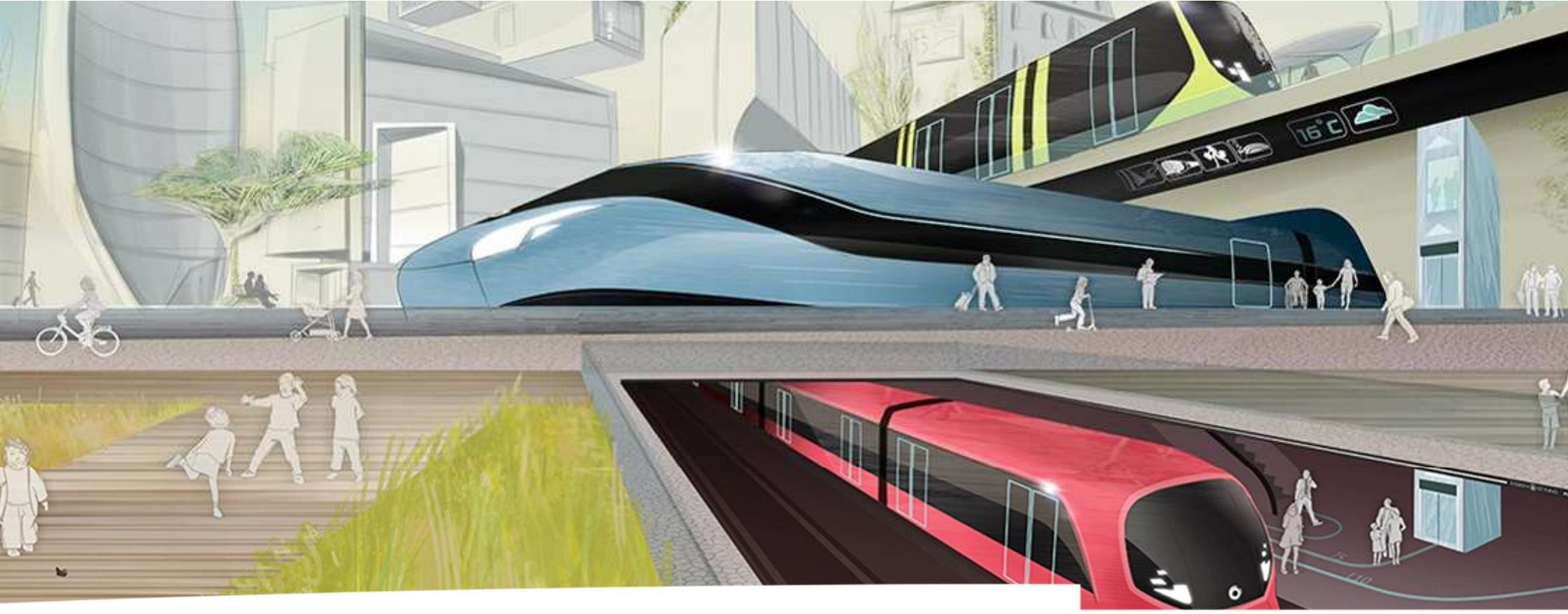

ATS Energy Saver

Denis Mulard

20/02/2018

ALSTOM
Designing fluidity

bjectives of the ATS Energy Saver

Minimizing regenerative energy losses

Avoiding instantaneous energy peaks

No hardware required

ransport System Context:

- *With regenerative energy*
- *Useless if there is energy storage hardware such as battery, ultra capacitors, flywheel or reversible substation(such as Alstom Hesop™)*
- *Better result in driverless (dwell time precision)*

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genda

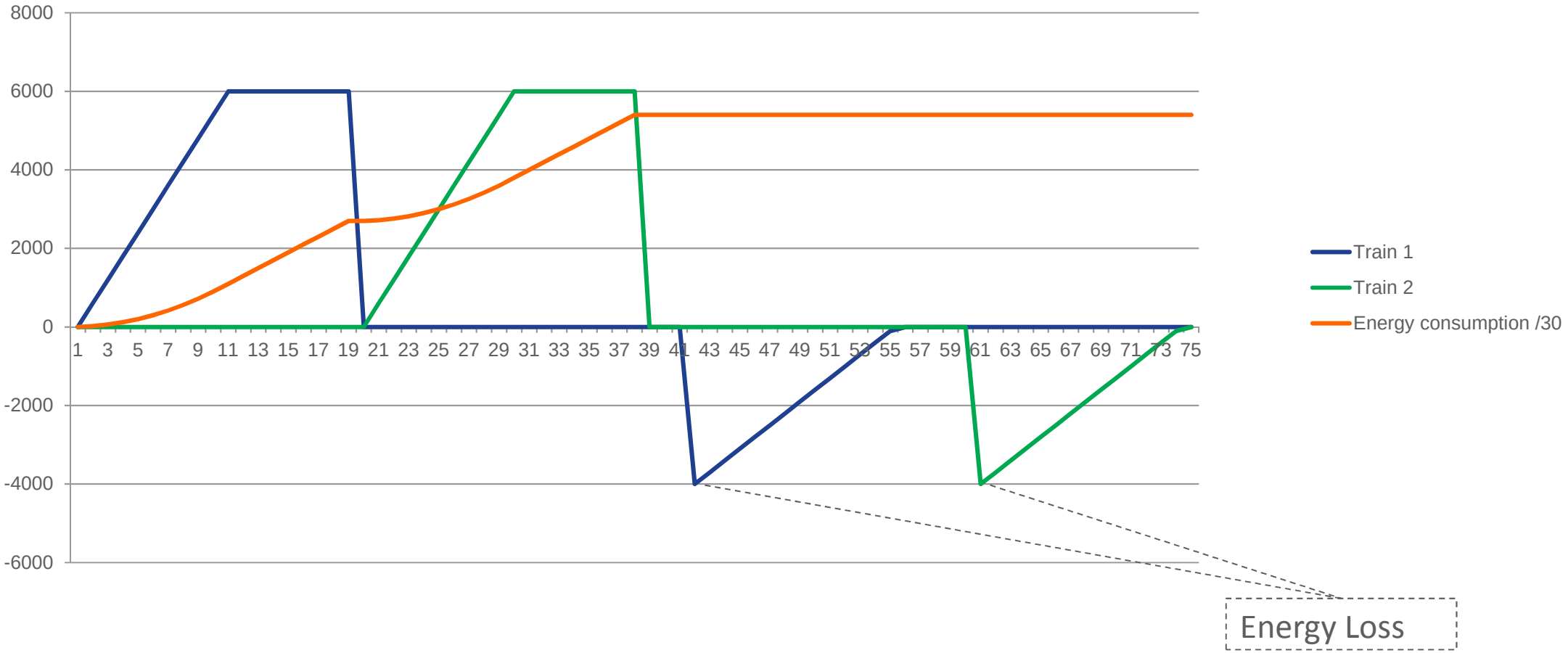
. **Principles**

. Case Studies

. Lessons learned

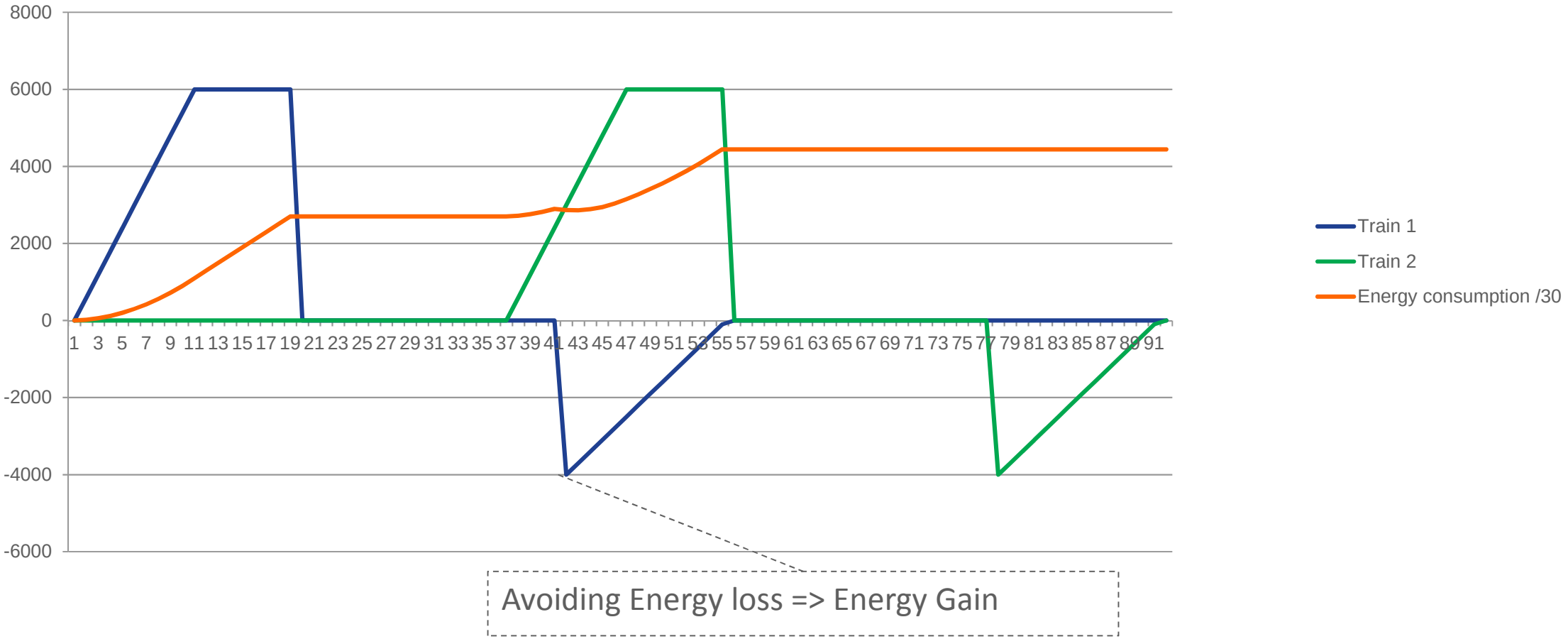
rinciples

proving synchronization between arrival and departures



rinciples

proving synchronization between arrival and departures



rinciples

T Optimizer: Context

Policy on possible modifications

(1) Terminal departure

QOS Tolerance:

2 modes/ 2 patented algorithms		
Mode	**Off line**	**On Line**
Optimization	Maximum	Fair
Response time	Slow	Fast
What for	To build a new reusable timetable	Adapting current active timetable (offer modification: adding or deleting trips)
Time window	The full day	According to modification

(1) Interstation Profile

(2) Distribution Matrix (power losses)

(3) Peak max

(1) Terminal capacities

(2) Loop back maneuver time

(3) ATC Minimum headway /platform

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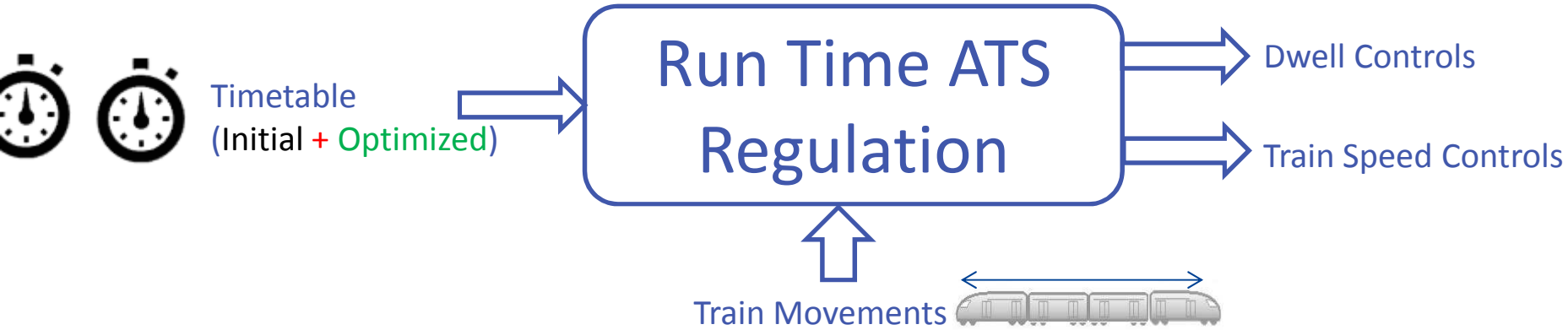
T Optimizer: Usage in run time



- ATS regulation has an QOS headway Tolerance HTReg (configuration)
- HTReg > HTOpt (used in optimization of Timetable)
  Example HTReg = 30%, HTOpt = 15%

- ACTUAL Headway <= HTOpt => Follow Optimized Timetable
- ACTUAL Headway > HTOpt => Follow Initial Timetable with standard ATS headway regulation objective (ie Quality of Service prevails on Energy Saving)

genda

. Principles

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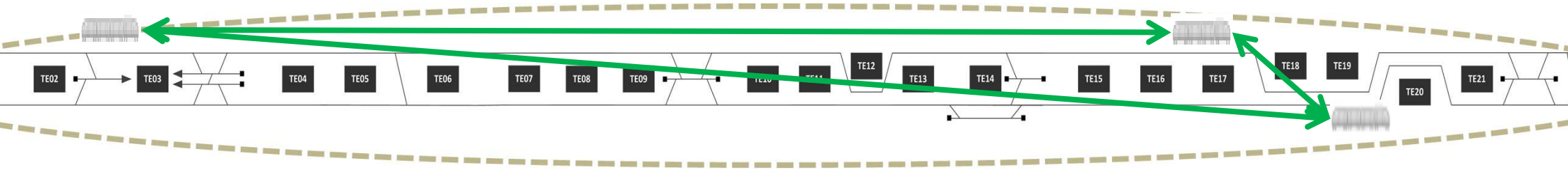
. Lessons learned

ase Studies

ifferent Power Network Model

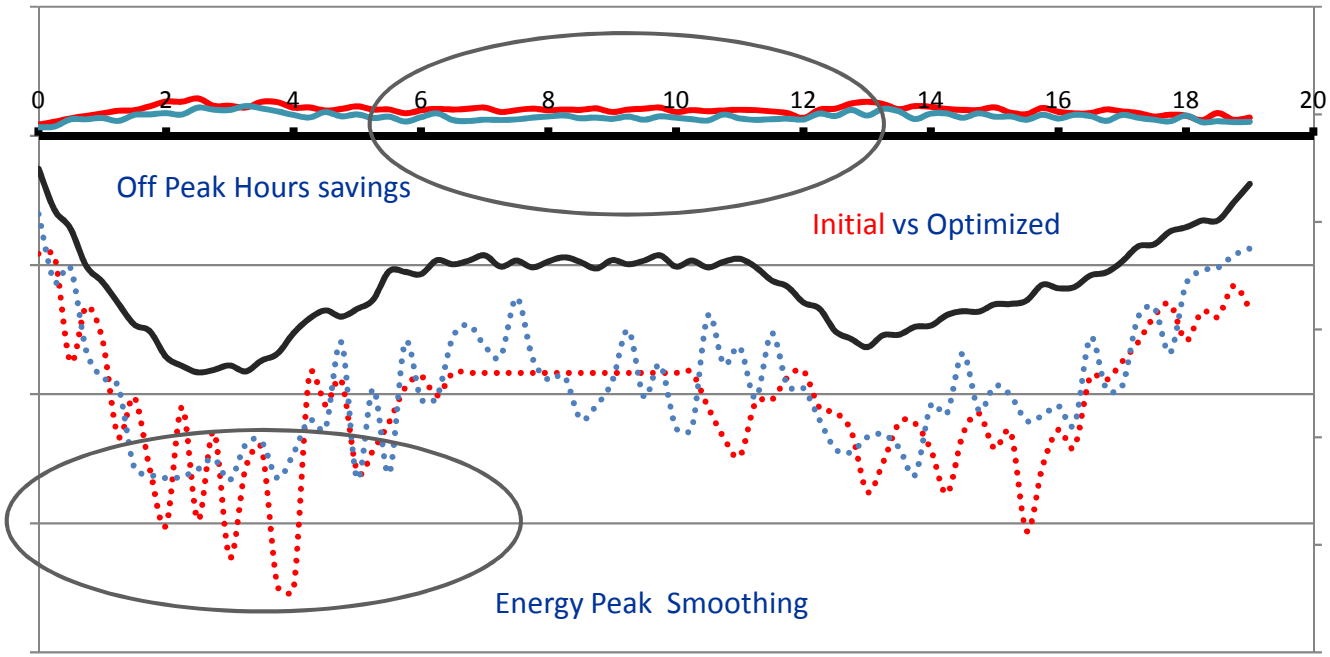
Study 1

- Regenerative energy available on the full line (matrix 100%)



ase Studies

ample Study 1



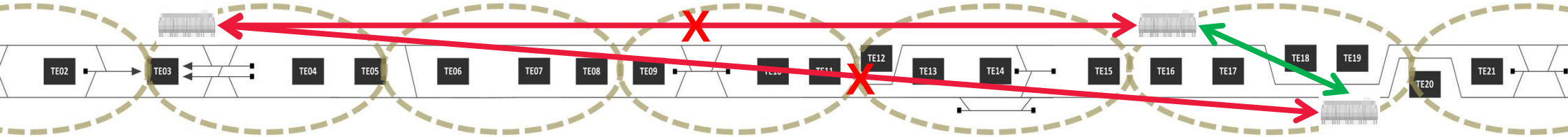
3,8% Energy Saving over 20 hours operation
Maximum Energy peak down by 23%

ase Studies

ifferent Power Network Model

Study 2:

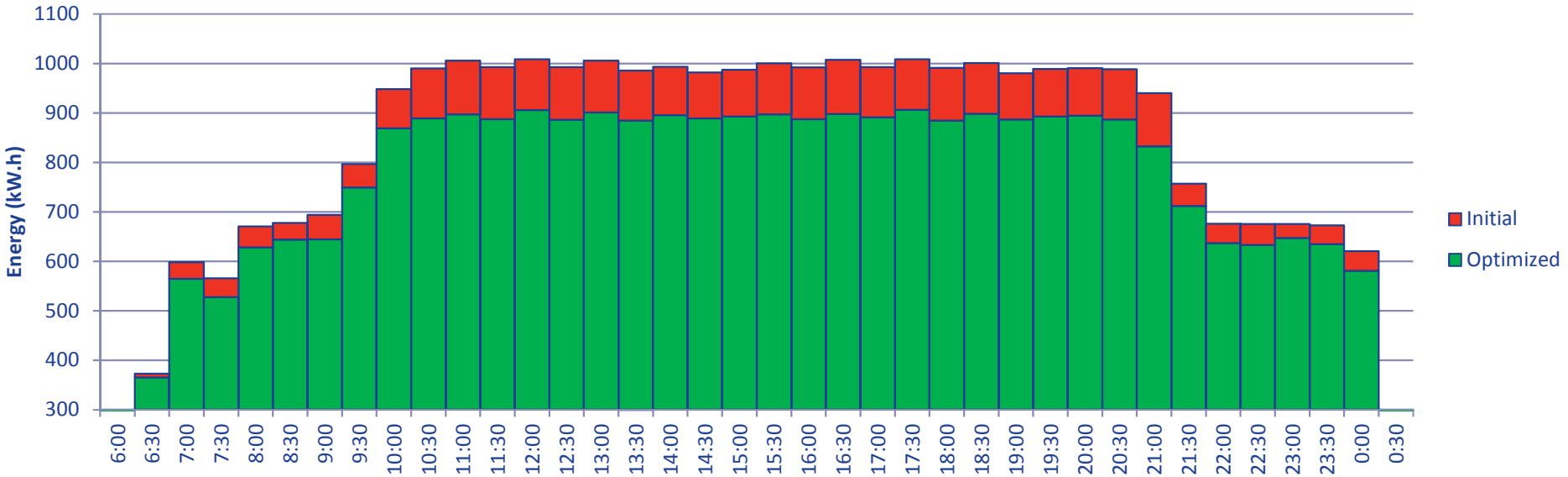
- Regenerative energy is limited to close trains (in same power station area)



ase Studies

ample Study 2 – Day 1

Timetable Energy Optimization
Initial consumption: 31.7 MWh
Optimized consumption: 28.8MWh (8.9% savings)



Dwell times modified within:	**-3s..+3s**
Maximum change in commercial speed:	**-20s..+20s**
Maximum headway modification:	**-20%..+20%**

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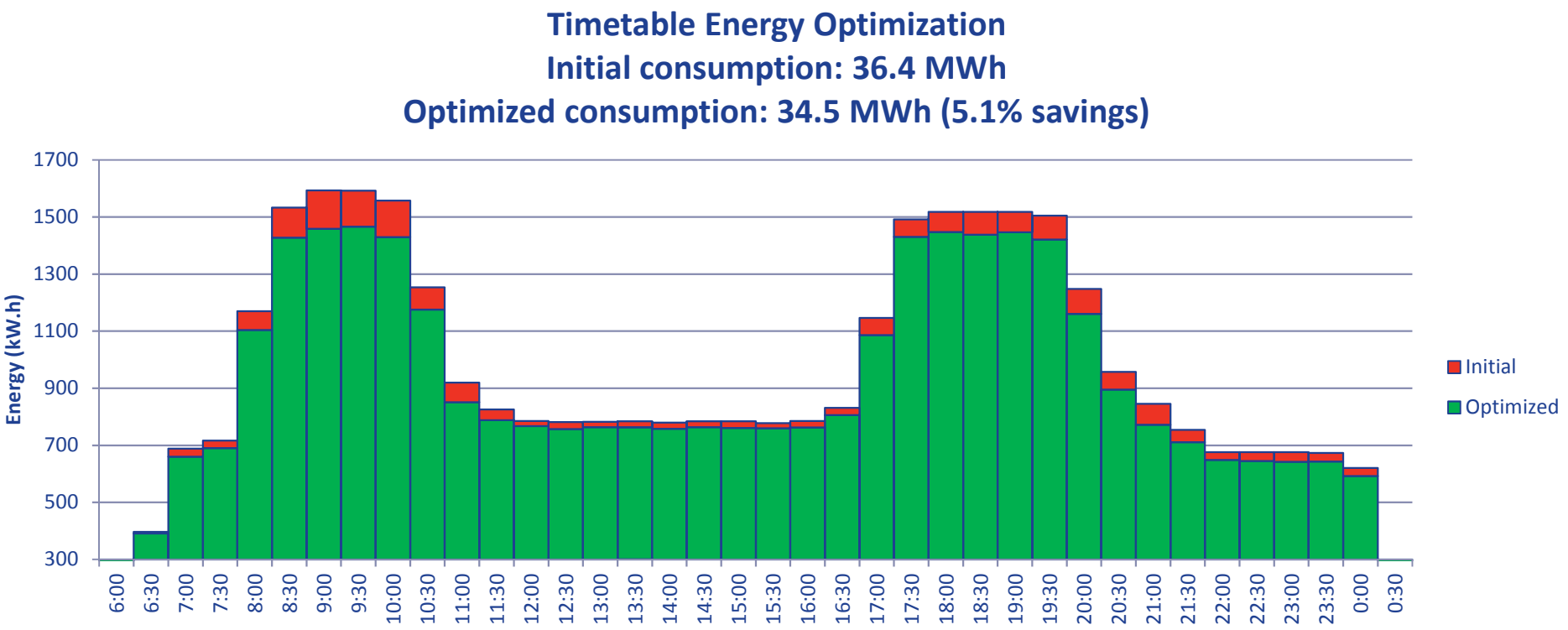
ample Study 2 – Day 2



Dwell times modified within:	**-3s..+3s**
Maximum change in commercial speed:	**-15s..+15s**
Maximum headway modification:	**-25%..+25%**

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essons learned

When Regenerative energy available on the full line (matrix 100%)

- Peak : Few energy losses. Balance is reached thank to the number of trains => small gain.
- Off Peak: More energy losses => some gain are possible

When Regenerative energy limited to close trains (in same power station area)

- Peak Hour: Gain in peak hours by synchronization of trains in same area.
- Off peak: there are not enough train candidates in same area => small gain.

Power network model is key

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tatus/ Current actions

Reinforcing confidence in results

By using RSS :

- Alstom Railway System Simulator
- Currently under development
- Include Power flow simulation

Nominal mode without perturbation

Perturbations impact

Adjusting run time regulation using optimized timetable

www.alstom.com

to David Fournier, François Fages, Jim Giardini, Charles Bousseau, Joshua He, Luc Vuillet.

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