

13th UIC Sustainability Conference



Railway electrical smart grids

A powerful tool towards the
sustainability

Eduardo Pilo de la Fuente
EP Rail R&C



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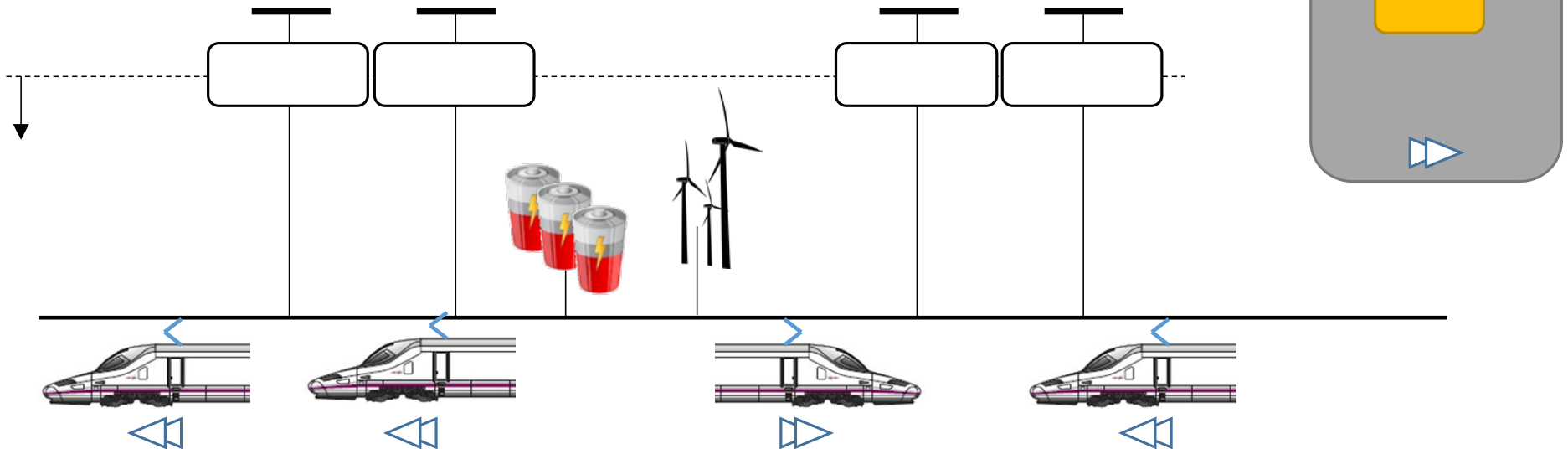


- Railway smart grids (RSG): a new paradigm
- Why are RSG useful to improve sustainability?
- What can we achieve with railway smart grids?



RSG: a new paradigm (1/4)

- Typical traffic and electrification operation:

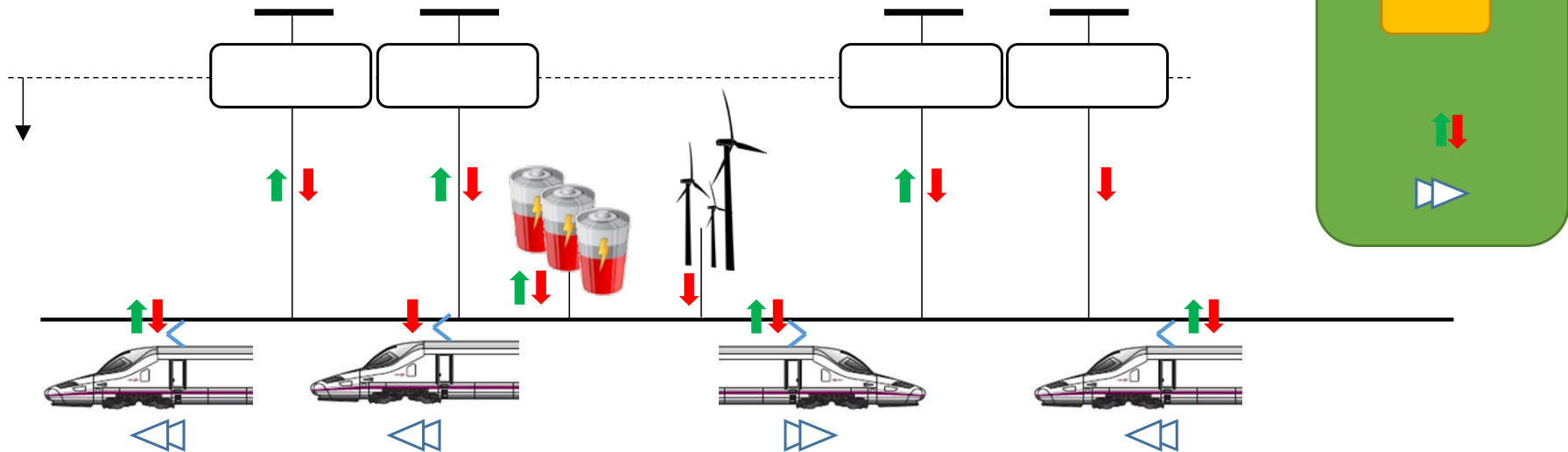


- Traffic flow controlled by the RSO (=IM)
- Trains consume power as they need, **as if the power supply had infinite capacity**
- Very few control actions in the electrification (usually, mainly topology modifications)



RSG: a new paradigm (2/4)

- In a railway smart grid, the operation scheme is enriched:



- **Traffic flow** and **power flow** both **controlled by the RSO** (=IM), in a coordinated way



RSG: a new paradigm (3/4)



- The concept of **railway smart grid** is **not** itself **related** to **energy efficiency**, but to

Controllability

“Ability to be controlled”, i.e. to respond to new instructions



RSG: a new paradigm (4/4)



- As the **cyber-physical system (CPS)** it is, a railway smart grid requires:
 - **A communications infrastructure**, but also algorithms to deal with communication problems.
 - A **cyber layer** able to **analyze** information received in real time from the elements of the system and **make decisions**, in several time scales.
- The definition of the interfaces will be very relevant to ensure the **interoperability**.



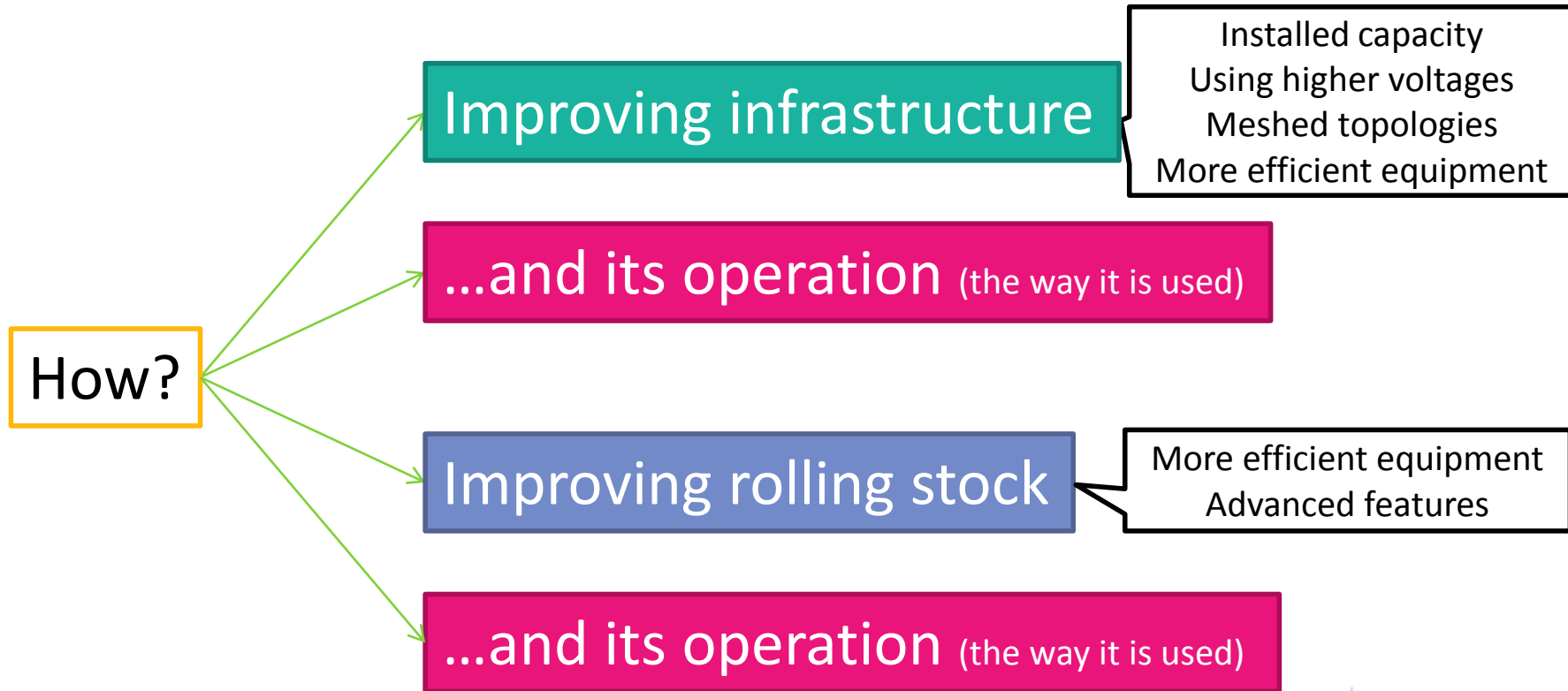
- Railway smart grids (RSG): a new paradigm
- Why are RSG useful to improve sustainability?
- What can we achieve with railway smart grids?



Why are RSGs useful? (1/4)



- In the last decade, **significant advances** in making railways more sustainable and **energy efficient**.



Why are RSGs useful? (2/4)

- To **improve** the operation **energy efficiency** :
 1. **Reducing** the **energy consumption** as much as possible (avoid consuming for returning back later)
 2. **Reducing** the energy wasted in **rheostatic brake** (i.e., increasing the ratio of regenerative braking)
 3. **Reducing losses**



Why are RSGs useful? (3/4)



- Also, **off-line optimizations** have been used and have led to **substantial improvements** so far, but...
- are **not able** to take into account any **unexpected event** that deviates from the planned operation:
 - **Traffic congestions** (different drivings, with more stops)
 - Any manual driving which is too different
 - Any train **propulsion failure**, leading to a power limitation.
 - Changing **weather** conditions (different power consumptions)
 - Any **failure** in the **electrical infrastructure**, introducing a power limitation.
 - etc.



Why are RSGs useful? (4/4)



- Using the **enhanced controllability** the RSG provides, many **purposes** can be pursued:
 - Optimize **energy efficiency** (reduction of amount of energy)
 - Optimize **economic efficiency** (reduction of the energy cost)
 - Improve **resiliency** of the system (management of degraded operation conditions)
 - Improve **quality of the electricity supply**
 - Improve **capacity utilization** (better effectiveness of the investments)
 - Improve **predictability** (important to access the electricity markets)



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What can we achieve with a RSG? (1/4)



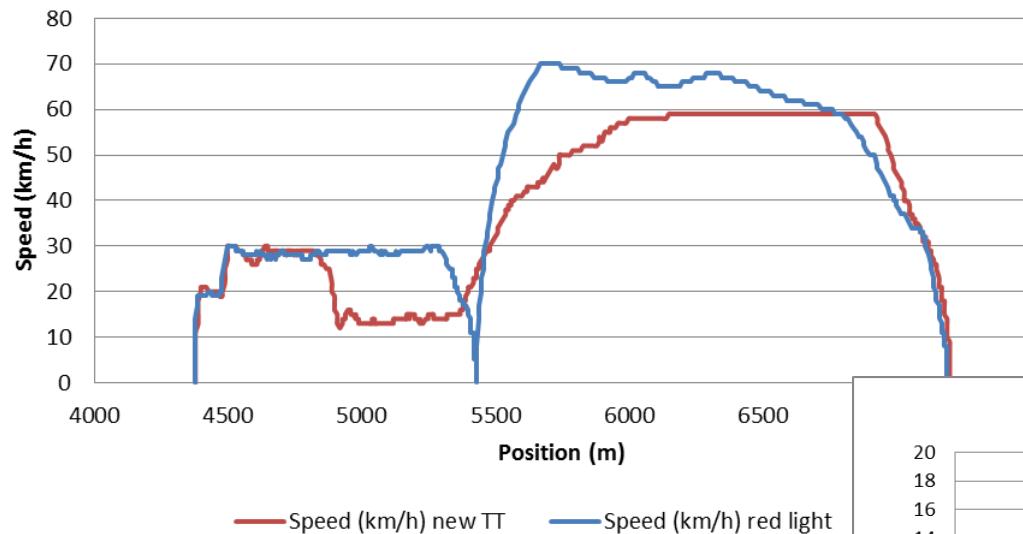
- The railway smart grid **is still a concept under development**, not yet a set of set of products based on standards and ready to be installed.
- In Europe, FP7 project Merlin (2013-15) proposed an **architecture** for the RSG and **analyzed its viability** in 5 scenario cases. Important step, but still not a product.
- Having said this....



What can we achieve with a RSG? (2/4)

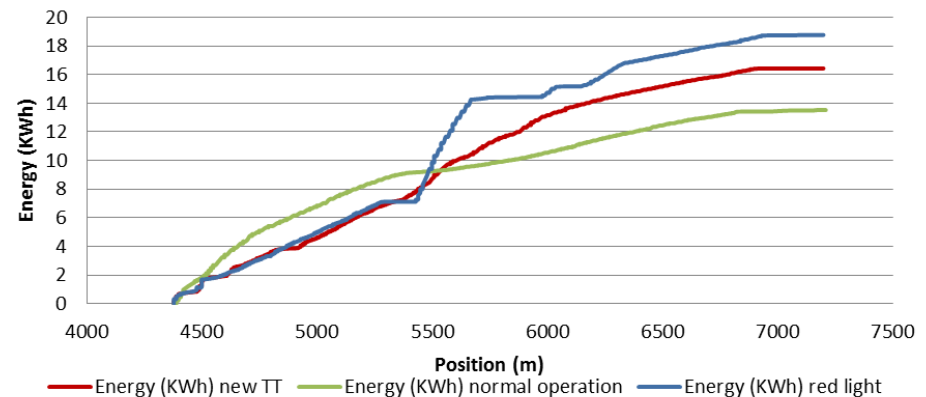
- Example 1. In **congested traffic conditions**, the systems detects a non-planned stop and adapts the train speed profile to **minimize energy consumption**.

Position vs Speed



From FP7 Project MERLIN (Scenario 3)
Prepared by CAF and ADIF.

Position vs Traction Energy

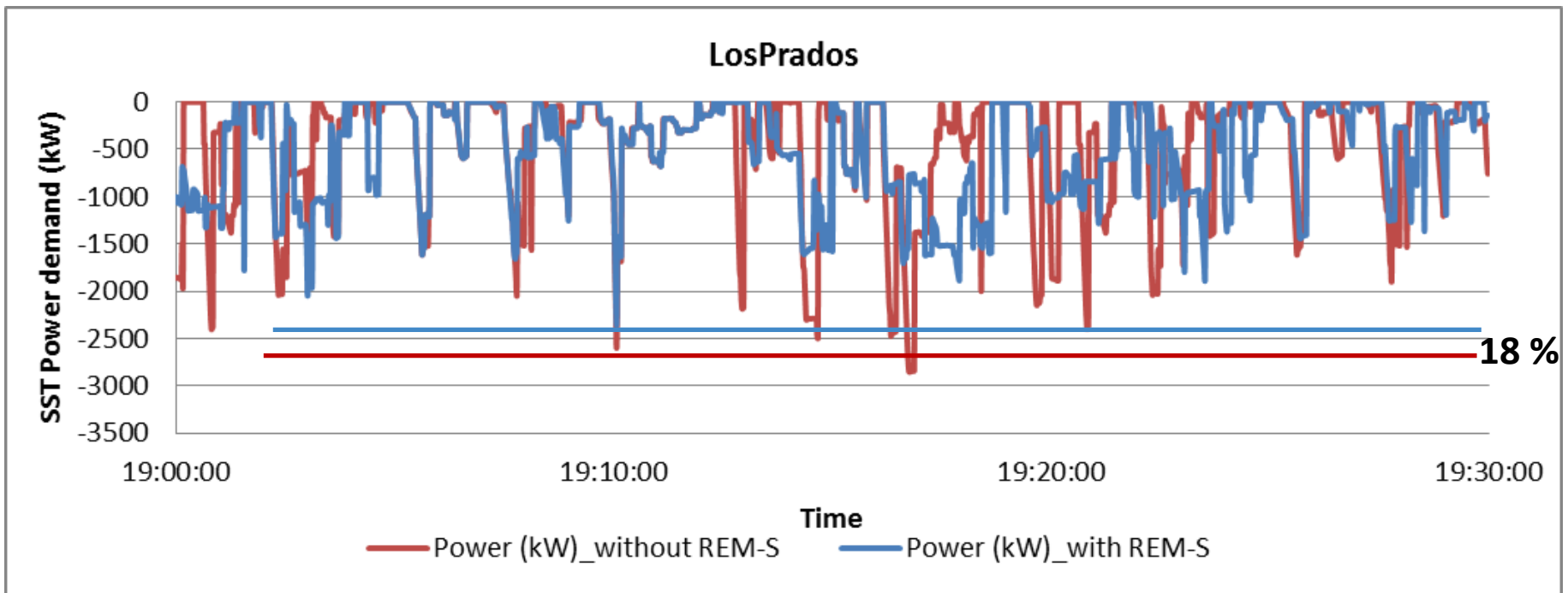


What can we achieve with a RSG? (3/4)



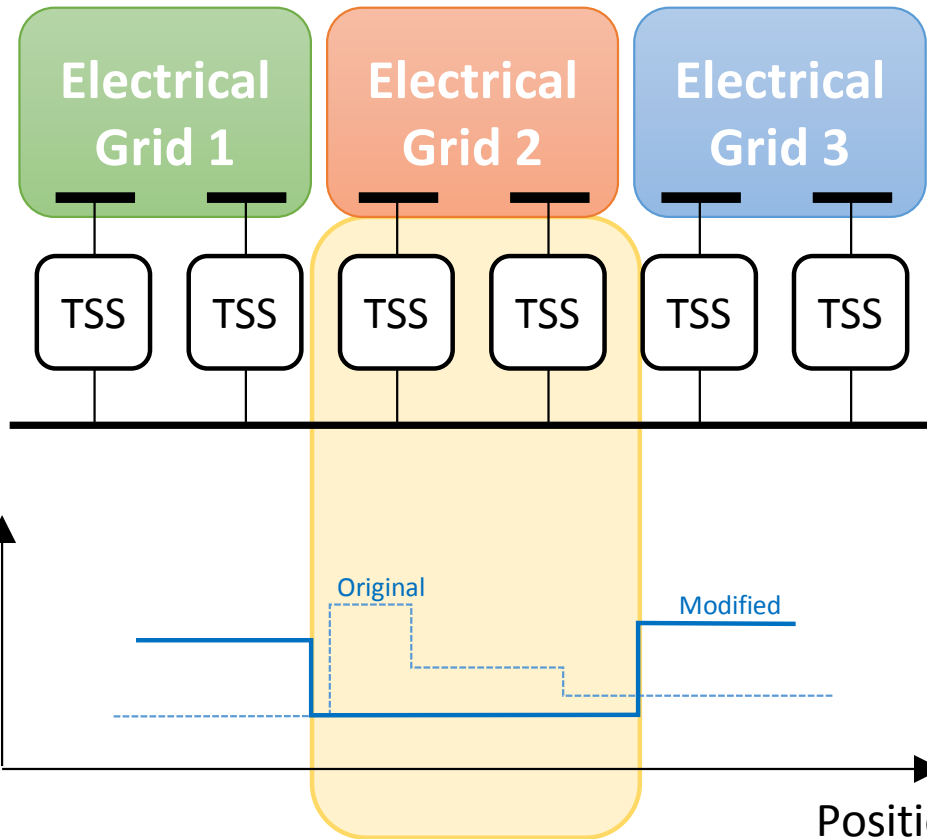
- Example 2. The optimization is configured to **minimize** the **power peak** in a substation.

From FP7 Project MERLIN (Scenario 3)
Prepared by CAF and ADIF.



What can we achieve with a RSG? (4/4)

- Example 3. Energy consumption transfer among areas (f.i, in case of infrastructure capacity limitation).



From E. Pilo, S. Mazumder and I. Gonzalez-Franco
Railway Electrical Smart Grids: An introduction to next-generation railway power systems and their operation.
IEEE Electrification Magazine, 2014, vol. 2, no 3, p. 49-55.

Energy transfer



Thank you for your attention

For any question/comment, you can contact me at:
eduardo.pilo@eprail.com

