I RAIL TECHNOLOGICAL FORUM FOR INTERNATIONALIZATION

28th of June 2011
Madrid

INGEBER SYSTEM FOR KINETIC ENERGY RECOVERY & METRO BILBAO EXPERIENCE

José Miguel Ortega
Director Desarrollo Corporativo
Metro Bilbao

Financed by:

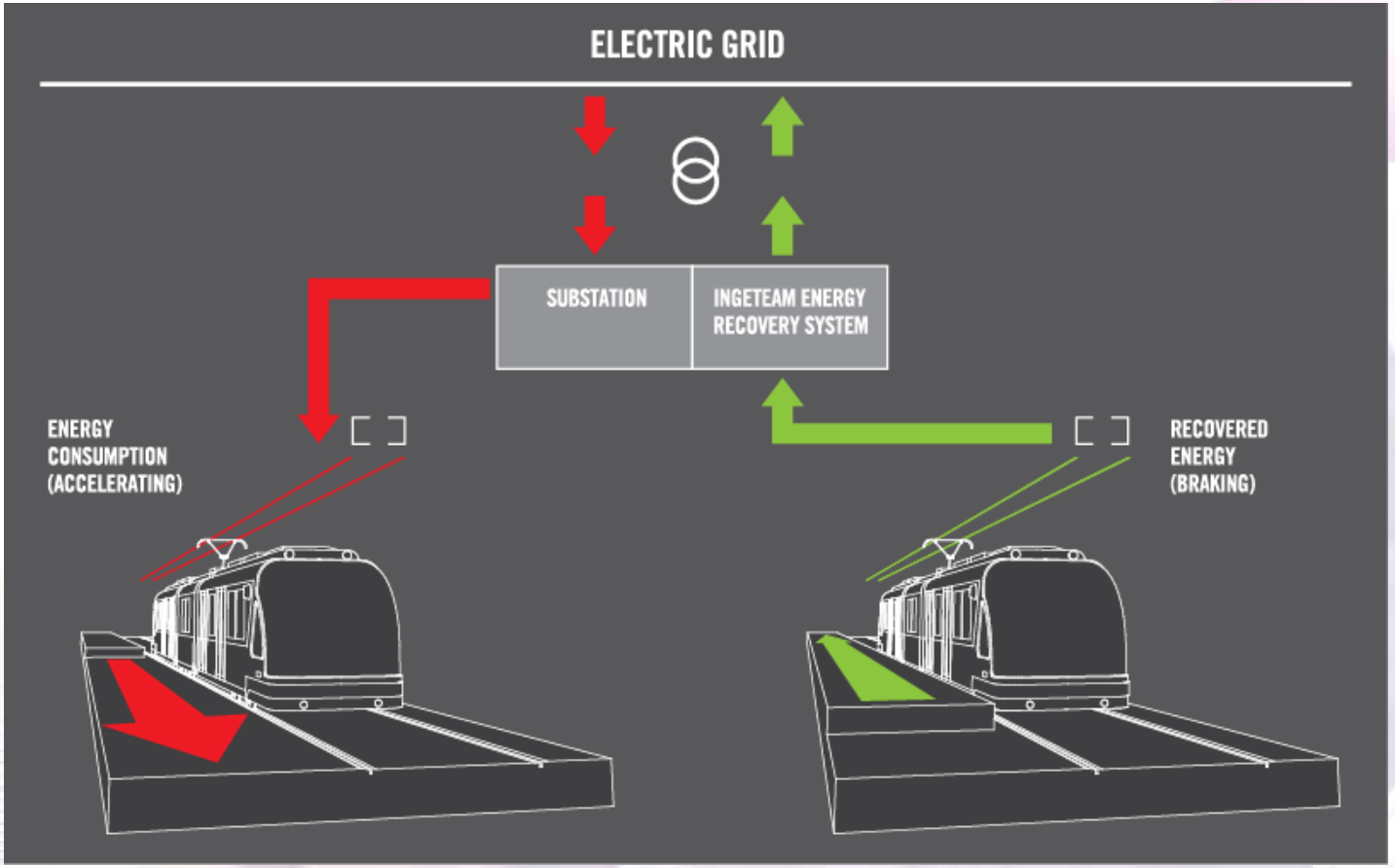
Organized by:

With the collaboration of:

INDEX :

Ingeber (I):

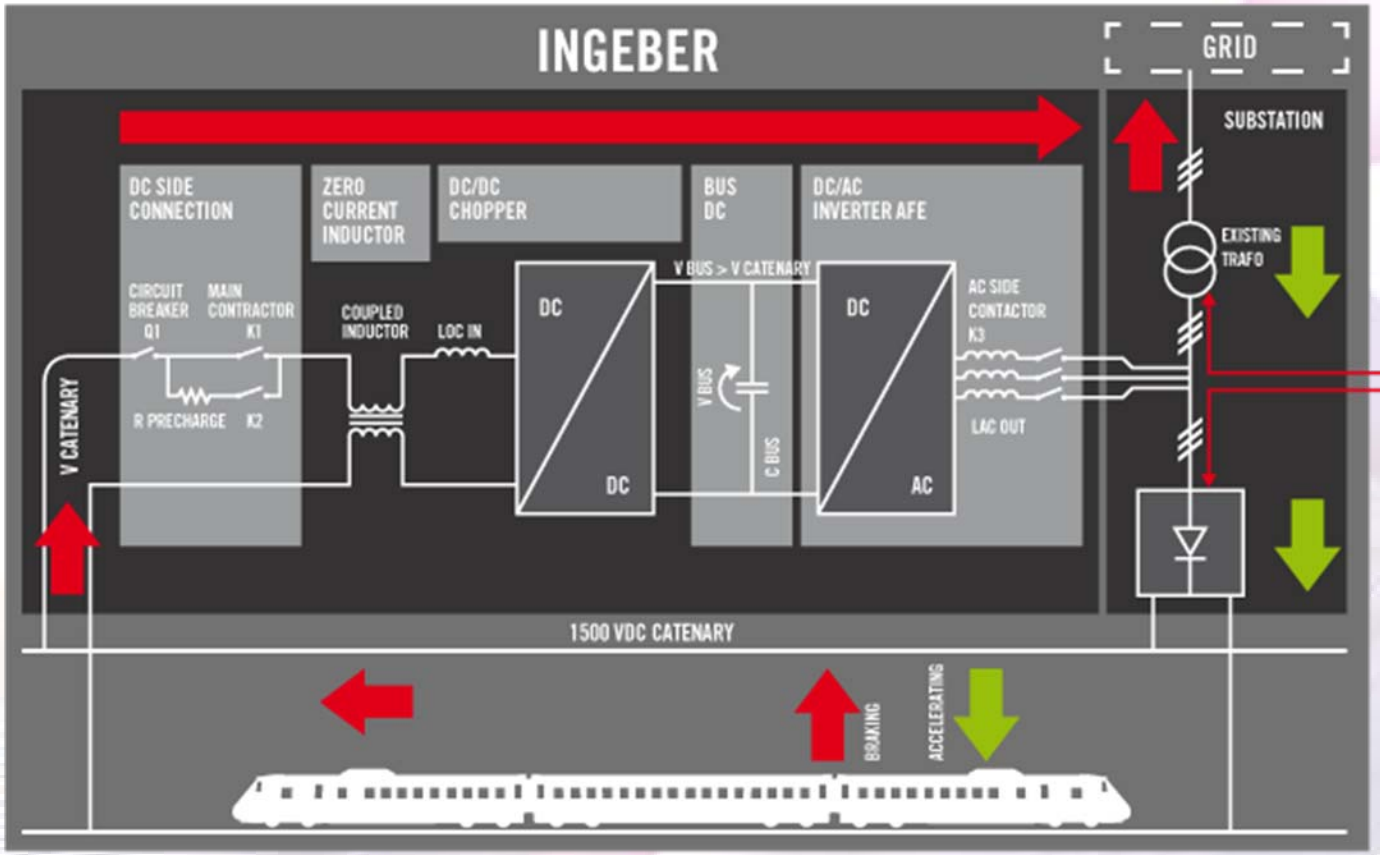
What is it?



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

Ingeber (II):

How does it work?

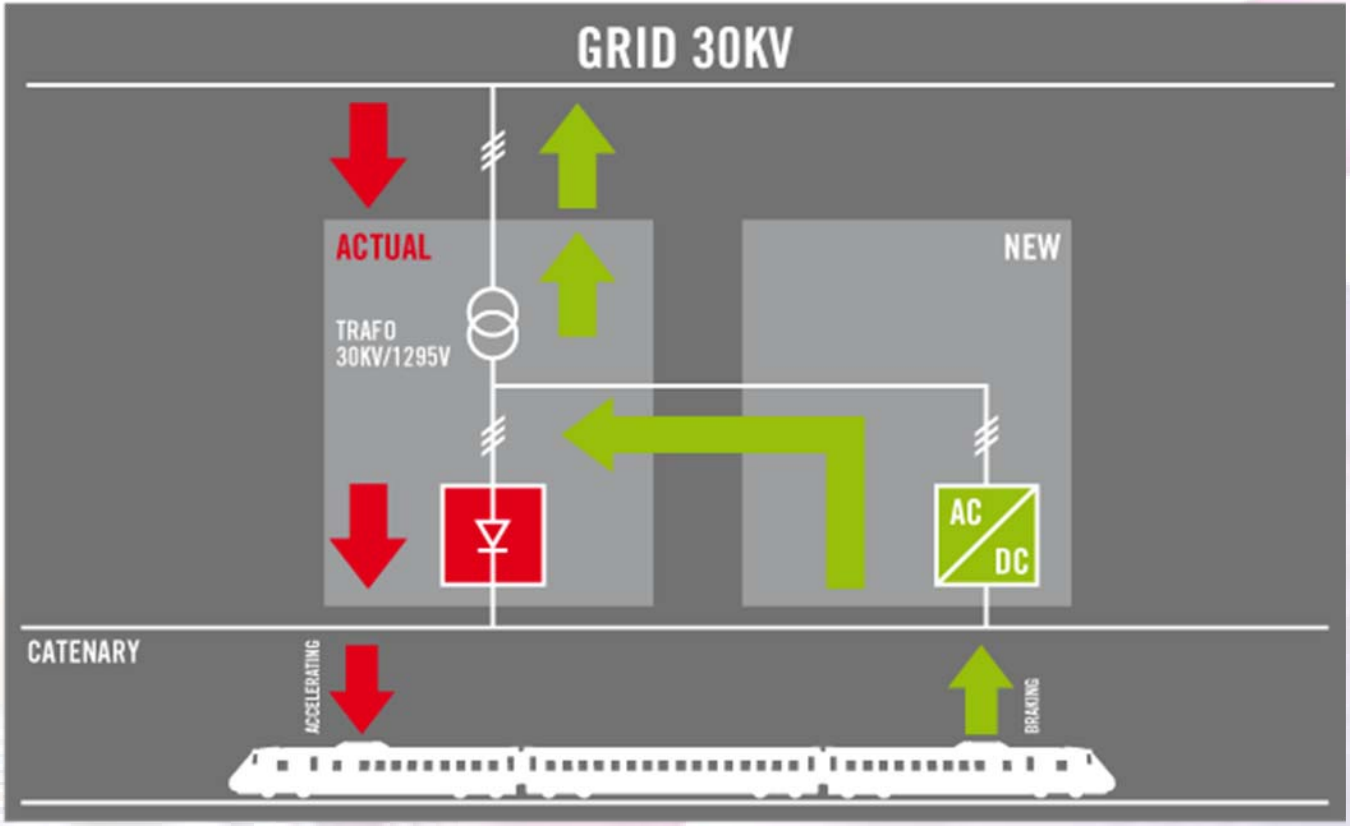


NO MODIFICATION!

The substation becomes reversible without modification of existing systems & without affecting its availability.

Ingeber (III):

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.

Ingeber (IV):
Main Advantages

✓ 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%)

INDEX :

- INGEBER System: Introduction
- INGEBER: Implementation phases
- Application: Metro Bilbao
- What to do with the energy recovered?

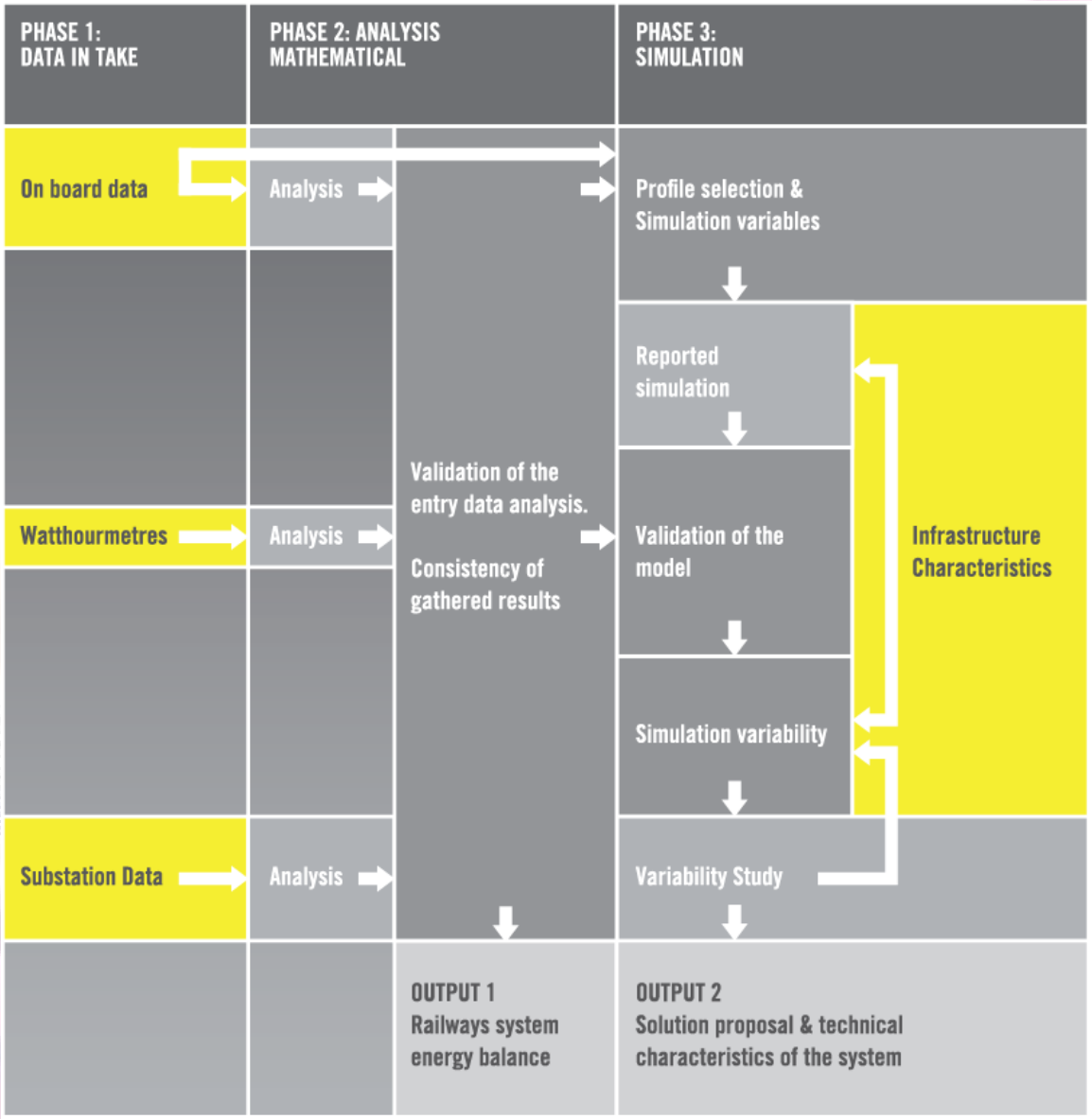
Every railways system has exclusive technical characteristics:

- Catenary topology
- Catenary voltages
- Network voltage
- Substations nr.
- Station nr.
- Line profile
- Traffic
- Rolling stock tipology
- Etc.

It is necessary to develop a previous engineering to evaluate the energy, power, optimal connection points, and the return on investment rate (ROI).

Implementation of Ingeber System

Phases



Implementation of Ingeber System

Phase I: Data Intake

- Rolling stock data
- On-board measures:
  - Voltage
  - Current
  - Speed

- Lines profiles & operation data
- Substation data
- If necessary :
  - Catenary voltage
  - Network voltage
  - Feeders´current

- Rolling stock data
  - Working time
  - Distances
  - Energy consumption & energy recovered

(By km point)

Implementation of Ingeber System

Phase II:

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.

Watt hour meters:

- 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.

Implementation of Ingeber System

Phase III:

Simulation

The simulation tool developed by the manufacturer 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

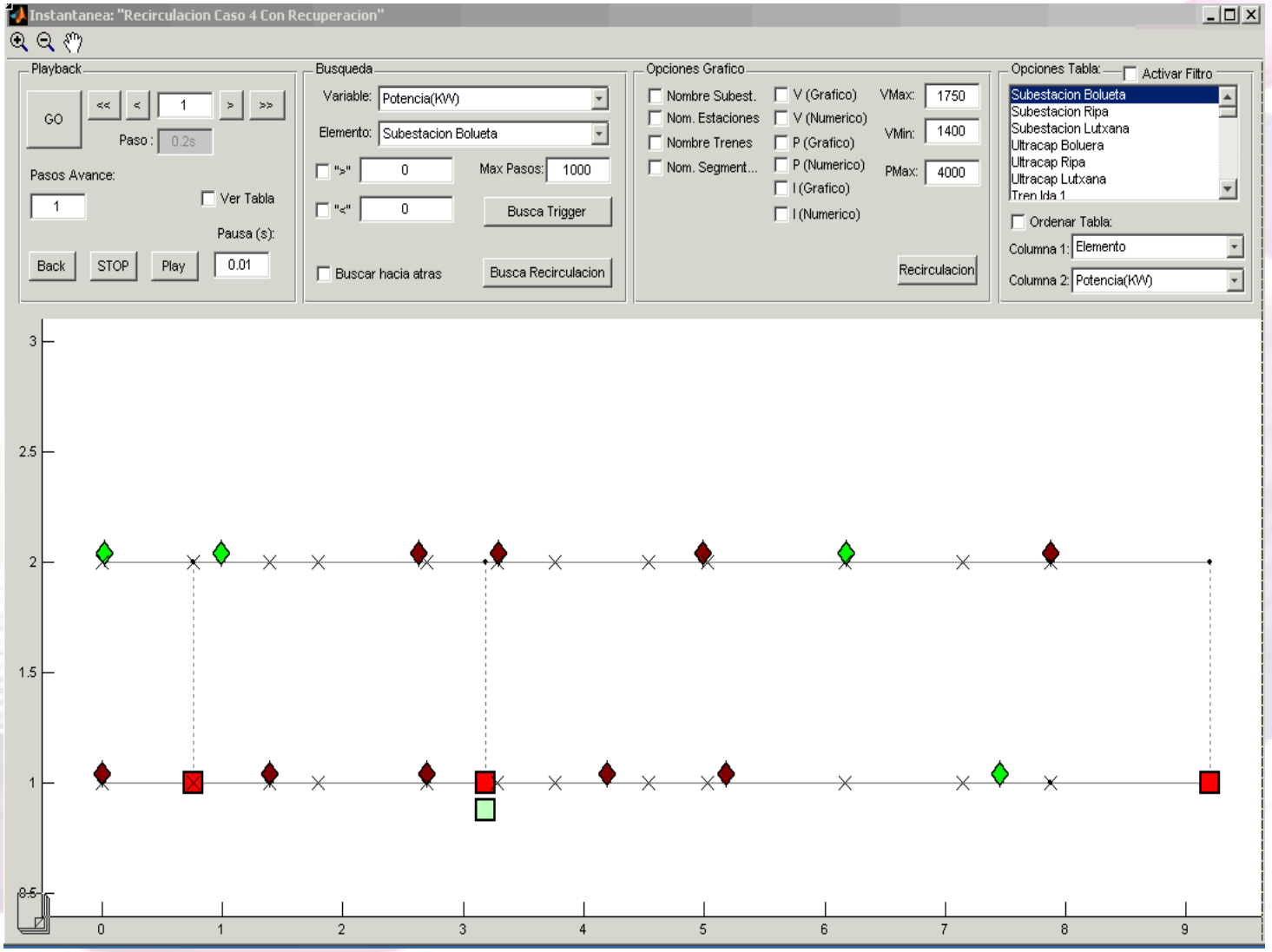
The tool is based on a impedance matrix (time variable) that is solved through pattern calculations.
The tool allows us to analyze voltage, current , energy and power on nearly real Basis on all points of the network.

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

Phase III: Simulation



With all data & simulations in hand, the manufacturer will present a complete engineering proposal, including:

- Nr of ingeber systems to be installed
- Geographical distribution of the systems
- Power output for each system

Finally, we will supply the equipments and we can participate on the fitting and start-up of the systems.

INDEX :

Application: Metro Bilbao (I)

metro bilbao

SUBSTATIONS
Ariz-Cocheras
Bolueta
Abando
Lutxana
Lamiako
Aiboa
Larrabasterra
Sopelana-Cocheras
Ansio
Urbinaga
CATENARY VOLTAGE: 1.500 Vdc

3rd PHASE

PROTOTYPE INSTALLED IN 2009

2nd PHASE

Application:

Metro Bilbao (II):

Starting Data

Profile of 1 &2 lines and location of substations.

Real data : effort, current, voltage & power on speed function.

Those data were taken along the lines 1 &2

- On different RS units
- At different times
- On units with different mass

Trains frequency for each section of line 1&2.

Application:
Metro Bilbao (III):

Simulation Process

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 (IV):

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, theoretically.

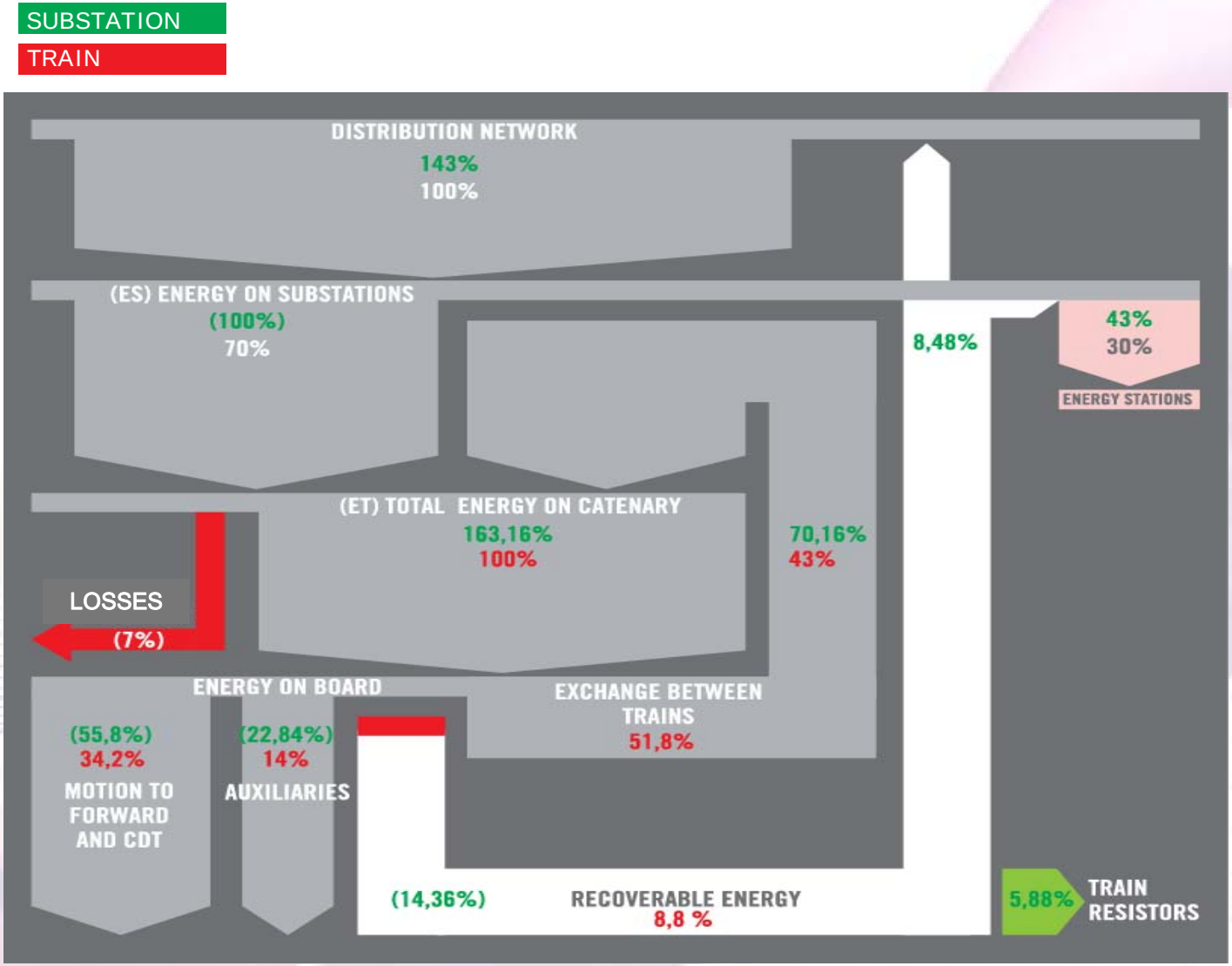
Global objective of the project (Network)

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

Application:

Metro Bilbao (V):

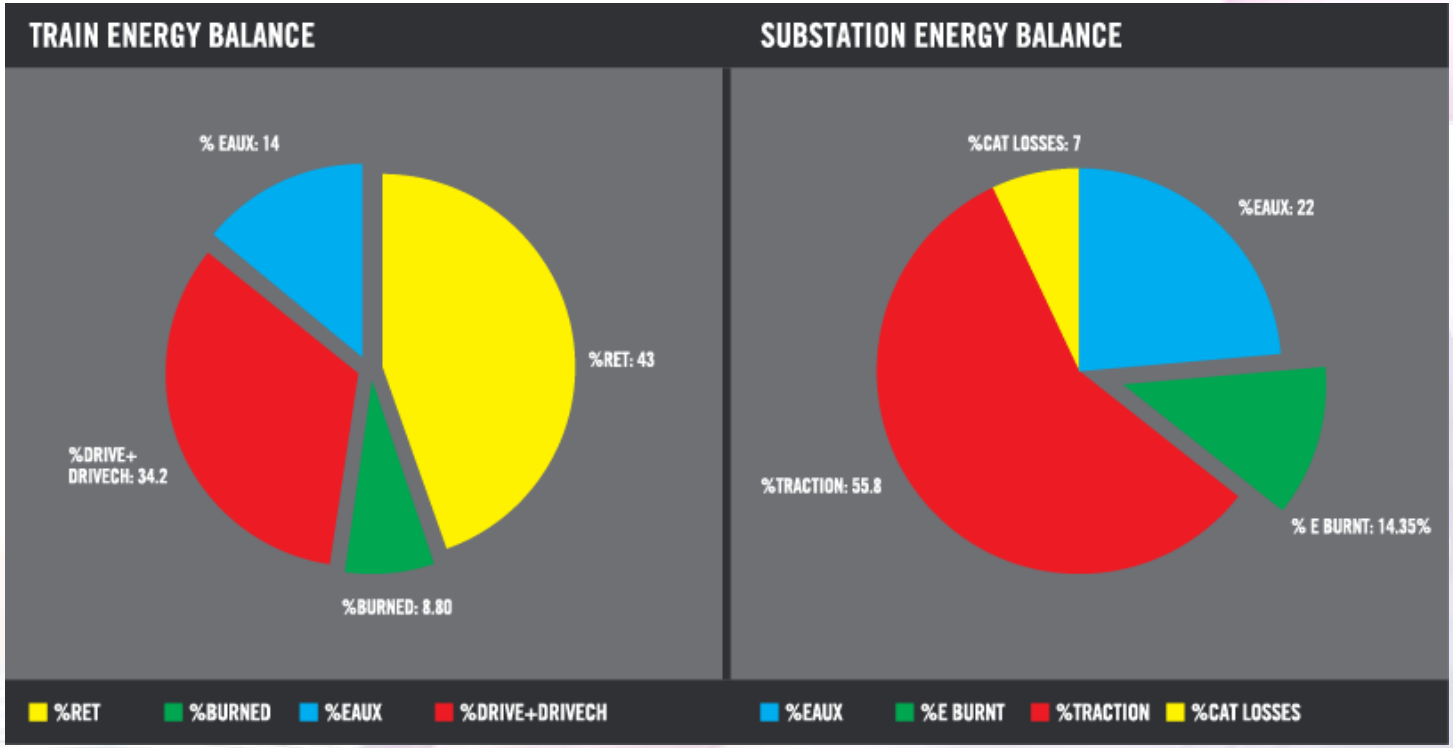
Energy Flow



Application:

Metro Bilbao (VI):

Energy Flow



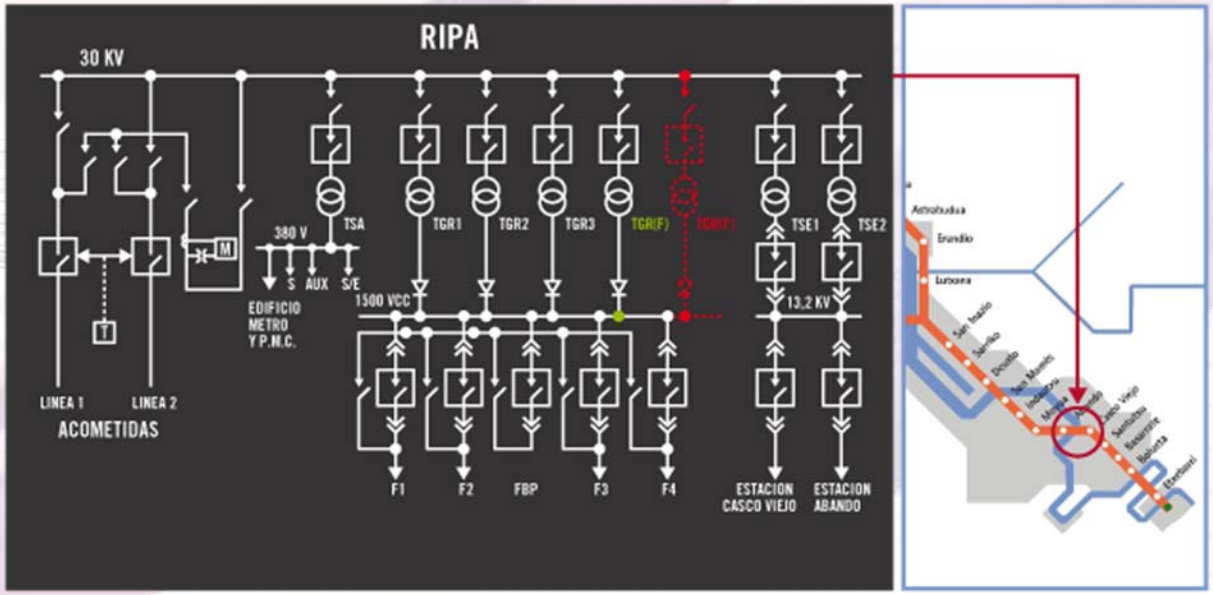
Application:
Metro Bilbao (VII):

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.



Application:
Metro Bilbao (VIII):

Savings on prototype installed

REAL DATA

85	Working days	2,640 kWh/day	Recovery per week= 23,080 kW/h/week		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

Application:

Metro Bilbao (X):

Prototype installed

POWER EQUIPMENT

CONTROL: ON-SITE OR REMOTE

Application:

Metro Bilbao (X):

Prototype installed

INGEBER System fitted on a 7,5 sq.m

Ingeber system installed on Ripa substation

INDEX :

- INGEBER System: Introduction
- INGEBER: Implementation phases
- Application: Metro Bilbao
- What to do with the energy recovered?

What to do with the energy recovered?

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).

What to do with the energy recovered? (II)

«Disposición adicional duodécima. *Vertidos a la red de energía eléctrica para consumidores que implanten sistemas de ahorro y eficiencia.*

1. Los consumidores de energía eléctrica conectados en alta tensión que debido a la implantación de un sistema de ahorro y eficiencia energética dispongan en determinados momentos de energía eléctrica que no pueda ser consumida en su propia instalación podrán ser autorizados excepcionalmente por la Dirección General de Política Energética y Minas del Ministerio de Industria, Turismo y Comercio, a verter dicha energía a la red siempre que cumplan los siguientes requisitos:

a) Que presenten certificado del gestor de la red a la que estén conectados acreditativo de haber obtenido el derecho de acceso para verter energía eléctrica de conformidad con lo previsto en el Título IV de este real decreto.

b) Que presenten un proyecto de las medidas de ahorro y eficiencia a adoptar indicando la incidencia en su consumo de energía eléctrica.

2. Para la facturación del suministro la energía vertida a la que se refiere el apartado anterior será descontada en cada hora de la energía eléctrica adquirida por el titular de la instalación. El saldo horario resultante entre la energía eléctrica adquirida y la energía vertida a la red no será en ningún caso negativo.

3. La energía vertida, a la que se refiere el apartado 1, podrá ser objeto de expedición de las garantías de origen de eficiencia que reglamentariamente se establezcan.

What to do with the energy recovered? (III)

Certificate by Electricity distribution Co.

IBERDROLA

Certificado de concesión del permiso de conexión a la red de distribución

Dña. Ana Lafuente González, con N.I.F. nº 21.470.355-Q, en nombre y representación de la empresa IBERDROLA DISTRIBUCION ELECTRICA, S.A.U., propietaria del punto de conexión de la red de distribución.

CERTIFICO

Para el proyecto "Mejora de la eficiencia energética y reutilización de energía limpia en Metro Bilbao" ubicado en las líneas de 30 kV Larraskitu-Metro I y II, STC 8252 "Metro Bilbao Ripa" de potencia 1.500 (kW) y cuyo titular es Metro Bilbao, lo siguiente:

1. La instalación puede afectar a la red de transporte o a la operación del sistema según lo establecido en el artículo 63 del Real Decreto 1955/2000, de 1 de diciembre, por lo que se ha dado traslado de este hecho al operador del sistema y gestor de la red de transporte, quien ha informado al respecto de forma:

   a. Favorable ☐
   b. Desfavorable o informativa ☐

   La instalación no se encuentra en el ámbito de aplicación del artículo 63 del Real Decreto 1955/2000, de 1 de diciembre, por lo que no se ha dado traslado de este hecho al operador del sistema y gestor de la red de transporte. ☒

   (Marcar la opción que corresponda de las tres anteriores)

2. A la instalación le ha sido otorgado permiso de conexión a la red con fecha 24 de Agosto de 2009

3. El permiso de conexión referido sigue vigente a la fecha del presente certificado.

4. El punto de conexión se encuentra en STC 8252 "Metro Bilbao Ripa" y su ubicación detallada es: líneas de 30 kV Laraskitu-Metro I y II, STC 8252 "Metro Bilbao Ripa"

Fdo.: DÑA. ANA LAFUENTE GONZALEZ

IBERDROLA DISTRIBUCIÓN ELÉCTRICA

Fecha: 27-10-2009

El documento de apoderamiento obra en poder de la Dirección General de Política Energética y Minas, del Ministerio de Industria, Turismo y Comercio.

THANK YOU
FOR YOUR ATTENTION