INGEBER SYSTEM FOR KINETIC ENERGY RECOVERY

Asier Ugarte

Sales Director.

INGETEAM ,Traction Division.

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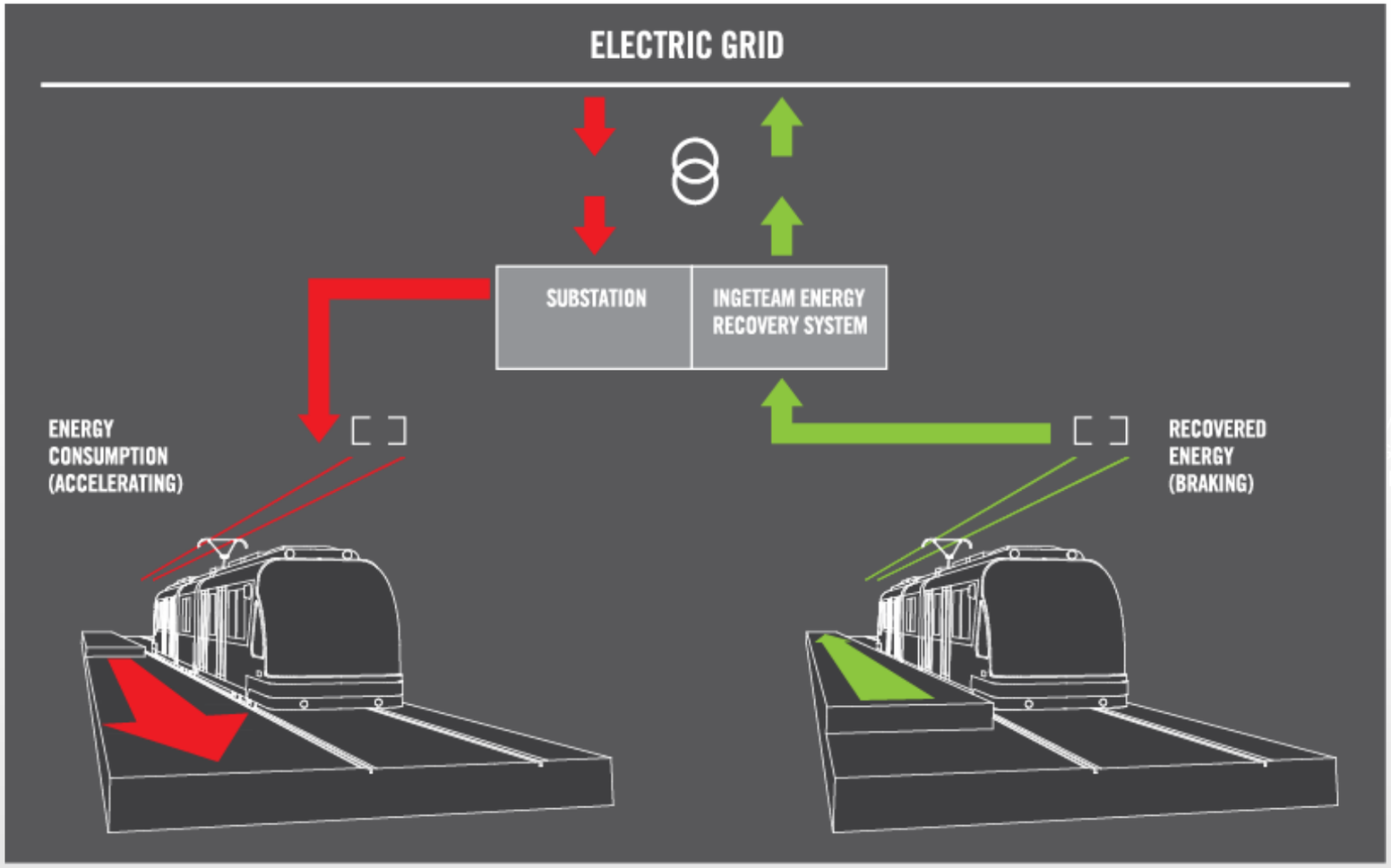
INGEBER System: Introduction

Ingeber (I): What is it?



The INGEBER system allows to recover energy from regenerative braking and to feed it back to the grid.

- ✓ Does not modify current substation installations, thus high-cost elements like transformer or rectifier can be reused.
- ✓ Its operation is transparent to the existing system: it´s possible to isolate it, without interrupting operation.
- ✓ The system´s power is planned based on previewed savings, not on installed power, hence costs are adjusted.
- ✓ Current transferred to the three-phase grid is of high quality (THD < 3%)

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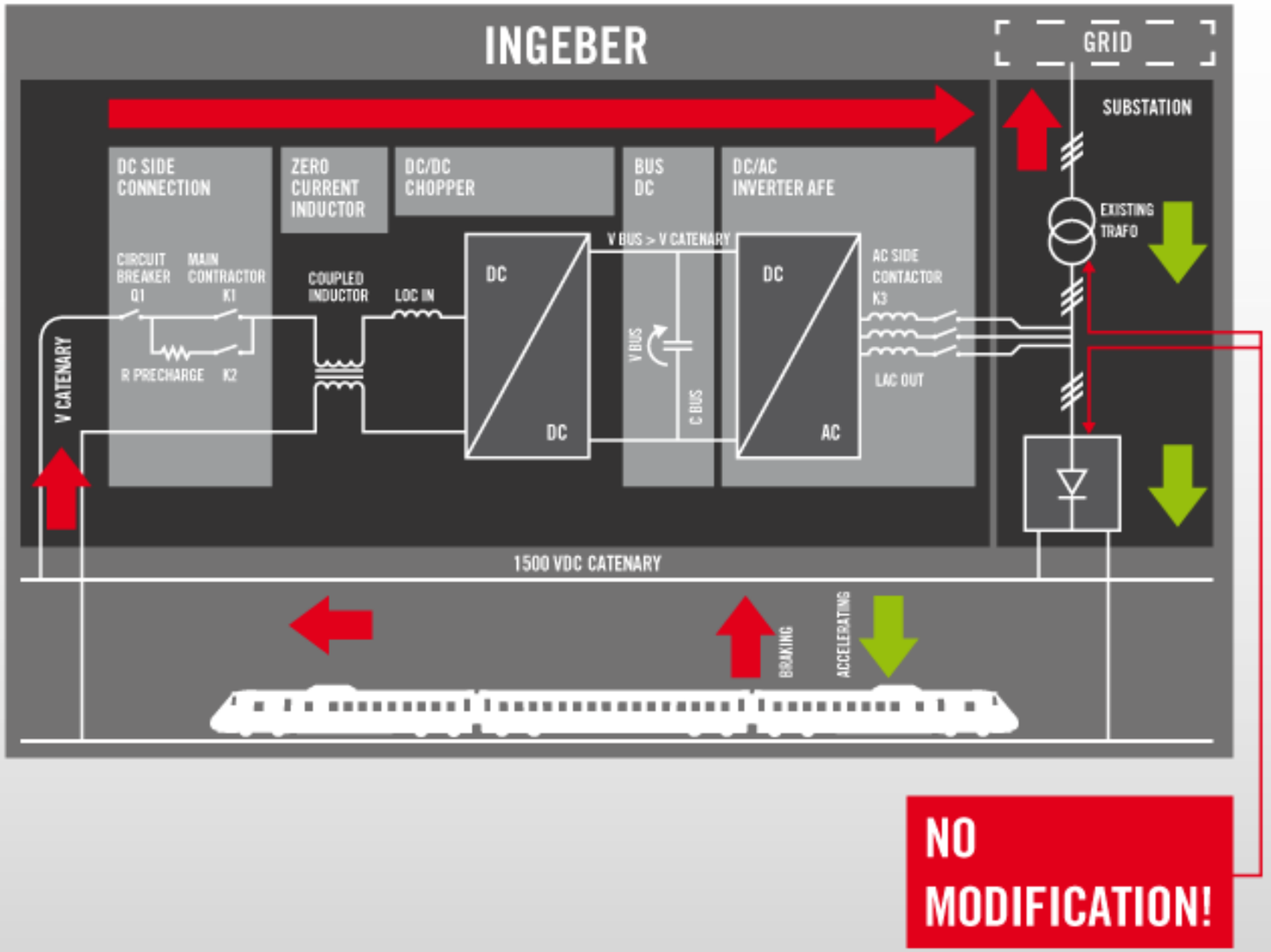
Ingeber (II): How does it work?



- ✓ DC/AC converter between catenary & secondary element of the transformer.
- ✓ Connection in parallel to the rectifier.
- ✓ Does not modify current substation installations.
- ✓ Guarantee the substation´s availability & efficiency ratios.

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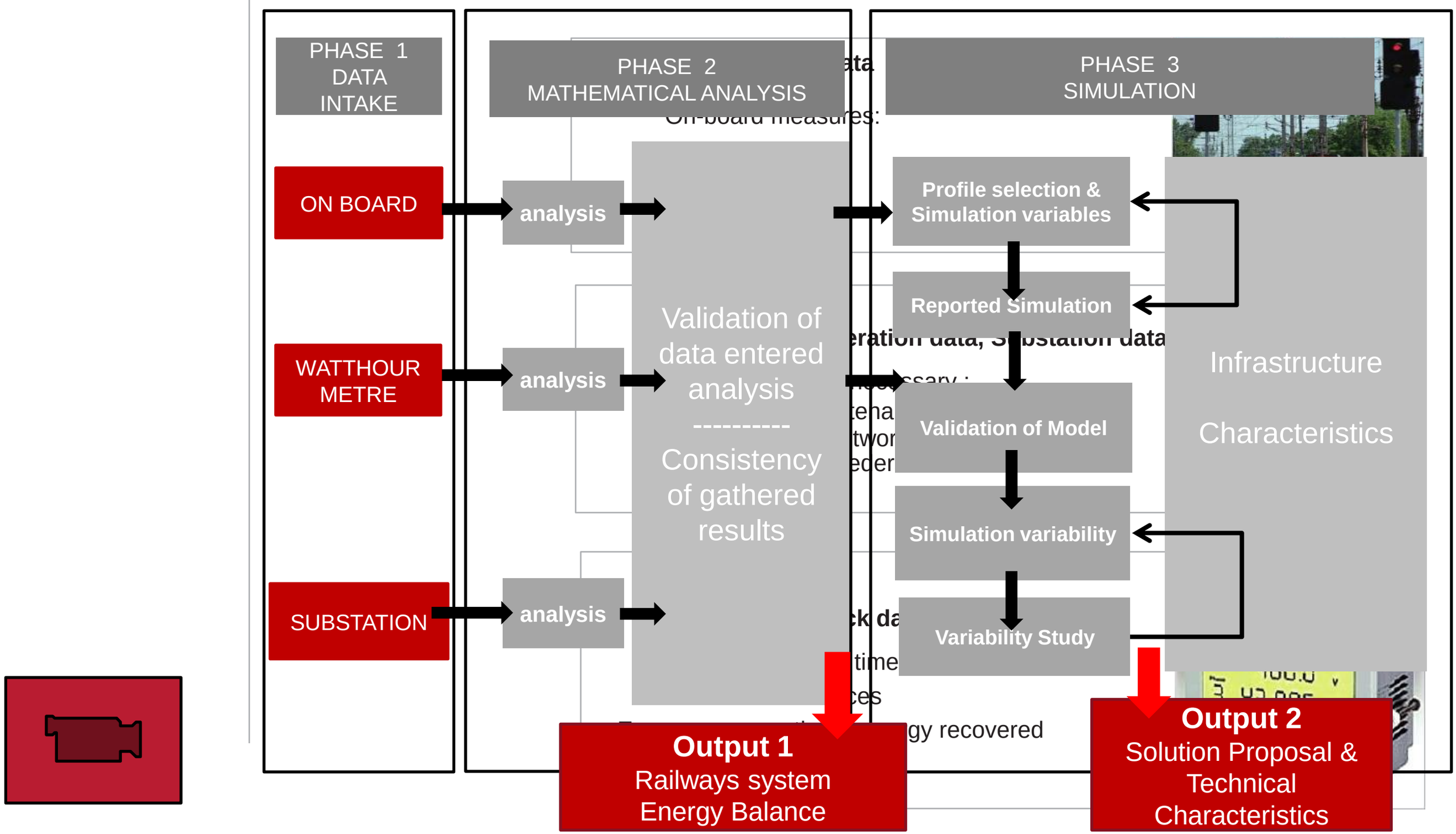
INGEBER: Implementation phases

Implementation of INGEBER system

Every railways system has exclusive technical characteristics:

- Catenary topology, voltages , Network voltage ,Substations
- Line profile, Traffic
- Rolling stock tipology

It is necessary to develop a previous engineering to evaluate the energy, power, optimal connection points, and ROI



Implementation of INGEBER system

Mathematical Analysis

Analysis of the data intake

- **On-board:**

  - Energy balance: energy consumption, energy recovered & energy burnt.
  - Auxiliary systems consumption.
  - Train resistance to motion & traction resistance.
  - Variations due to the timetable & synchronization of trains.
  - Geographical distribution of the energy not used along the line.

- **Watthourmetres:**

  - Energy balance: energy consumption, energy recovered.
  - Energy consumption & recovered / km.
  - Variation rate and average values on significant nr. Of journeys.

- **Substation:**

  - Traction net consumption.
  - Consumption distribution.
  - Influence of the feeding voltage.
  - Analysis of the variations on the catenary voltage at substation point.

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Simulation Tool

Developed by Ingeteam, allows the analysis of different
Data that will have an influence on the solution, such as:

- Operation schedule
- Type of trains
- Nominal values of line voltages
- Geographical distribution of recovery systems

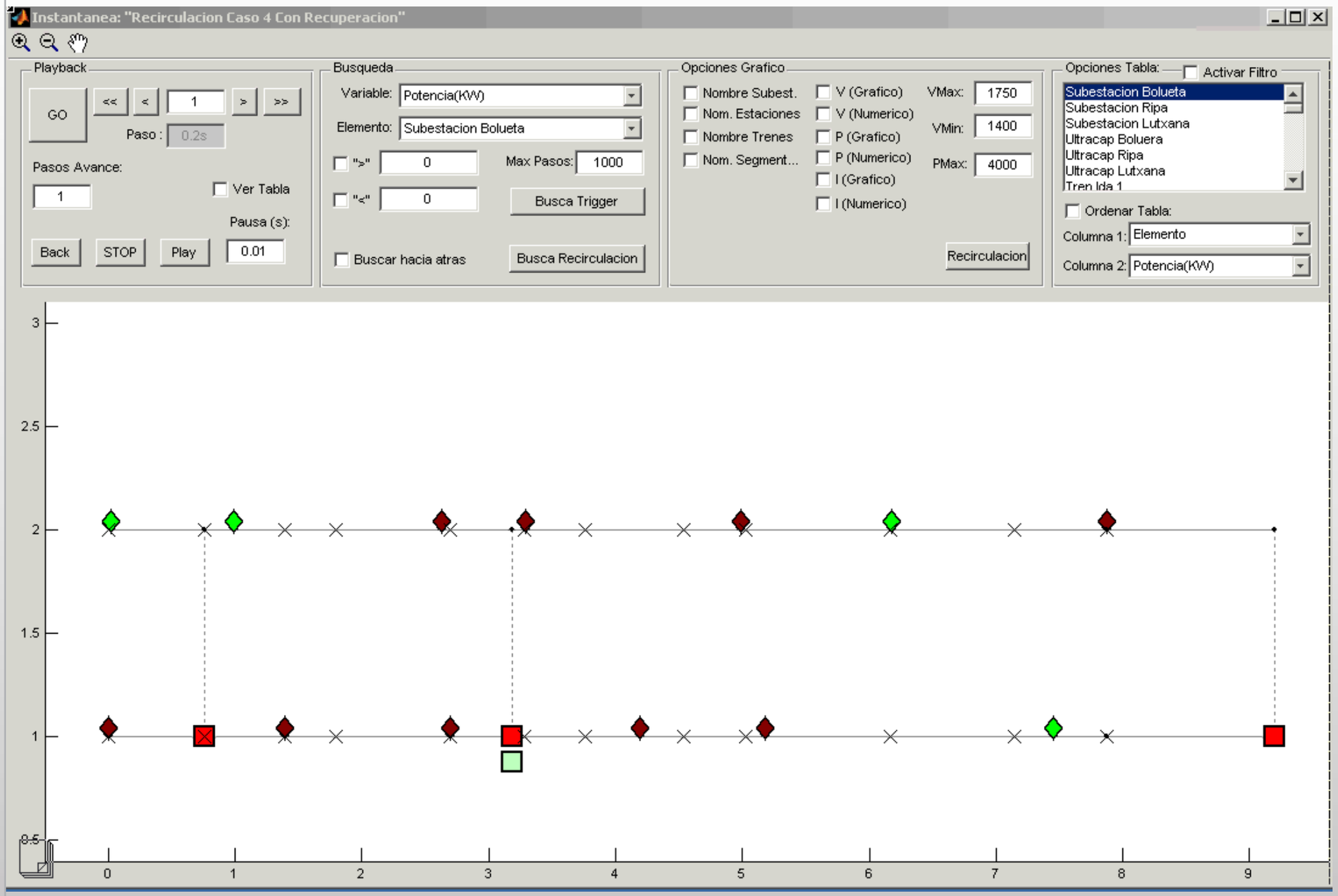
The tool is based on a impedance matrix (time variable) that is solved through pattern calculations.
The tool allows us to analyse voltage, current , energy and power on nearly real Basis on all points of the network.

Results:

- Validation of the mathematical model & energy balance results
- Nr. Of substations to be fitted with the system
- Optimal power for each converter
- To preview savings to be achieved.
- Investment needed and return on investment rate.

Implementation of INGEBER system

Simulation



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Application: Metro Bilbao

Application
Metro Bilbao (I)

metro bilbao

SUBSTATIONS

- Ariz-Cocheras
- Bolueta
- Abando
- Lutxana
- Lamiako
- Aiboa
- Larrabasterra
- Sopelana-Cocheras
- Ansio
- Urbinaga

CATENARY VOLTAGE: 1.500 Vdc

2nd PHASE : On-going

PROTOTYPE INSTALLED IN 2009

2nd PHASE : On-going

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metro bilbao

- From real data, we obtained
  - Power output available at each point.
  - Rolling stock speed on each position of the network.

- Various simulations have been made,
  - Characteristics and geographical location of substations
  - Proposal of new configuration of substations.
  - Different catenary voltages
  - Different time schedules
  - Taking into account random synchronization delays.

- From all simulations, extrapolations have been made:
  - Average working characteristics of the system to calculate annual savings

Application
Metro Bilbao (III)
Simulation results

- 52% of traction energy is recovered during braking
  - 44% of traction energy is feeded back to the catenary
  - 8% of traction energy is burnt on resistors.
- 7% of traction energy is lost on the catenary
- 8% of total traction energy means 13.05% of total energy consumed on the network for traction. This is the maximum saving, theorically.

Global objective of the project (Network) :

Cogenerated Energy = 0.1305 x 52,500 MW.h = 6,851.3 MW.h

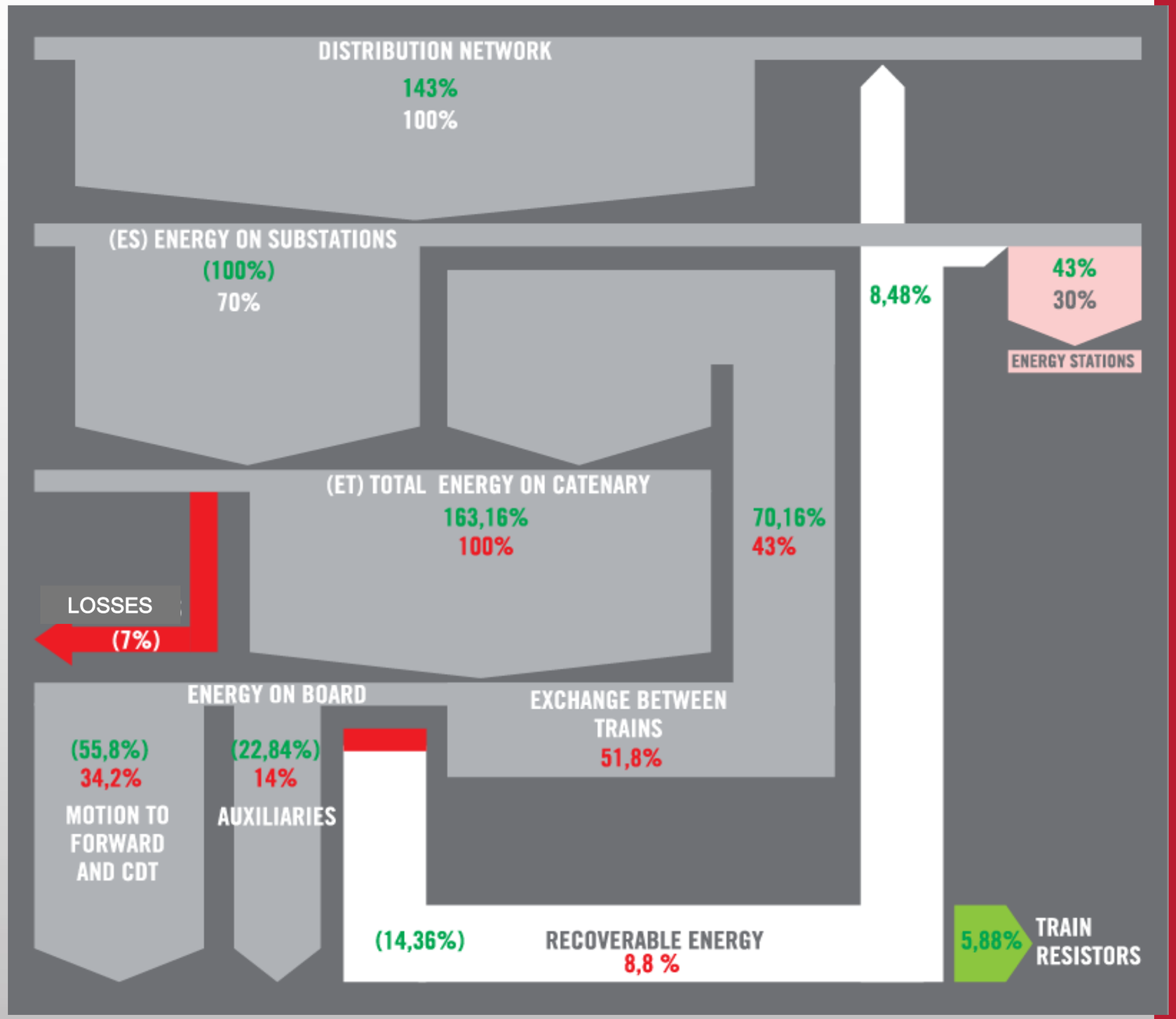
Application MetroBilbao (IV)

Energy Flow

SUBSTATION

TRAIN

metro bilbao



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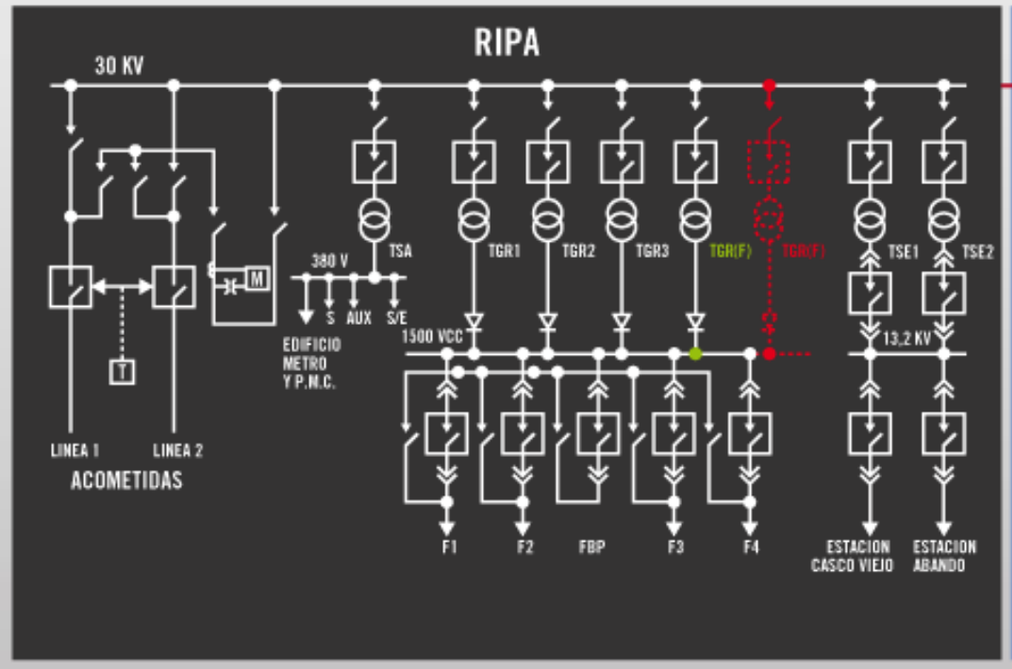
Prototype

- First prototype has been fitted at Ripa substation.

This particular substation has been choosed because it is the one with most disadvantages, in order to demonstrate the suitability of INGEBER system.

- ✓ This substation is located on the section with more traffic and frequency of trains. Therefore there is more energy exchange between trains.
- ✓ High network voltage.



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Application
MetroBilbao (VII)

Savings
on prototype
installed

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REAL DATA

85	Working days	2,640 kWh/day	**Recovery per week= 23,080 kW/h/week**	13.3%	**Rec. annual 1.203.391,20 kWh/year**
22	Friday N	800 kWh/day			
24	Saturday	3,130 kWh/day	**Energy Consumption in Traction = 167,879 kW/h**		
19	Saturday N	1,880 kW/h			
20	Sunday	4,050 kW/h			

Total Recovery of energy,
previously burnt on braking resistors: 1,204 MW.h

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Application MetroBilbao(VII)

Conclusions

metro bilbao

- Real savings on the substation of 1mio/kWh, total power installed 1,5 MkW: if power is increased, savings do not increase accordingly
- Amortization period: 6 years
- Energy feeded back to the grid is regulated by law, RD-1011-2009: Administrative process is simple and short.
- Installation is small and independent. Its operation is transparent to the existing system. Therefore in case of breakdown it´s possible to isolate it, without interrupting operation.
- Energy feeded back to the grid fulfill with supplier´s requirements (Pulse and wave quality)

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Application

Metro Bilbao(IX)

Prototype Installed

metro bilbao

POWER EQUIPMENT

CONTROL: ON-SITE OR REMOTE

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Application

Metro Bilbao(X)

Prototype Installed

INGEBER System fitted on a 7,5 sq.m

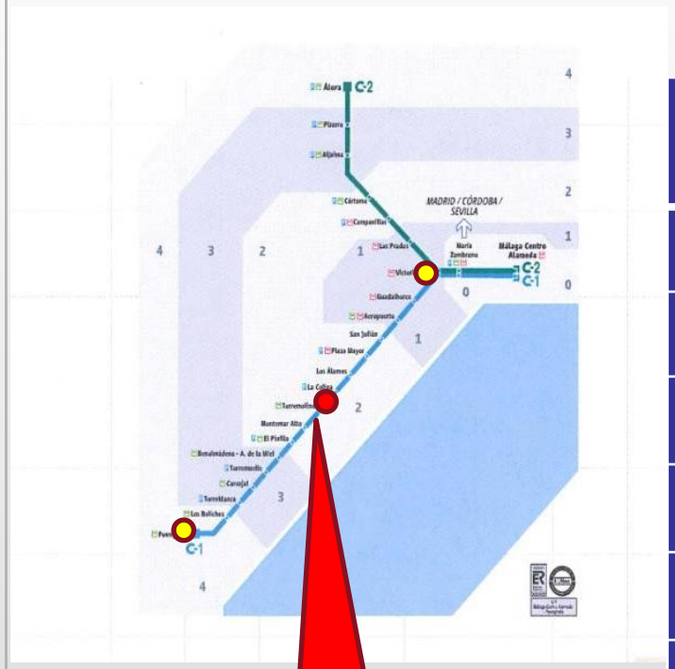
Ingeber system installed on Ripa substation

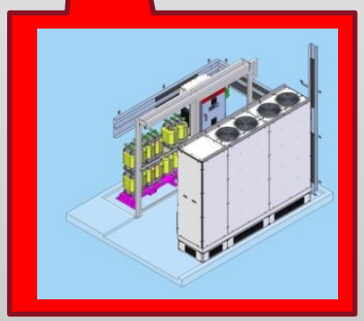
Other Projects

Application
ADIF (I)

Final customer : ADIF . 3000v DC Network

Ingeteam: Study, design , EPC of 1 energy recovery system.





INGEBER SYSTEM	LA COMBA, Malaga C-1
Max. Power Instant	2000kW
Nominal Voltage	3300Vdc
Max.DC side Voltage	4000Vdc
Max. DS side Current	606A
AC nom. Voltage[±7%]	1300Vac
AC side Max. Current	955A
Grid current THD%	<5%
Output Frequency	50Hz
System Cooling	Forced air cooling
Installation Area	Traction Substation

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Global objective of the project (Network) / Year :

Feeded-Back Energy = 1,400 MW.h

Application
ADIF (II)

Final customer : ADIF . 3000v DC Network

Ingeteam: Study, design , EPC of 1 energy recovery system

Installation On-going

Area: 2 x 12m ^{2}

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What to do with the energy recovered?

What to do with the energy recovered? (I)

Energy recovered has 2 possible destinations:

- Internal use, on the operator´s network.

- Feed-back to the electric distribution grid.

  This is possible if

  - there is a previous agreement.

  - there is a legislation that regulates how to discount on the operator´s energy bill the energy feeded-back.

    For instance, in Spain this situation has been already regulated by the national government (RD 1011-2009).

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Ingeteam (I)

Customer oriented

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INDUSTRY Division

MARINE Division

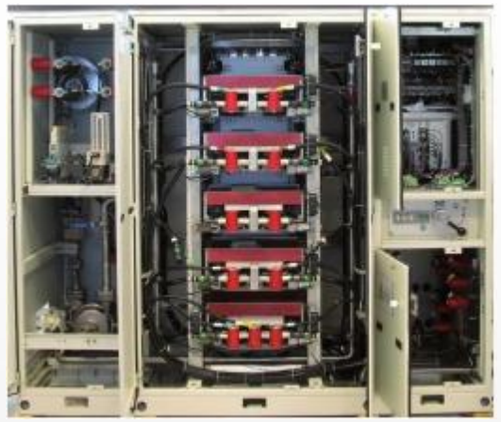
TRACTION Division

BASIC TECH. Division

SERVICE Division

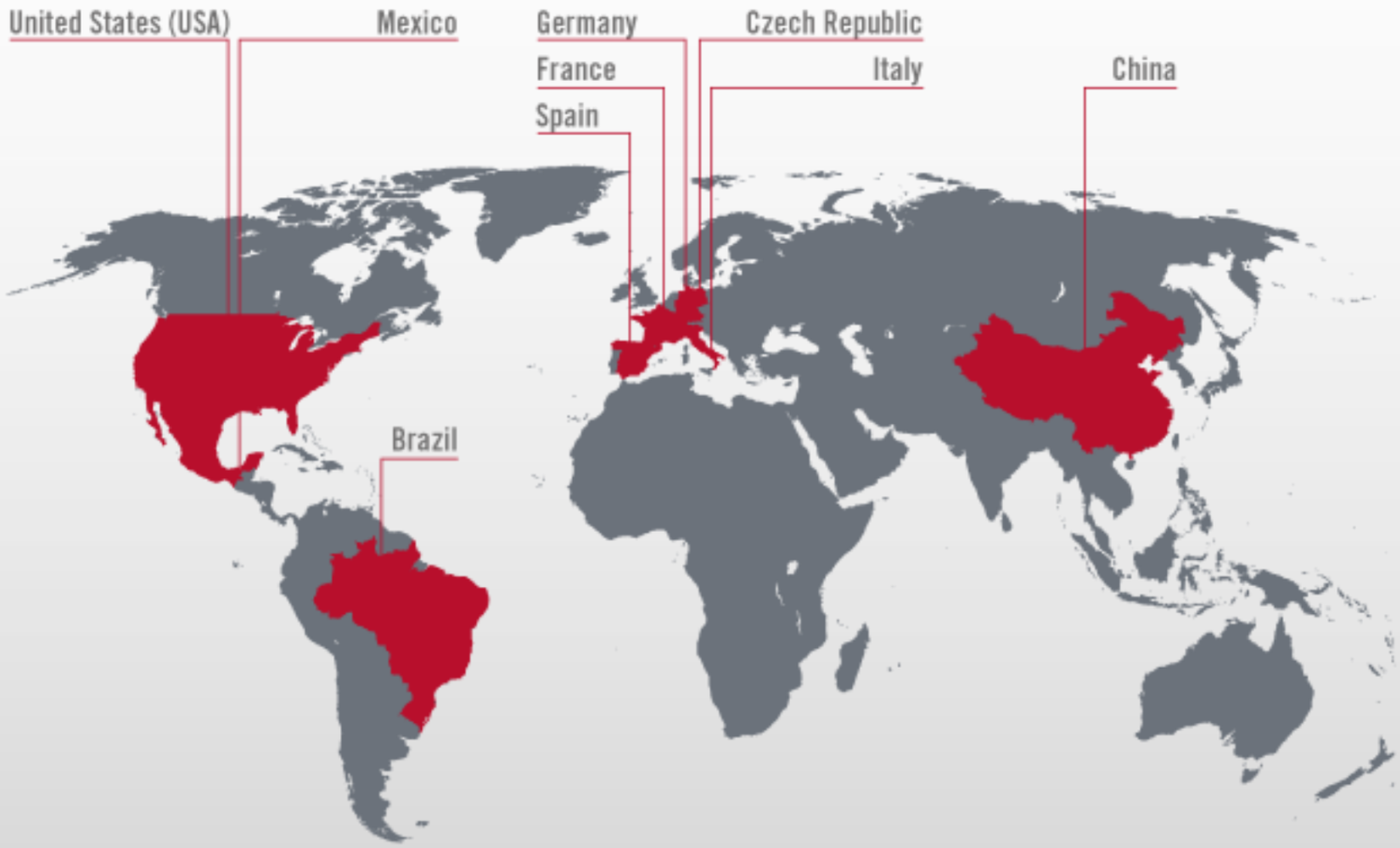
Ingeteam (II)

Experience on power traction equipment



Ingeteam (III)

Worlwide presence



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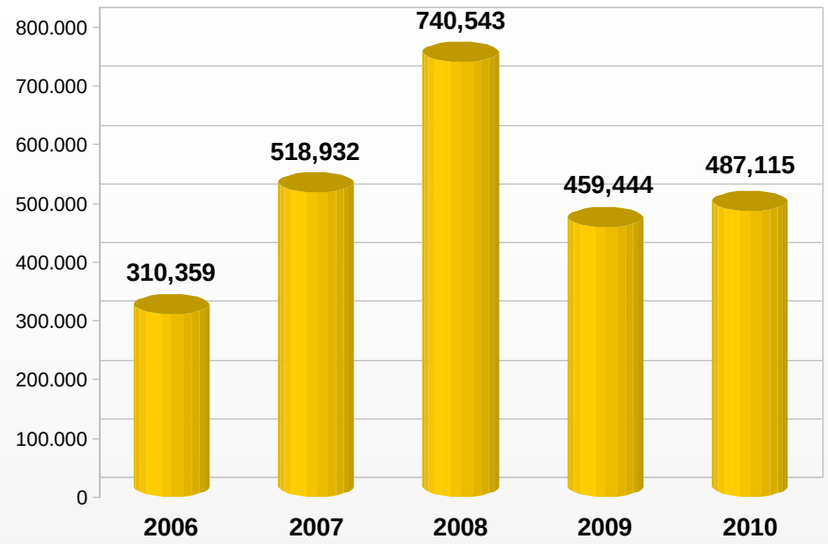
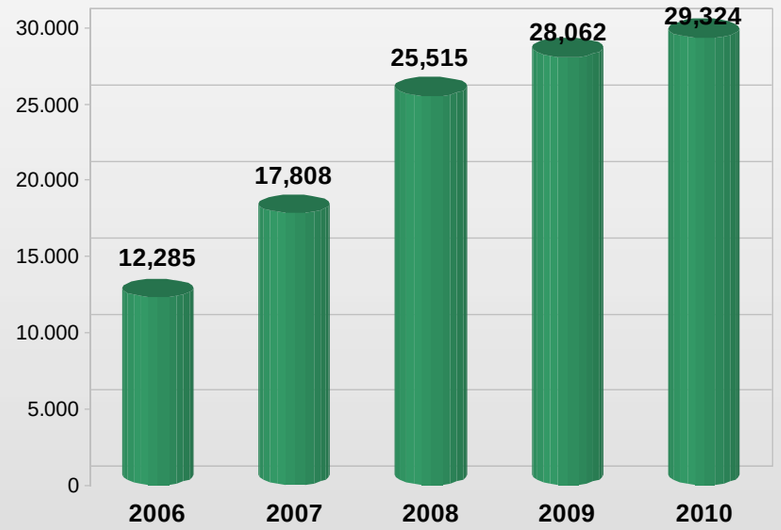
Ingeteam (IV)

Basic Data

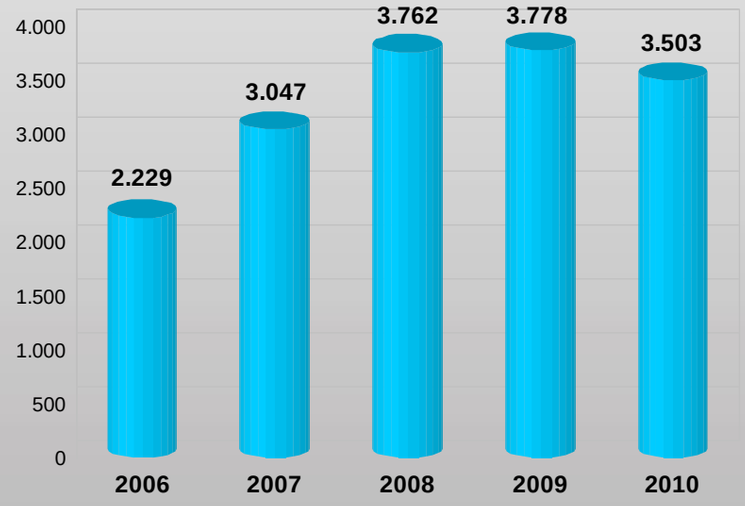
Net sales (K euros)



R&D (K euros)



Personnel



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Thanks for your attention