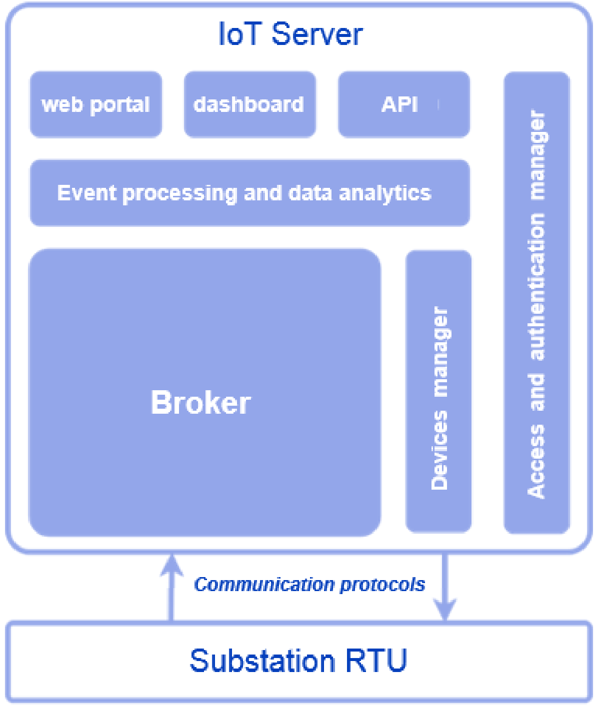
- **Sharing data with other platform/systems under IoT paradigm** to improve network exploitation processes and service quality levels.
- **Providing enhanced information to final users** (open-data).
- **Ensuring privacy** of sensible operational information.
- **Improved cybersecurity mechanisms** required.
- **Multiprotocol/multiplatform** capabilities to facilitate integration.

Communication interface:

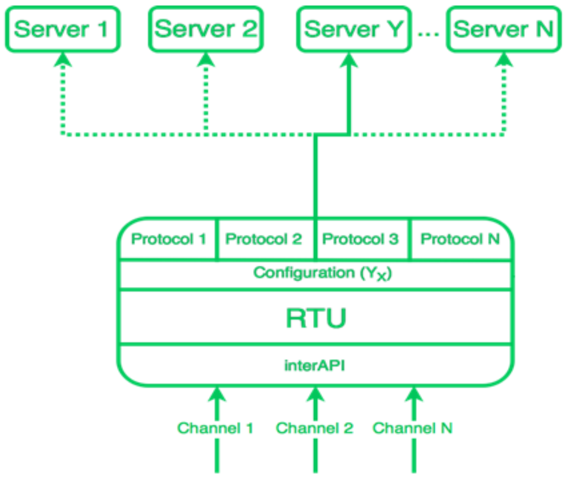
- **Current standards in IoT environment will be adopted** (MQTT, XMPP, XMPP-IoT, REST, MQTT, OPC UA , …)
- **Integration with main open/proprietary platforms** (Fiware, MsAzure…).

Interface configuration tool:

- **Authentication and data-privacy** management
- **New API will be designed to enable publication of selected data** according to REST/Linked Data standards.



Reference architecture for client-server IoT communication



High-level design for IoT RTU interface

3S-CS Project

Cybersecurity threats and risk analysis for electrical substations

Upgrading cybersecurity levels of electrical substations (critical infrastructure) according to most strict standards (**IEC 62351 y IEEE 1686**):

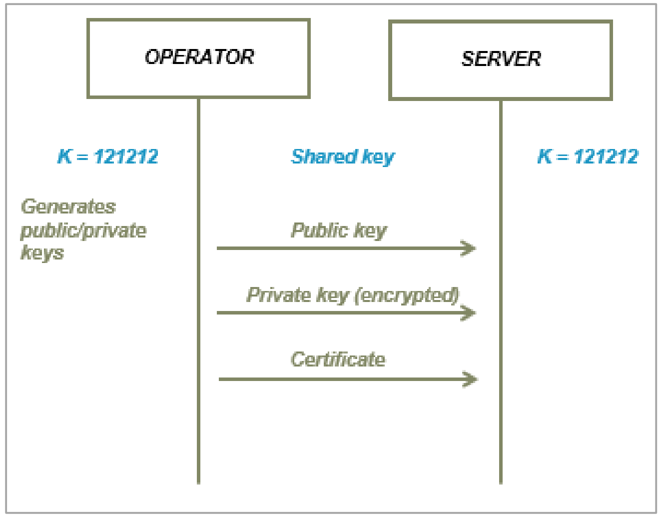
- Analysis centered in **RTU device vulnerabilities** and new solutions proposal.
- Analysis of **security politics in communications and control system access**.

Risk analysis according to different methodologies (Ms Threat modelling, VAST modelling, TRIKE, …)

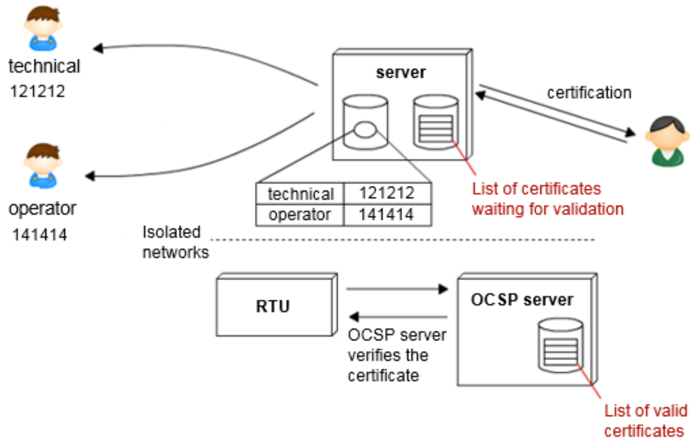
Communication SW of **RTU will be upgraded to provide VPN secure connectivity:**

- **VPN over IPsec.**
- VPN over TLS/SSL (**OpenVPN**).

Additional security features are considered (RBAC for accesses, secured control protocols, …).



General VPN certification process via external server



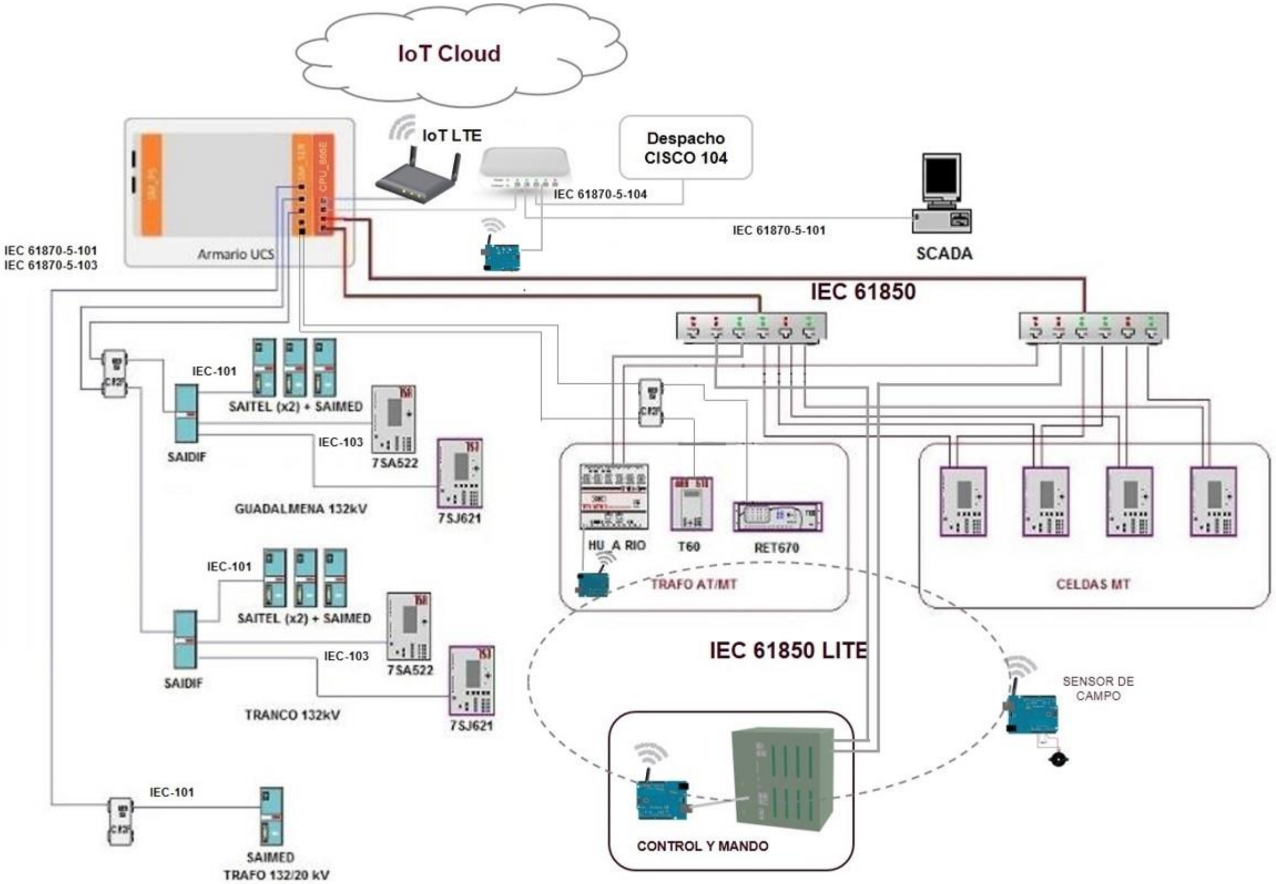
Reference architecture for VPN implementation. Authentication vía external server (OCSP server)

3S-CS Project

Demo site

Existing Endesa substation Puente Genave (P_GENAVE):

- ✓ Located in Jaen (Spain)
- ✓ Planned works for new MV bays installation and RTU upgrading.
- ✓ *Mixed-substation* configuration:
  - *Legacy devices* in transformer and AT bays
    - Siemens 7SA522 – 7SJ621
    - ABB RET670
    - General electric TT60
  - *Native IEC61850 devices* in MV bays:
    - Siemens 7SJ85



Thank you