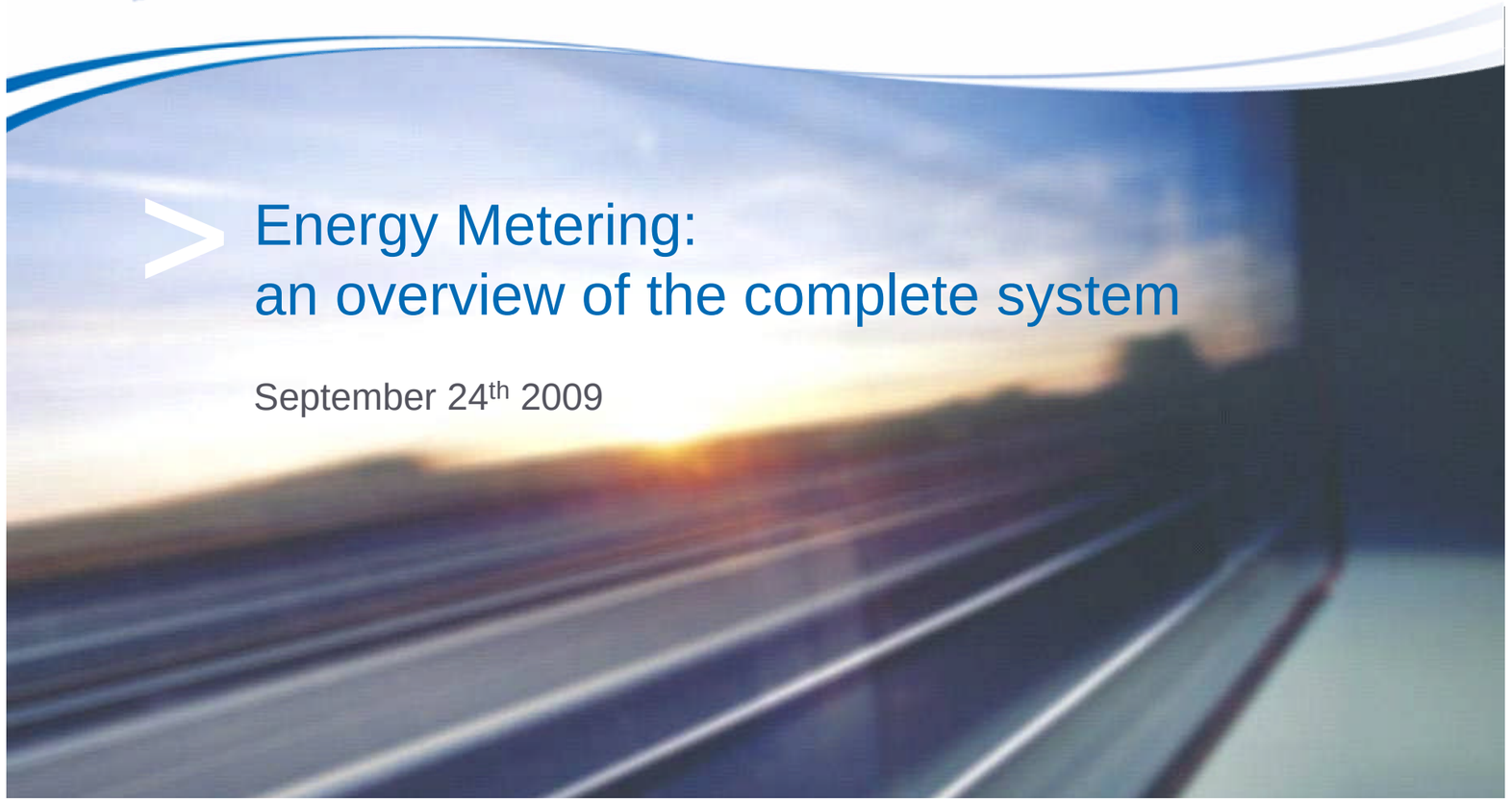
Infrabel

When rail
means service



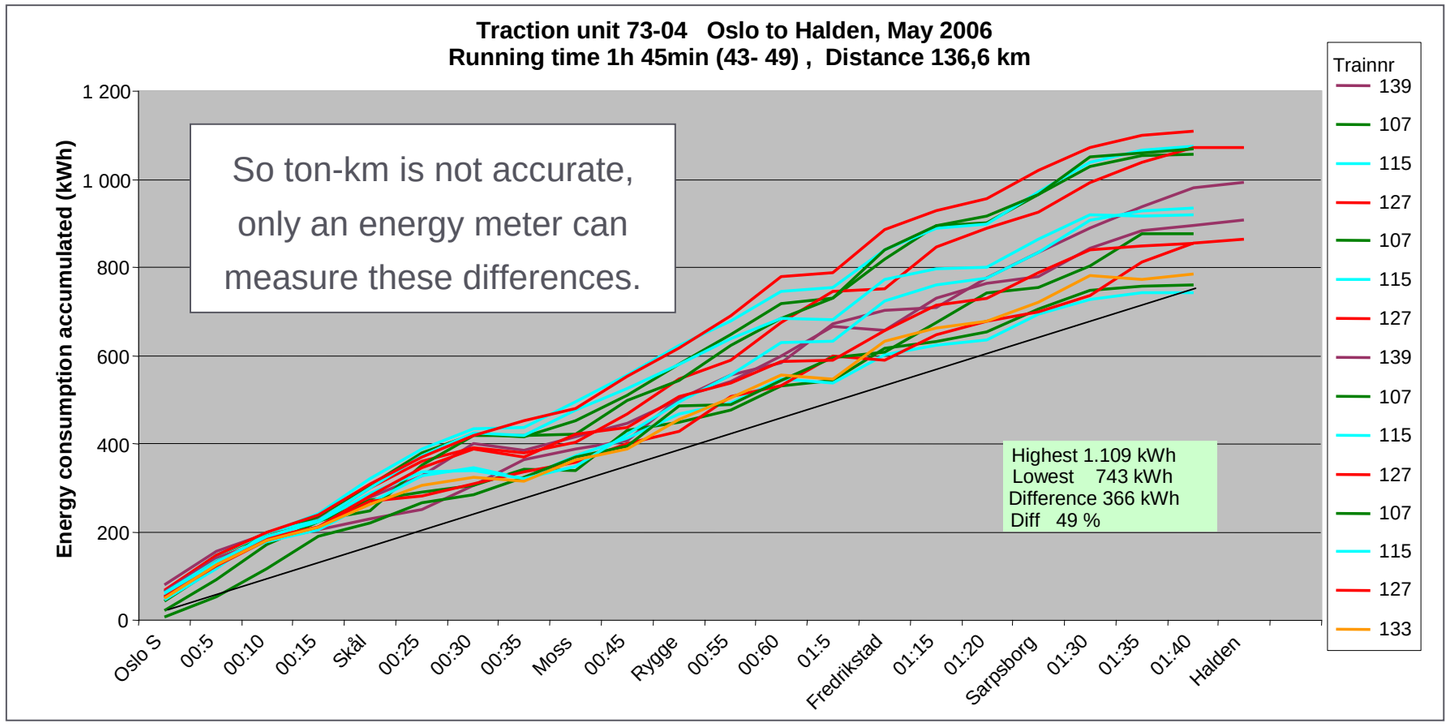
Energy Metering:
an overview of the complete system

September 24th 2009

Bart Van der Spiegel
Energy Management

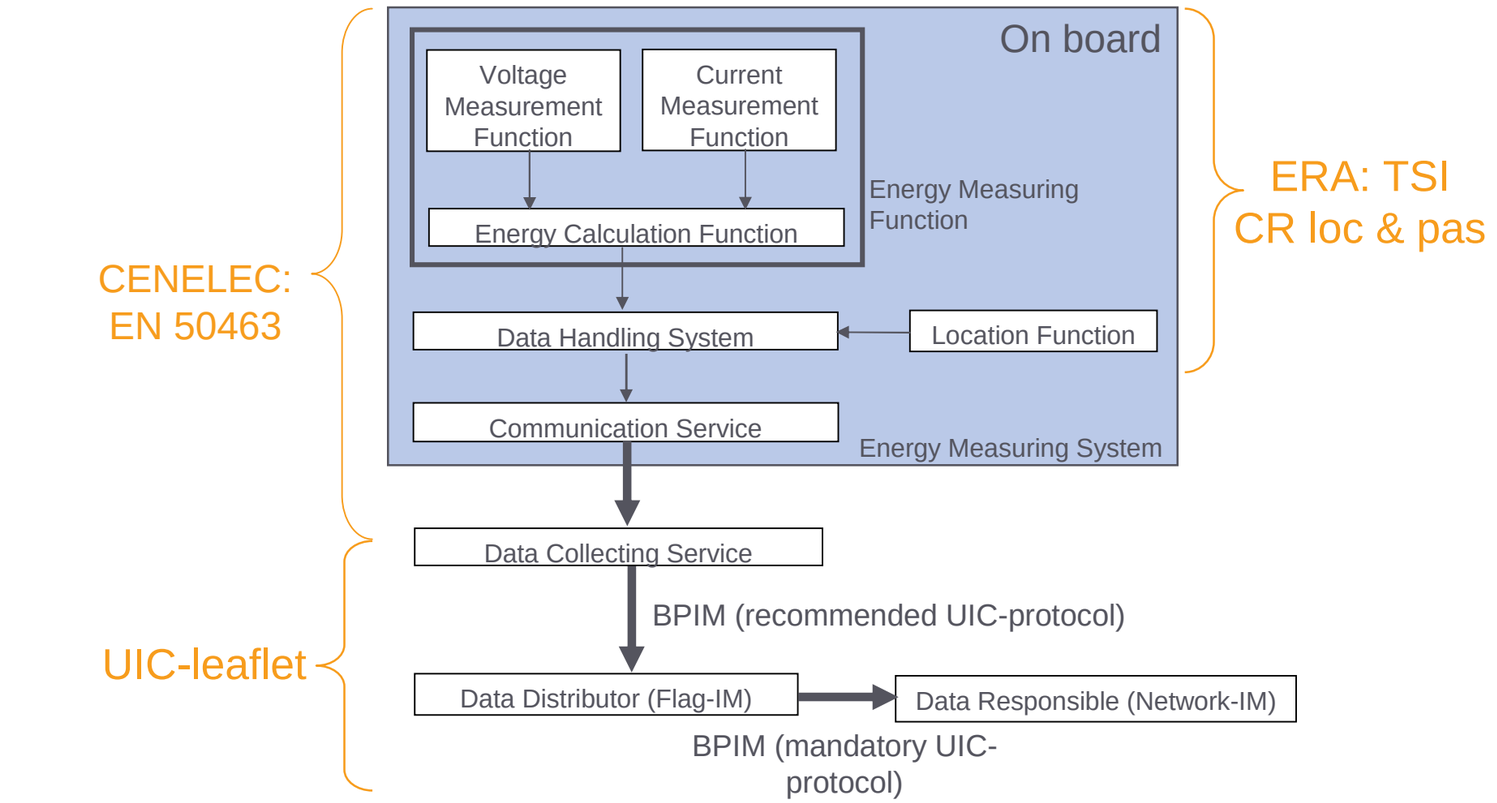

Östersund
Örnsköldsvik
Härnösand
Sundsvall
Electricity bill to
Railway Undertaking
Sogndal
Bergen
OSLO
Network-IM
Drammen
Moss
Stavanger
Kristiansand
Frederikshavn
Aalborg
Århus
DENMARK
KØBENHAVN
Göteborg
Jönköping
Västerås
Uppsala
STOCKHOLM
Flag-IM
Nyköping
Linköping
Karlskrona
Sea
OK
Date Time Code 1 5
2002/10/02 12:18:00 00 00025 00000
2002/10/02 12:17:00 00 00018 00000
2002/10/02 12:16:00 00 00022 00000
2002/10/02 12:15:00 00 00037 00000
2002/10/02 12:14:00 00 00032 00000
2002/10/02 12:13:00 00 00076 00000
2002/10/02 12:12:00 00 00035 00000
00035

The need to measure the energy consumption



Data supplied by ERESS and analysed by NSB AS

Energy measuring

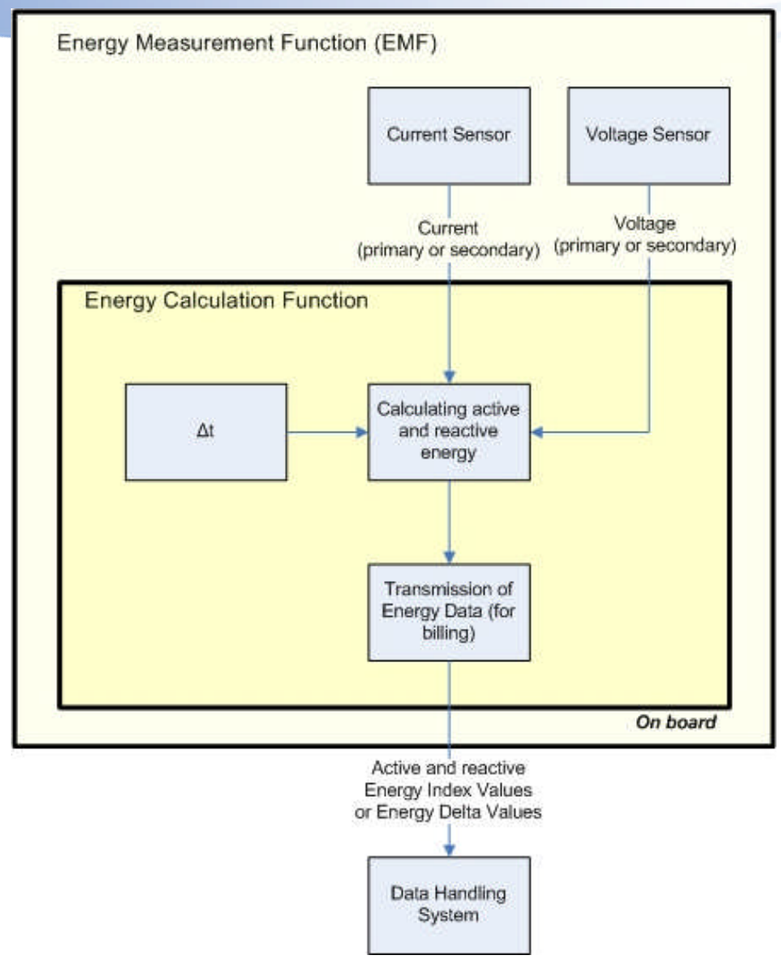


The on board Energy Measuring System

Trains generally use the following voltage systems U_n:
- 25 kV / 50 Hz
- 15 kV /16,7 Hz
- d.c.: 750 V; 1500 V or 3000 V

Big fluctuations on voltage are permitted, e.g. from 2000 V (U_{min1}) to 3900 V (U_{max2}) for a 3000 V-grid.

Some trains can run on different voltage systems.



The on board Energy Measuring System

Overall accuracy based on next formula:

$$A_{overall} = \sqrt{A_{current}^{2} + A_{voltage}^{2} + A_{energy\ meter}^{2}}$$

These are the accuracies for new equipments to be tested in laboratories under the following conditions:

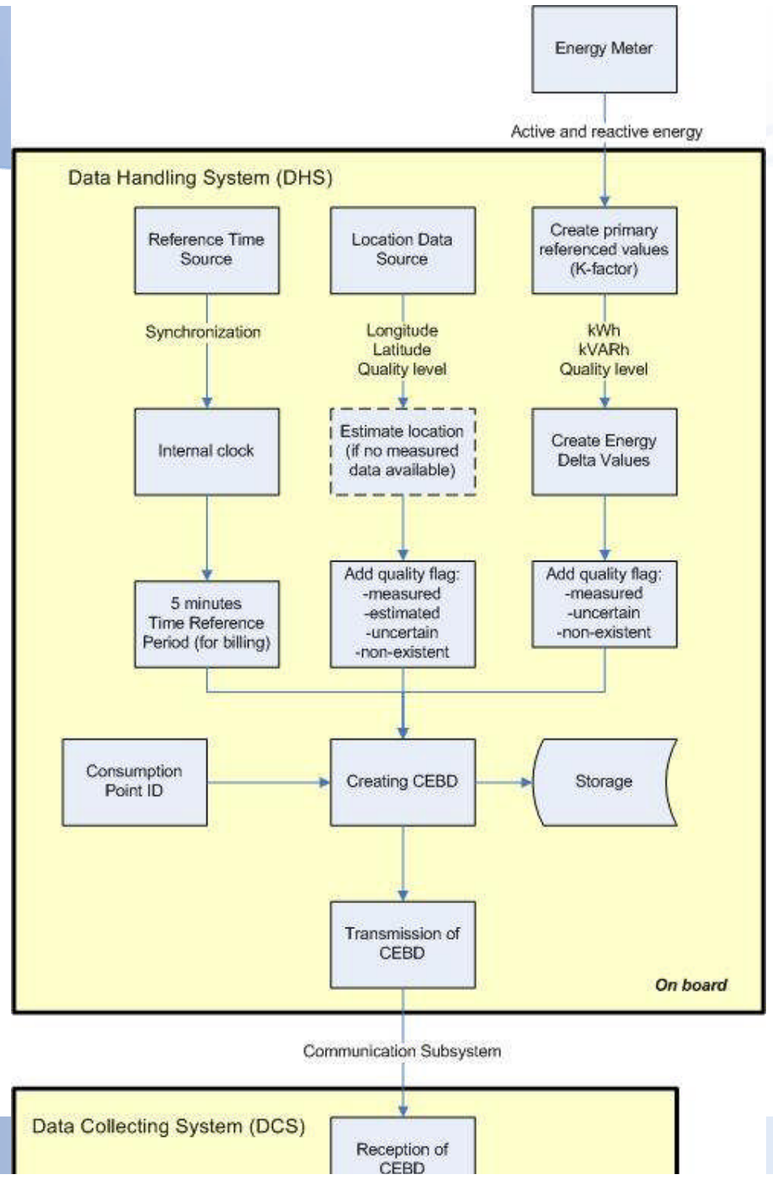
- voltage at input of Voltage Sensor in between U_{min1} and U_{max2}
- current through Current Sensor in between 10 % I_n and 120 % I_n (with I_n the Rated Primary Current of the EMF)
- ambient temperature of 23°C (± 2°C)
- other reference conditions and influence parameters

NOTE The EMF shall be chosen in such a way that the nominal current of a Traction Unit is in between 80 % and 120 % of the Rated Primary Current of the EMF.

The on board
Energy Measuring System

Every 5 minutes the next set of data is produced:

- → date-timestamp
- → active and reactive energy (consumed and regenerated)
- → last known location (longitude and latitude)
- → unique identifier (Consumption Point ID)



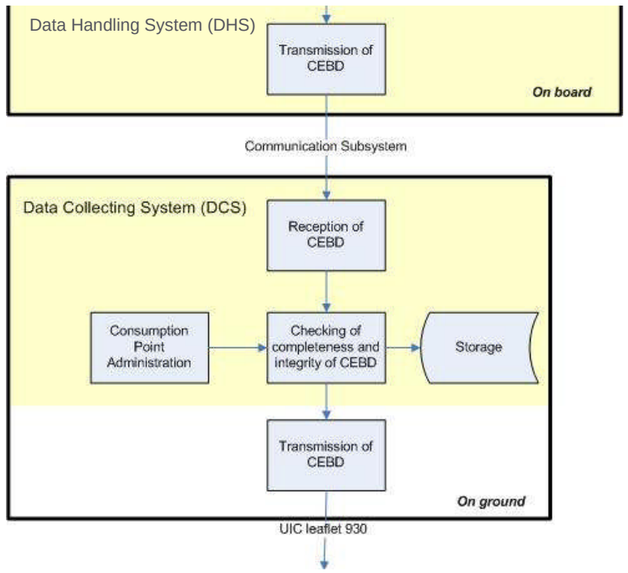
Energy Managing and Billing

The data created on board is transmitted to ground at least once a day.

This has to be done using mobile communication. Actually different solution are already operational, e.g. GPRS, WiFi, serial communication on GSM-R.

A standard XML is proposed for this communication.

The data is received in a Data Collecting Server. The format is changed into a standardized UTIL-TS message based on ebIX-methodology (format similar to format used by ENTSO-e with added features for location).



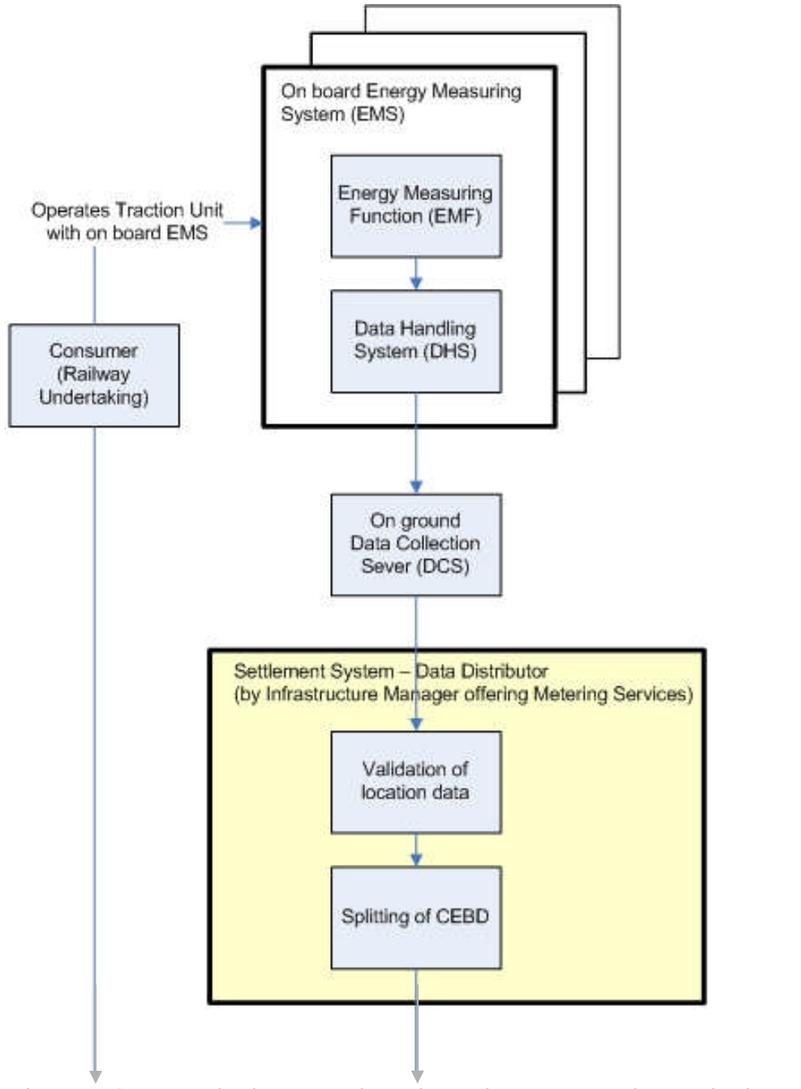
Energy Managing and Billing

The data coming from the Data Collecting Servers is transmitted to a first Settlement System from the Infrastructure Manager offering Metering Services (flag-IM).

The Location Data is validated. This data is necessary to determine where the consumption took place.

The data is distributed to the Settlement System of the Infrastructure Manager owning the network where the consumption took place (network-IM).

Also for this communication the exact UTIL-TS protocol is ready.

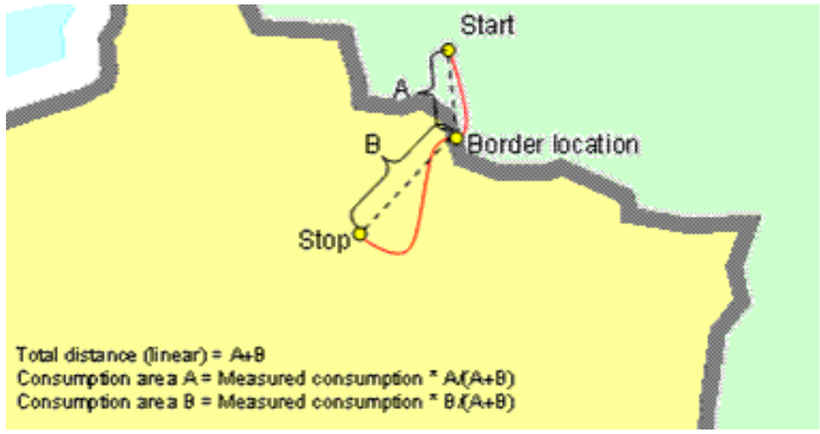


Energy Managing and Billing

When a train crosses a border, the consumption of the five minutes is divided in a consumption in country A and a consumption in country B.

The data is distributed by using a simple linear interpolation.

NOTE Special treatment is foreseen for more difficult border crossings.



Energy Managing and Billing

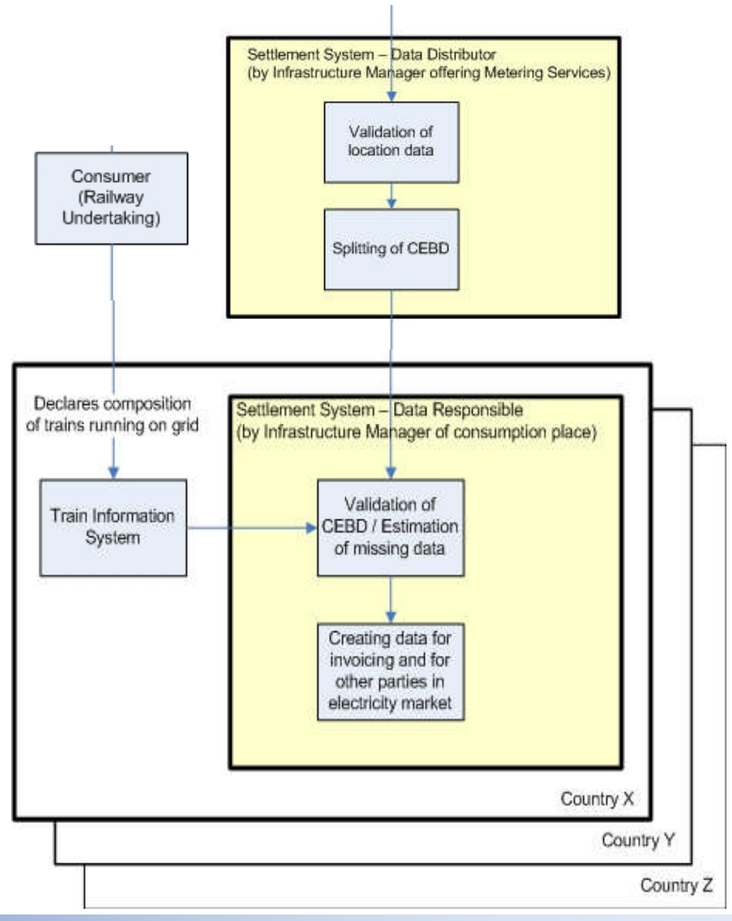
The Network-IM needs to:

→ validate the measured data

→ estimate the consumption of trains (or parts of a train) without meter

To be able to fulfill this role, he needs to have the exact composition of all trains running on the network.

For the transfer of data from Train Information System to Settlement System, an XML-file format is under development (at ERESS).



ERA

ERA, the European Railway Agency, is appointed to develop the TSI's, needed to be able to implement the Railway Directives.

- → Directives: essential requirements
- → TSI: more detail on how to implement, but still only the basic parameters
- → TSI can refer to EN => harmonised European Standard
- → Standards remain voluntary

ERA

Directive 2008/57/EC ANNEX II - 2. Description of the subsystems - 2.2. Energy

The electrification system, including overhead lines and ***on-board parts of the electric consumptions measuring equipment****.*

Energy TSI - 4.2.21. Electric energy consumption measuring – **DRAFT !**

→ *requirements are set out in the CR LOC&PAS TSI.*

→ *not mandatory.*

→ *when required for billing purposes, it shall be compatible with CR LOC&PAS TSI clause 4.2.8.2.8 and data provided by this system shall be accepted for billing.*

Infrabel

ERA

All equipment fulfilling these basic parameters and accepted by a Notified Body in one Member State shall be accepted in other Member States.

CR LOC&PAS TSI - 4.2.8.2.8 Energy Consumption Measuring Function – **DRAFT !**

→ *only for Electric units*

→ *if a electric unit is required to be fitted with an energy measuring system intended to be used for energy billing purpose, this energy measuring system shall comply with the requirements of the Annex D*

→ *recorded in the rolling stock register*

Annex D of this CR LOC&PAS TSI has the basic parameters.

European Railway Agency

Next steps: workshop, legal acceptance Member States, translation, cross-check

Publication expected spring 2011

CENELEC

SCOPE OF NEW WORK ITEM FOR TC9X – WG11

This Series of European Standards applies to newly manufactured energy measurement systems for use on on-board traction units powered by ac and/or dc supply voltages as listed in EN 50163.

The Energy Management System (EMS) shall be capable of metering, storing and transmitting data on board and on board to ground of energy absorbed and regenerated on board of the train, taking into account the interoperability requirements.

Standardization is a difficult process that continues till late at night.

CENELEC: ready for secretary enquiry

EN 50463-1

Scope, general architecture, document structure, normative references, general requirements

Ready October

EN 50463-2

The measurement chain from the voltage/current sensors to the energy meter

Ready October

EN 50463-3

All the input/output data handling (location, time, unique ID,...) and the storage of the data on board

Ready October

EN 50463

System Standard functional approach

EN 50463-4

On-board and "on-board to ground" communication systems

Ready October or December

EN 50463-5

Conformity assessment of the complete Energy Measuring System while installed on board

Ready December

May 2010: prEN for comments
December 2010: fprEN for voting

Publication expected summer 2011

UIC-Working Group Bergen, January 2006
Saraha and Knut, the first positive result of the Railway Energy Metering-project.

UIC defines roles:

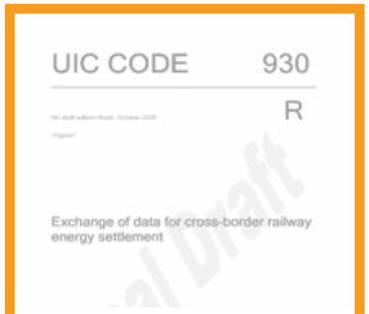
- → Railway Undertaking can own the equipment on board and transmit the data to a Data Collecting Server (outside scope of leaflet).
- → An IM must take responsibility on the collection of the data and e.g. require an external audit to check the process. This flag-IM shall also distribute the data to the IM owning the grid on which the consumption took place (= network-IM).
- → The network-IM shall validate this data, shall estimate missing data and shall create the data needed for invoicing the customer (Railway Undertaking running the train)
- → Leaflet doesn't define if network-IM should invoice. This could also be an electricity supplier, a one-stop-shop or …

Publication
September
2009

UIC

Added to leaflet during 2009:

- → Annex with border crossings coordinates and methods on how to split the data on complex border crossings
- → Annex with recommendations for validation of metered data and estimation of unmetered data
- → Annex with recommandations to help Railway Undertaking to control their invoices (available data, published method)



Feb 3rd 2010
UIC Metering and Billing Forum

EIM: Position Paper, July 2009

- *Any infrastructure manager should be able to use the data coming from such standard energy meters. Where fitted the Energy TSI should make the usage of data coming from interoperable on board Energy Measuring Systems mandatory.*
- *A settlement system should be designed to support the varying requirements of the electricity suppliers and the commercial contracts in place across the member states of Europe without impacting the operation of the railway.*
- *It is recognized that both the railway and electricity supply industry will benefit if the settlement system is standardized. It will be beneficial to the railway and electricity supply industry if the settlement system is certified to a European Standard.*

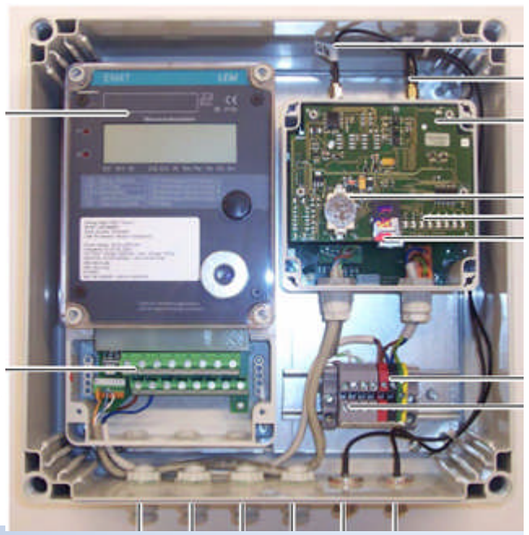
Traction Energy as essential service for Infrabel

- → Delivering traction energy is considered to be an essential service of Infrabel.
- → Actually traction energy is invoiced using estimations based on the transported ton-km.
- → Infrabel needs to find better solutions.
- → Solution: measuring the consumed and regenerated energy.
- → To be able to manage the data of such energy meters, Infrabel joined ERESS, the European Railway Energy Settlement System

Benefits of ERESS for Infrabel

- → Possibility to offer competitive solutions for metering equipment to be installed by Railway Undertakings on their rolling stock
- → Reading out and validating the Energy Data coming from these meters
- → Validating Energy Data coming from other meters
- → Estimating consumption of trains without meters
- → Preparing data for invoicing to Railway Undertaking based on measurements and estimations

Check out website:
www.eress.eu



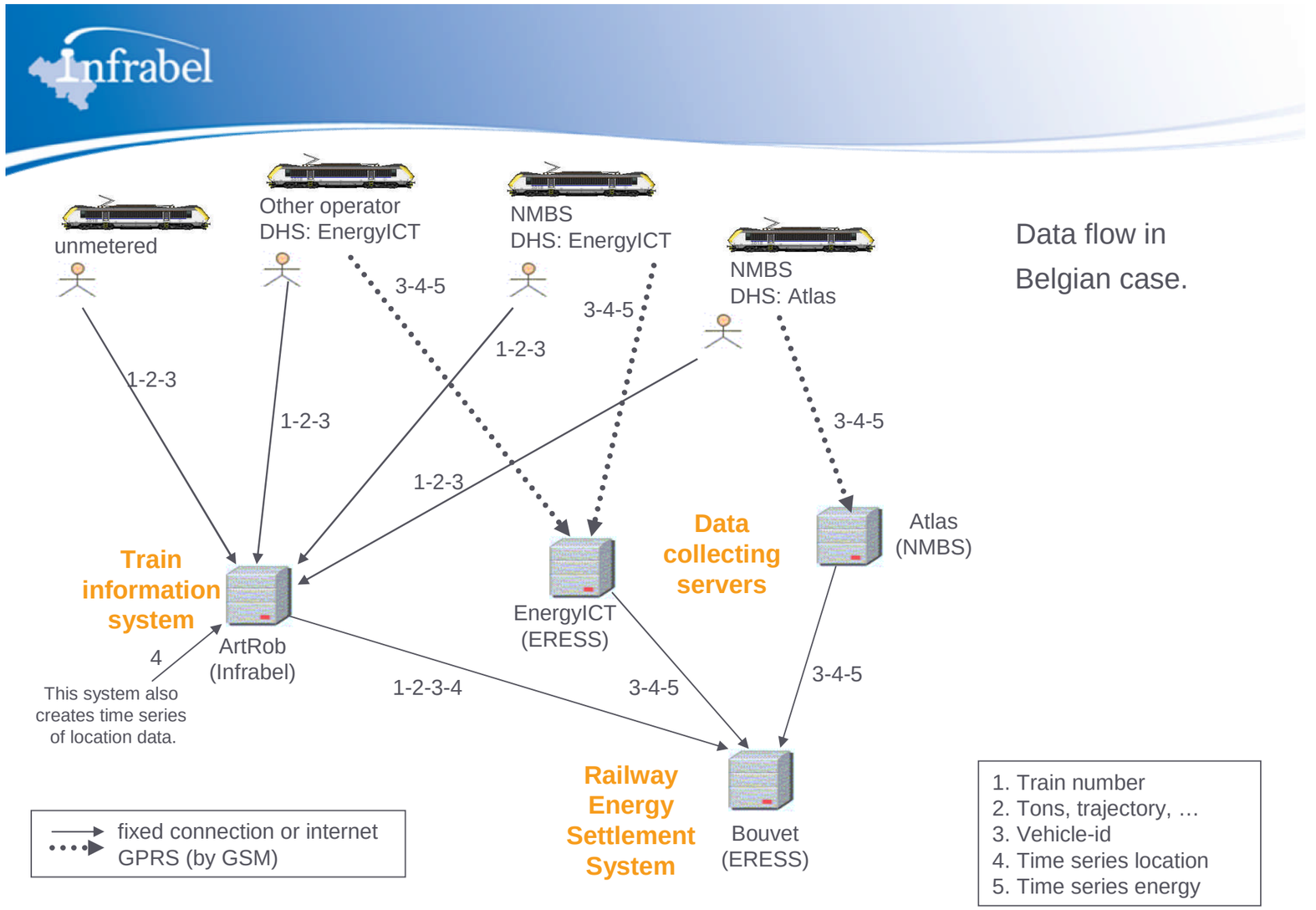
Energy Measuring Unit offered through ERESS

Masterplan Efficient Traction Electricity

This plan is approved by the Executive Committee Infrabel on June 17th 2009 and has the ambition to reduce the CO2-impact by passenger-km and by ton-km.

This plan contains the following measures:

- offer 20 meters to be installed on board of trains running on our grid (as a pilot project)
- invoicing based on metering starting from January 2011
- optimizing the purchasing and the use of transformer-rectifiers
- assigning a manager responsible for energy consumption
- organizing workshop and communication campaign to reduce consumption
- make real time data available for driver assistance tools
- use energy efficiency as criterion when calculating train paths



Data flow in Belgian case.

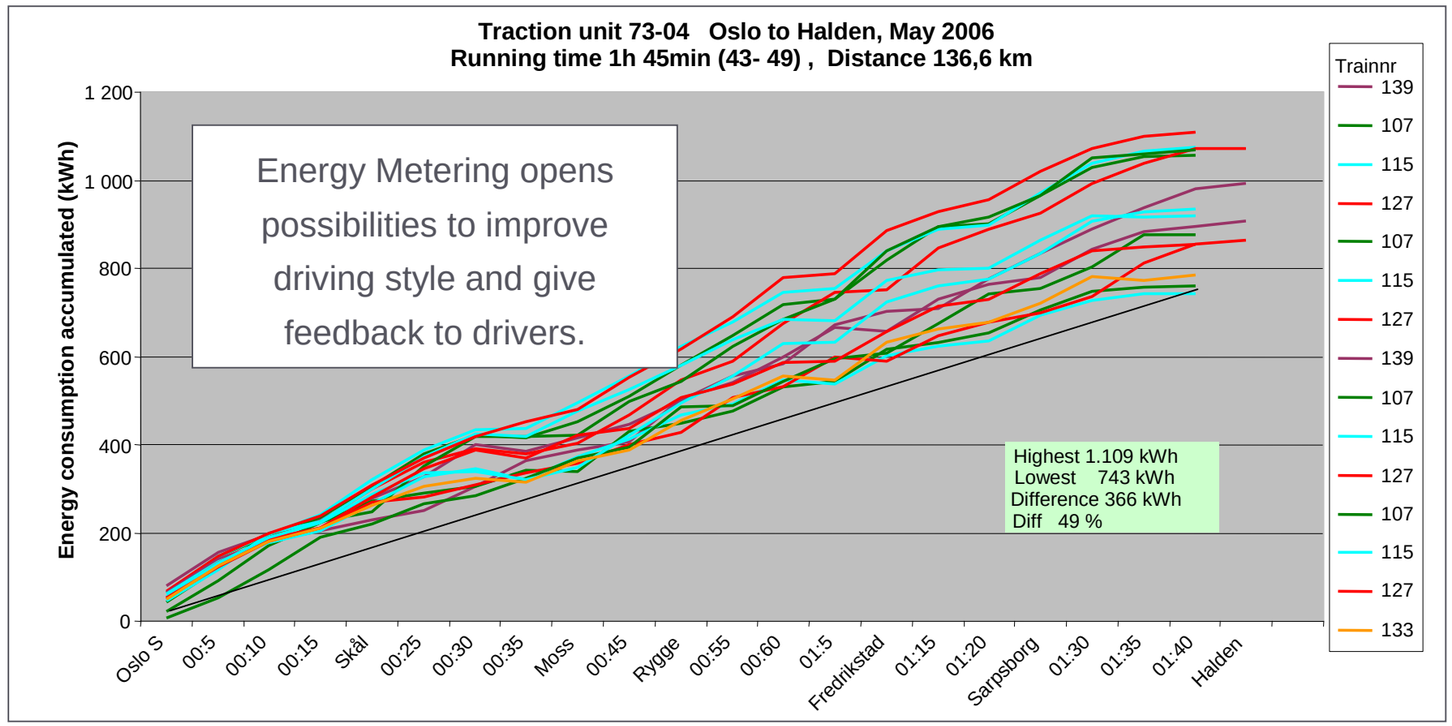
Meters on all new trains of NMBS

- → Direction Committee of NMBS agreed on May 5th to install on board EMS on all new Traction Units (including locomotives type 18 and the 305 RER-consists, both manufactured by Siemens).
- → The accuracy shall be in conformance with the CR loc&pas TSI (in approval). After approval of TSI, the conformance shall be tested by Notified Body.
- → NMBS will use the existing ATLAS (EBI star and ground from Bombardier) to store the data on board and transmit the data to ground.
- → Infrabel will order an external audit to check the integrity on this data flow. *Can the data stored in the Data Collecting Server (of the Railway Undertaking) be trusted to be used for billing?*
- → The ground server of ATLAS will transfer the data format to the UTIL-TS messages defined in the UIC-leaflet 930 to the Settlement Server of ERESS.

Invoicing based on measured data

- Infrabel shall use the consumption recorded by the on board EMS starting from January 2011 (if annex of Network Statement get adjusted this autumn).
- A coefficient will be added to take into account the losses in the substation and on the Overhead Contact Line.
- We will use three different tariff periods (approximate prices):
  - PEAK: ± 180 EUR/MWh
  - DAY: ± 90 EUR/MWh
  - NIGHT and WEEKEND: ± 60 EUR/MWh

Huge opportunities for saving energy



Data supplied by ERESS and analysed by NSB AS

Is retrofitting profitable?

Business case for Belgium (hypothesis)

Onboard equipment	
Number of engines to be equipped	1400
Unitary investment & installation cost per metering equipment (€)	12.000 €
Rythm of equipment (% per year)	15%
Annual maintenance cost per equipment (€)	500 €
Metering equipment lifetime (in years)	8
Metering equipment replacement cost (€)	6.000 €
Unitary driving assistance system cost (€)	2.000 €

Drivers' training & management	
Ratio of the number of drivers / engine	3
Rythm of drivers training (% per year)	20%
Total training cost per driver (€)	2.000 €

Is retrofitting profitable?

Business case for Belgium (hypothesis)

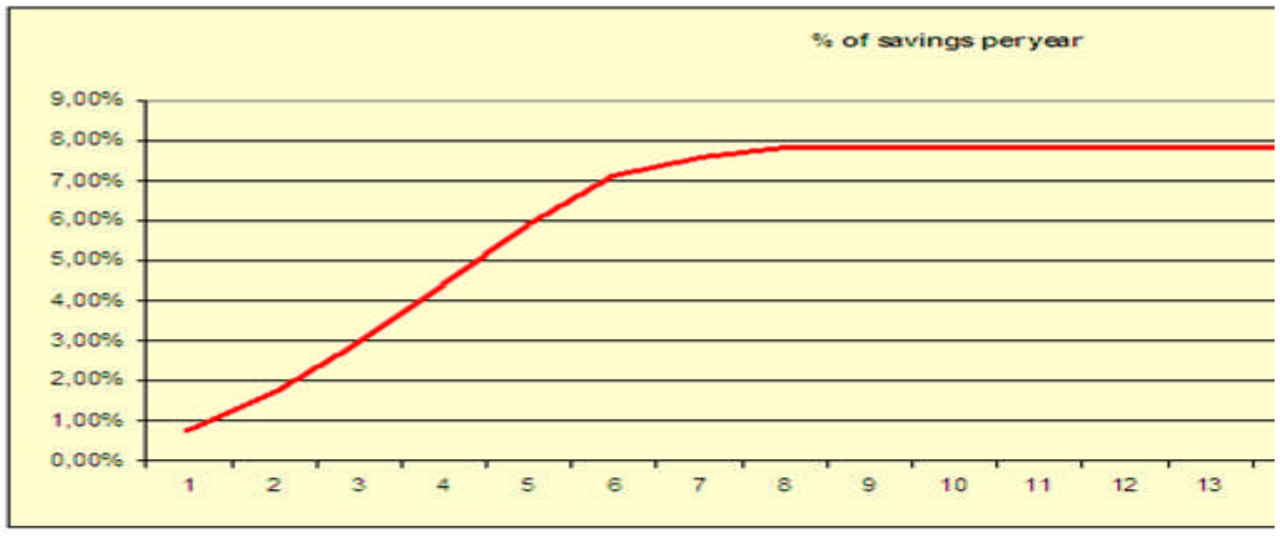
By joining ERESS, we only paid a fourth of this. In ERESS these costs are equally split among the partners.

Software & Communication	
Initial software investment costs (€)	2.000.000 €
Annual software maintenance & operating costs (€)	500.000 €
Annual communication costs per metering equipment (€)	200 €

Economic parameters	
Potential of energy savings per trained driver (%)	5%
Number of years to achieve potential (training time included)	4
Potential of energy savings through schedule optimization	3%
Number of years to achieve potential	6
Unitary annual consumption per engine (MWH)	2000
Actualisation rate	4,00%
Electricity price per MWH (including transport)	100 €

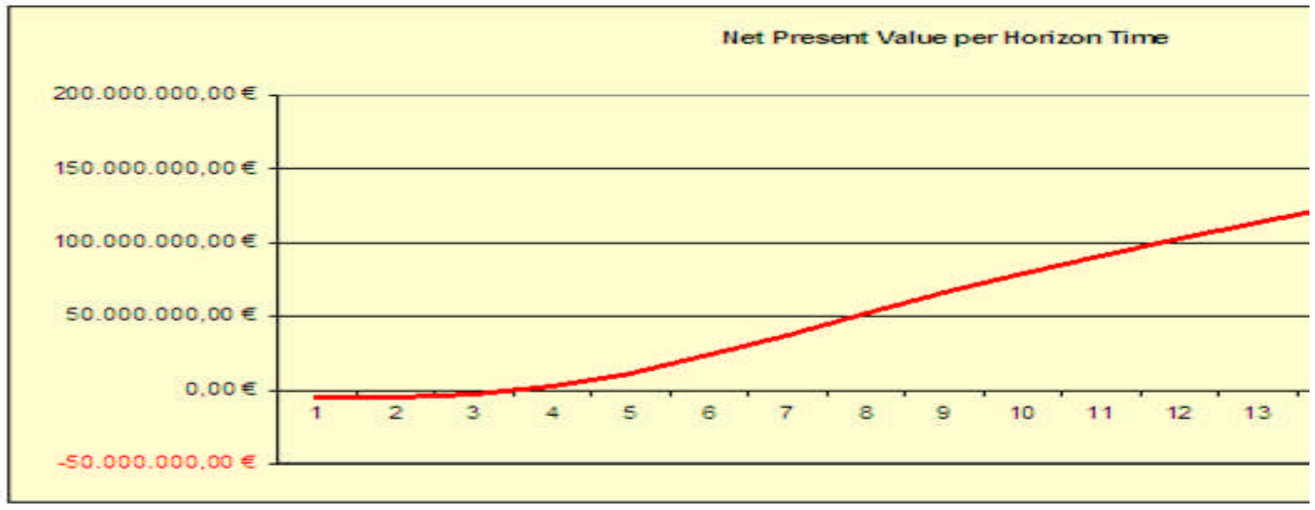
Retrofitting is profitable!

Business case for Belgium (results)



Retrofitting is profitable!

Business case for Belgium (results)



Thank you for your attention!

Questions are possible during panel discussion or during breaks.

More information: www.eress.eu