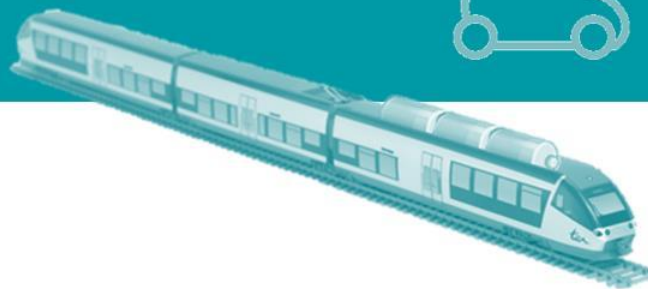




INNOVATION & RESEARCH

RAILWAY SYSTEM CONTRIBUTION TO NATIONAL ELECTRICITY SUSTAINABILITY



INTRODUCTION

ENERGY IS THE MAIN FUEL FOR REDUCING TIME/DISTANCE



17 TWh energy consumption

for SNCF Group in 2015

10% of industrial electricity market

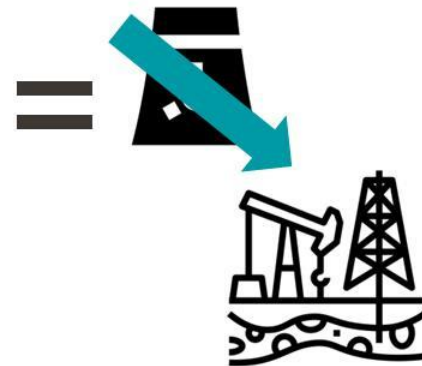
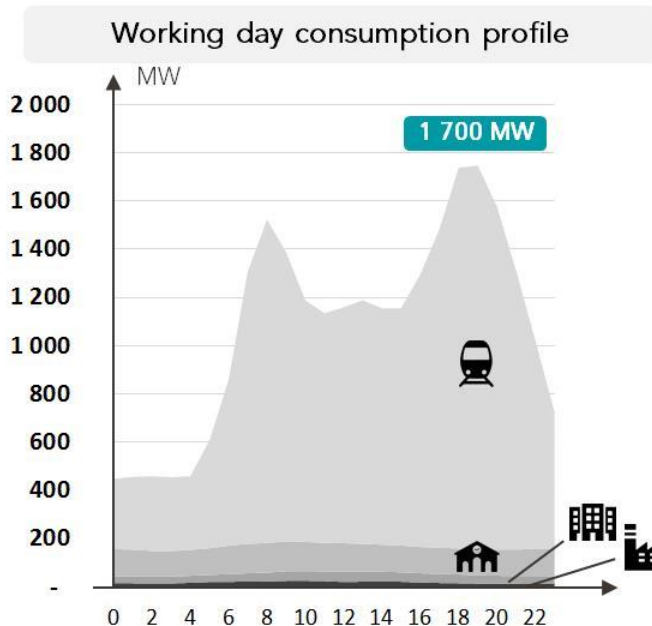
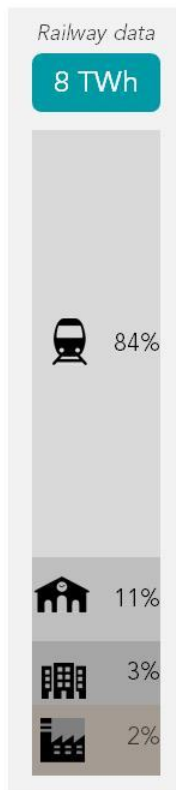
for SNCF railway activities in 2015

Energy policy

- Improve the economic efficiency
- Engage for energy transition
- Innovate and seize business opportunities
- Make people move
- Make SNCF Group an influent stakeholder

INTRODUCTION

RAILWAY, AN ELECTRIC ENERGY CONSUMER?



➤ an instant power consumer

INTRODUCTION

THE ELECTRIC FLEXIBILITY ENHANCEMENT

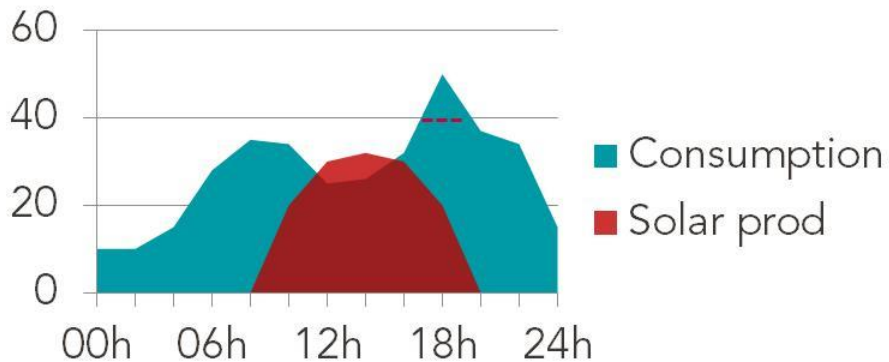


GRID



INTRODUCTION

A SIMPLE CONSUMER?

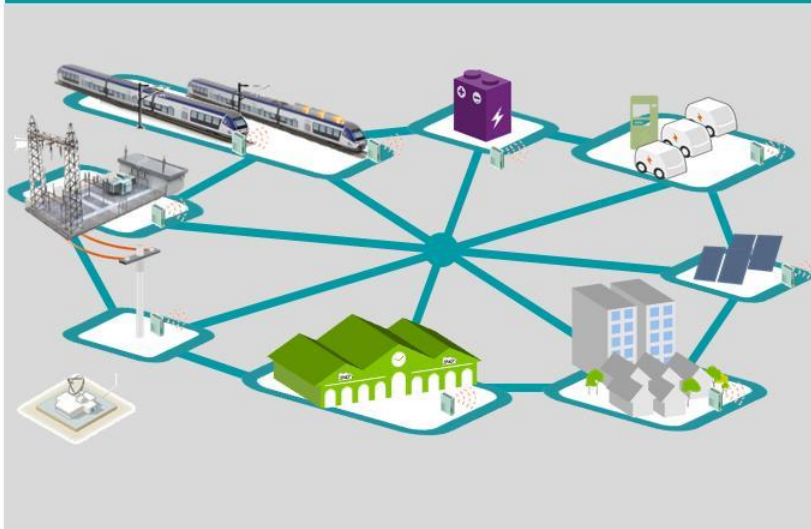


FLEXIBILITY

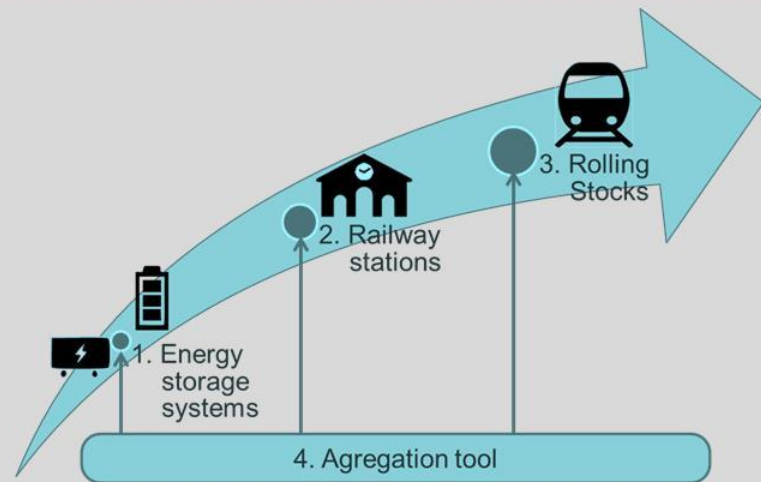
OUTLINE

OUTLINE

RAILWAY SMARTGRID



STUDIED FLEXIBILITY BUSINESS CASES



CONCLUSION AND DISCUSSIONS

SMARTGRID

ELECTRIC NETWORK NOWADAYS AND FUTURE

L'électricité d'aujourd'hui



Les choix de demain



Bi-directional energy flows

Decentralized production



Parc éolien

Toiture photovoltaïque

Industrie

Intelligent consumers

Centrales

Energy Storage Systems

Parc photovoltaïque

charges à distance

Station intelligente

Cogénération

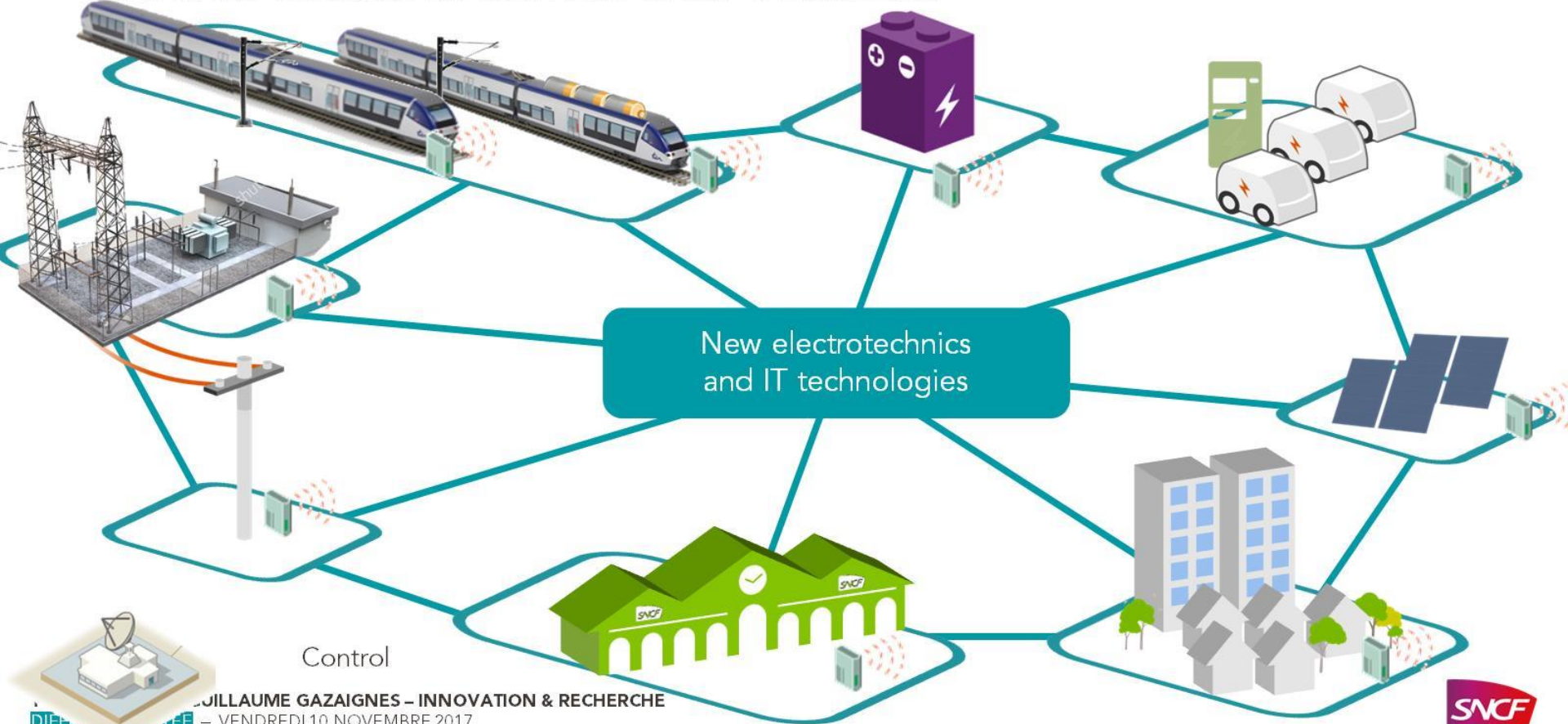
Electric grid management center

Local control and management



RAILWAY SMARTGRID

DIFFERENT CONSUMERS WITH DIFFERENT BEHAVIOURS



SMARTGRID FOR RAILWAY

FIVE NEEDS AND TWO DEGREES OF FREEDOM



Railway reliability : predictive maint., stand alone behaviour



Integrate renewable energy sources easily



New load integration without reinforcement



Modulate consumption



Use energetic buffers



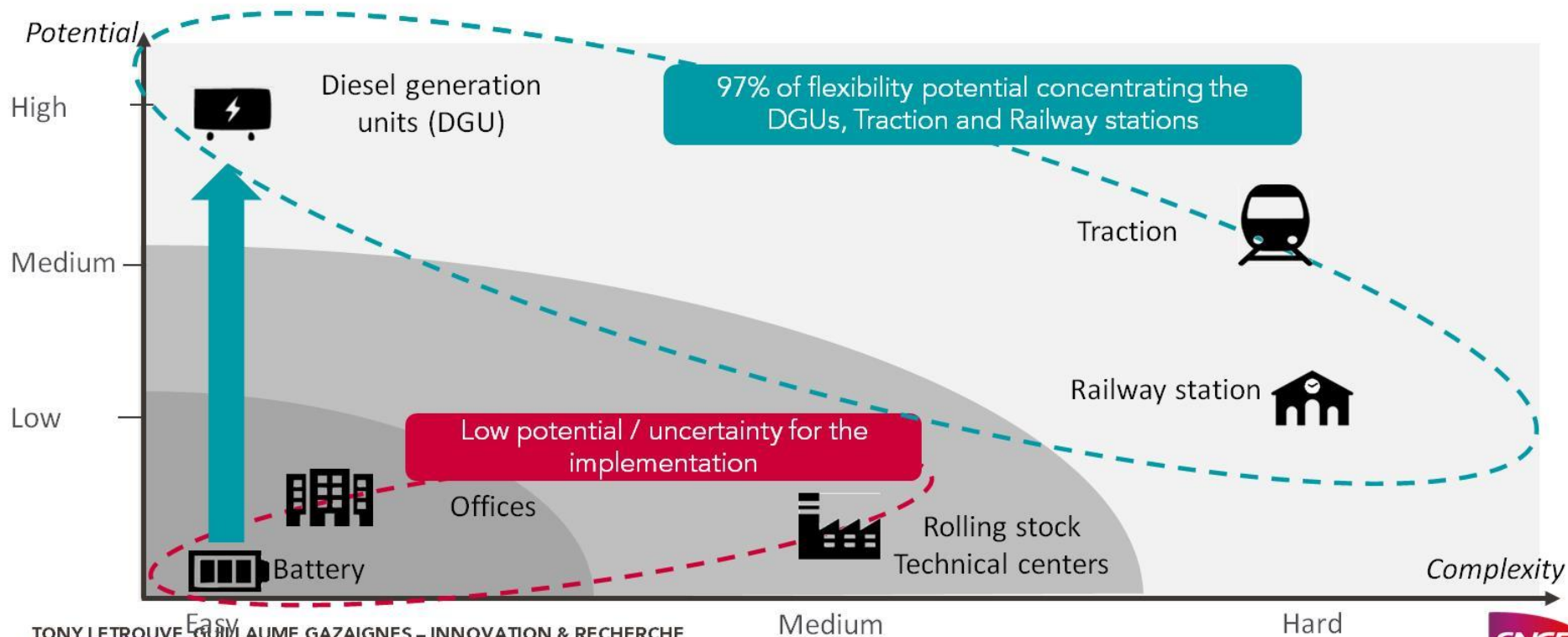
Energetic efficiency : losses reduction



New business

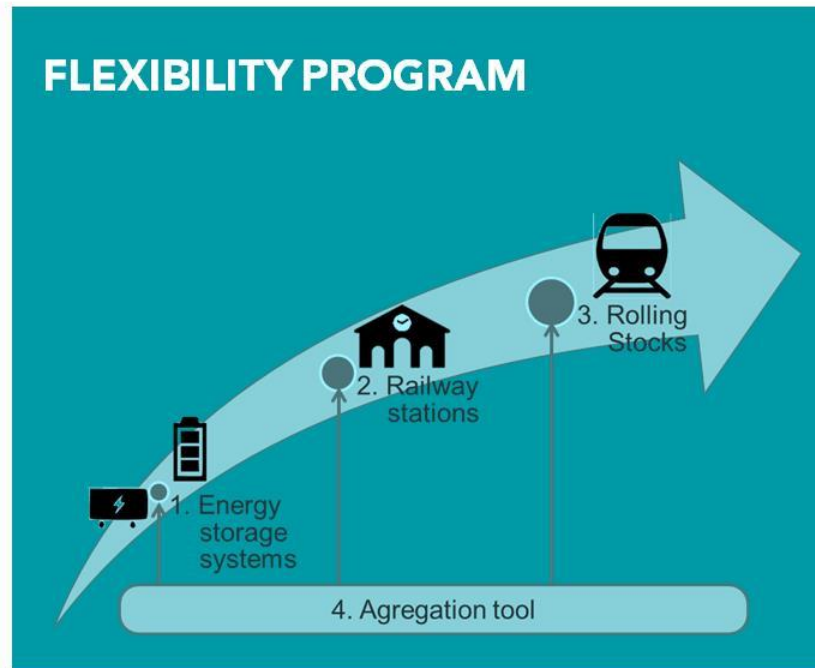
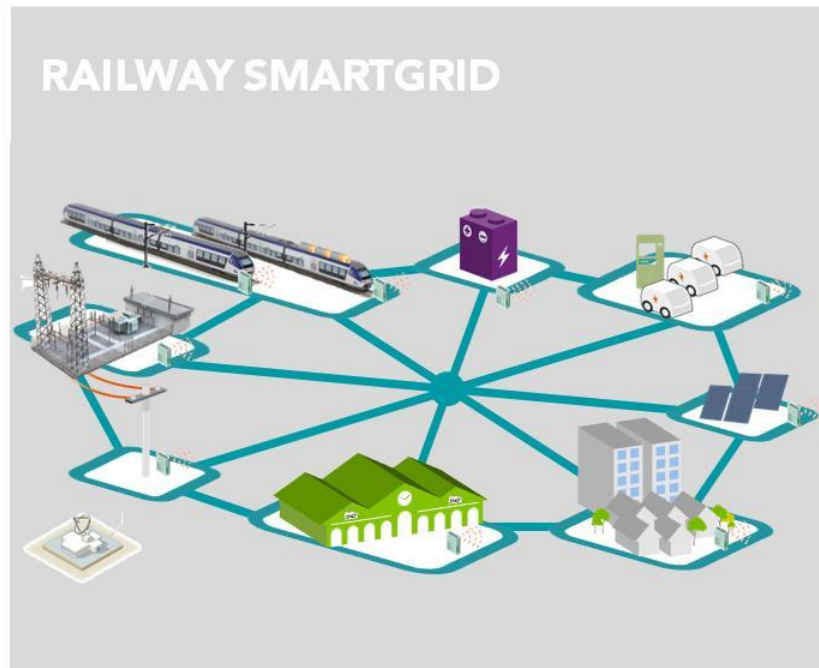
ENERGETIC FLEXIBILITY

POTENTIAL SOURCES OF FLEXIBILITY



OUTLINE

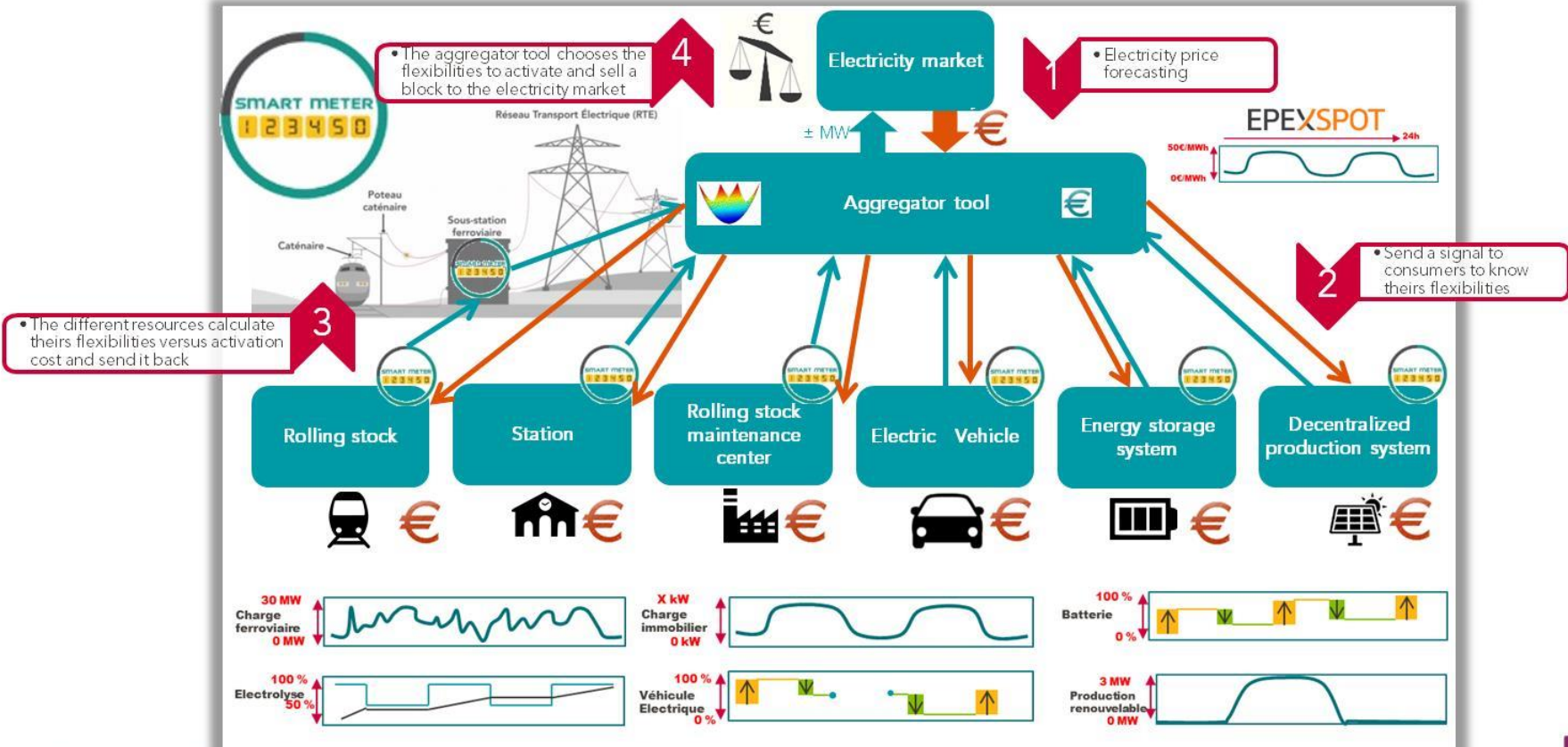
OUTLINE



CONCLUSION AND DISCUSSIONS

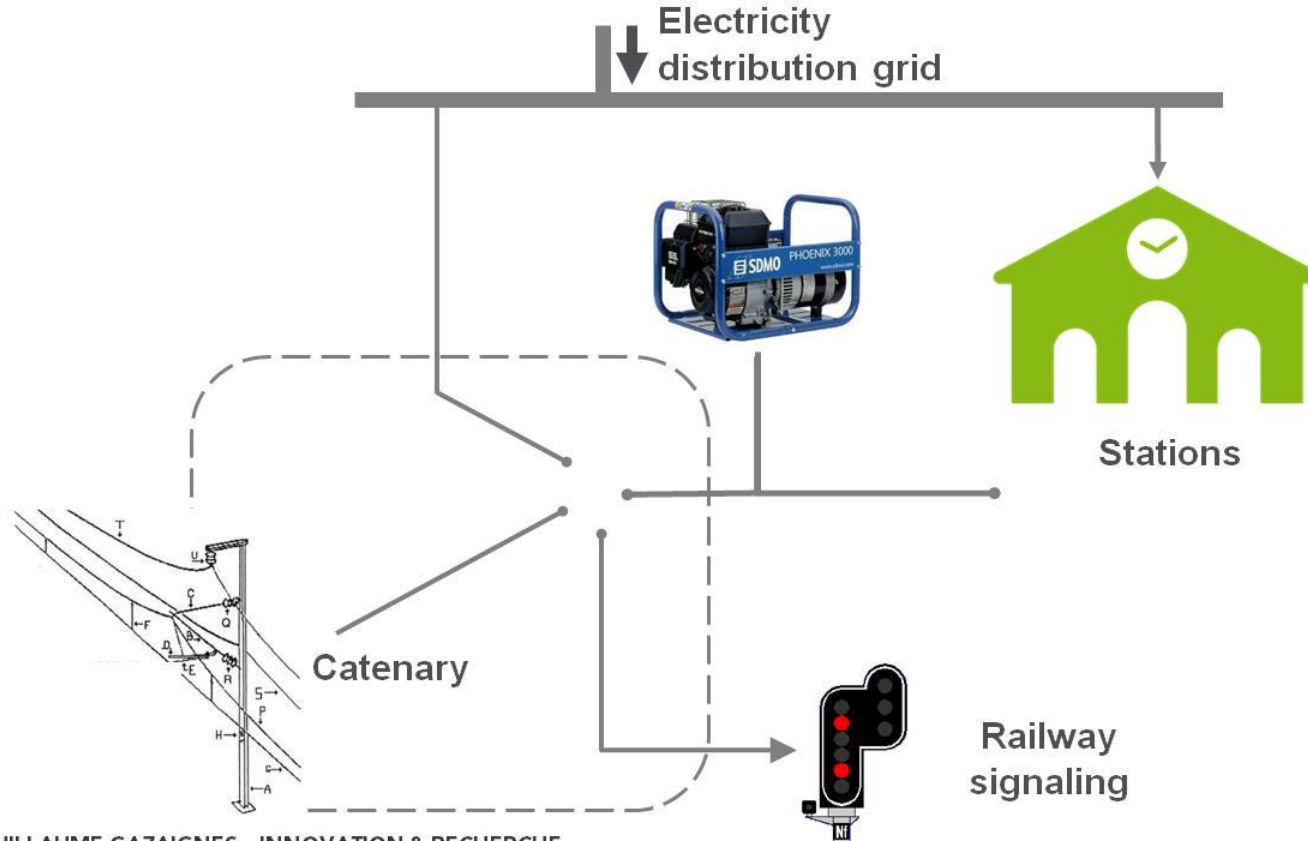
AGREGATION PRINCIPLE

A TOOL TO DEFINE THE BENEFITS OF SNCF AS AN AGGREGATOR



ENERGY STORAGE SYSTEMS FLEXIBILITY

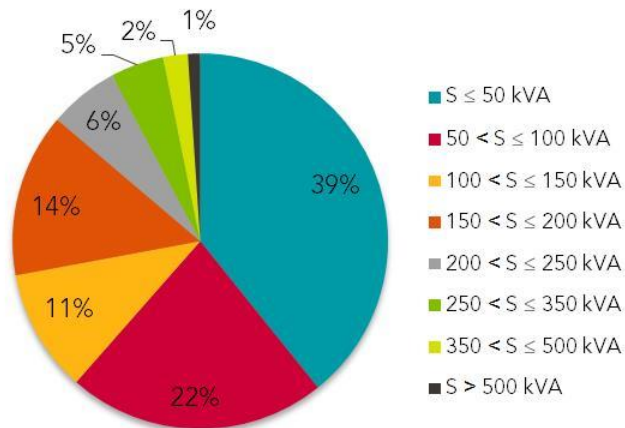
VALORISATION OF EXISTING ASSETS



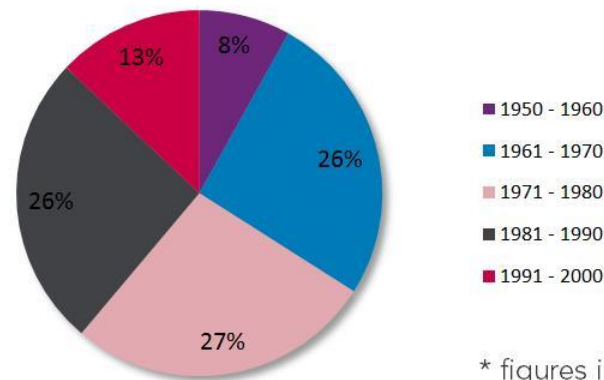
ENERGY STORAGE SYSTEMS FLEXIBILITY

A LARGE POTENTIAL

Backup generators inventory



Generators construction date *



* figures in 2000

➤ 280 generators

➤ Old generators : not reliable and pollutant

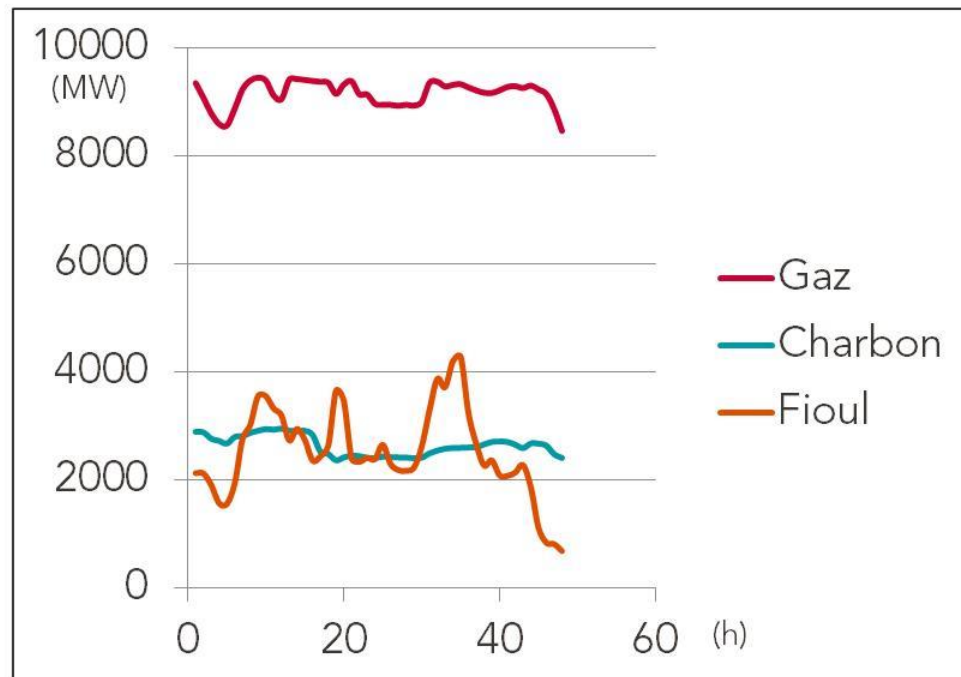
ENERGY STORAGE SYSTEMS FLEXIBILITY

SEARCHING FOR ALTERNATIVE FUELS

	Stockage	Réserve	Injection	Vaporisation	Combustion	Emissions	Durabilité
B30?	Masse volumique	Pouvoir calorifique	Masse volumique	Viscosité	Pouvoir calorifique	Pouvoir calorifique	Stabilité à l'oxydation
	Stabilité à l'oxydation	Comportement à froid	Teneur en soufre	Volatilité	Indice de cétane	Indice de cétane	
			Viscosité		Masse volumique	Teneur en soufre	
			Pouvoir calorifique			Viscosité	

	Stockage	Réserve	Injection	Vaporisation	Combustion	Emissions	Durabilité
B100?	Masse volumique	Pouvoir calorifique	Masse volumique	Viscosité	Pouvoir calorifique	Pouvoir calorifique	Stabilité à l'oxydation
	Stabilité à l'oxydation	Comportement à froid	Teneur en soufre	Volatilité	Indice de cétane	Indice de cétane	
			Viscosité		Masse volumique	Teneur en soufre	
			Pouvoir calorifique			Viscosité	

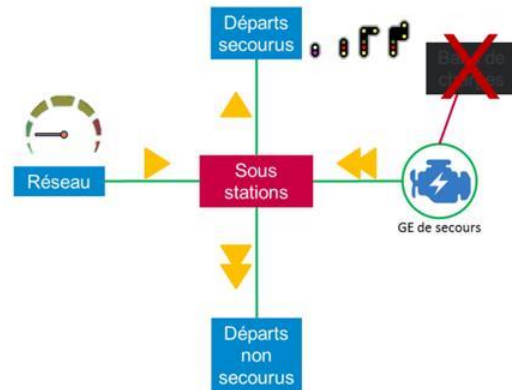
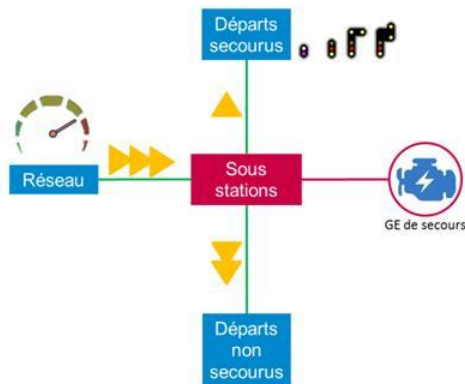
	Stockage	Réserve	Injection	Vaporisation	Combustion	Emissions	Durabilité
HVO?	Masse volumique	Pouvoir calorifique	Masse volumique	Viscosité	Pouvoir calorifique	Pouvoir calorifique	Stabilité à l'oxydation
	Stabilité à l'oxydation	Comportement à froid	Teneur en soufre	Volatilité	Indice de cétane	Indice de cétane	
			Viscosité		Masse volumique	Teneur en soufre	
			Pouvoir calorifique			Viscosité	



Source: RTE, January 19-20 2017

ENERGY STORAGE SYSTEMS FLEXIBILITY

ENERGY TRANSITION LEADING TO NEW LIFE FOR AGING ASSETS



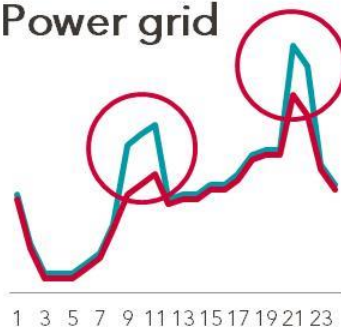
Power grid



730

geqCO₂/kWh

Power grid



<700

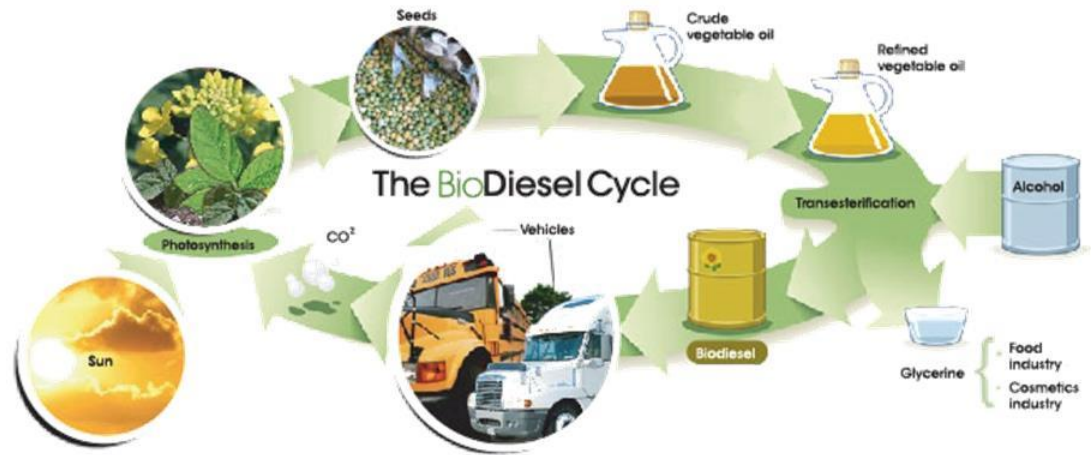
geqCO₂/kWh

€
4 to 12
years ROI

ENERGY STORAGE SYSTEMS FLEXIBILITY

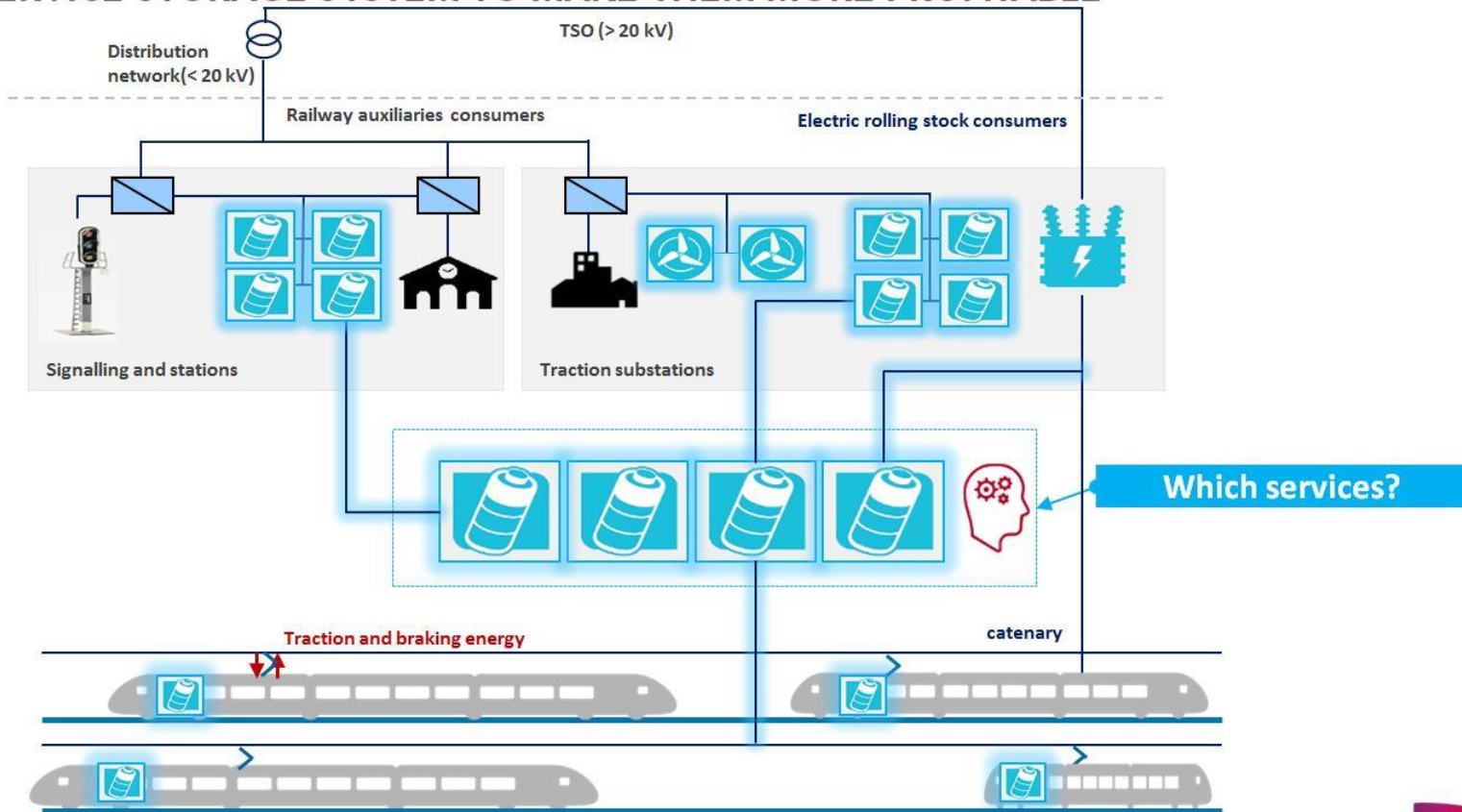
BIOFUELS : FIRST, SECOND, THIRD GENERATION ?

- Energy self-sufficiency
- Life cycle analysis positive compared to fossil fuels
- Complex topic and general public controversies



ENERGY STORAGE SYSTEMS FLEXIBILITY

A MULTI-SERVICE STORAGE SYSTEM TO MAKE THEM MORE PROFITABLE



RAILWAY STATION FLEXIBILITY

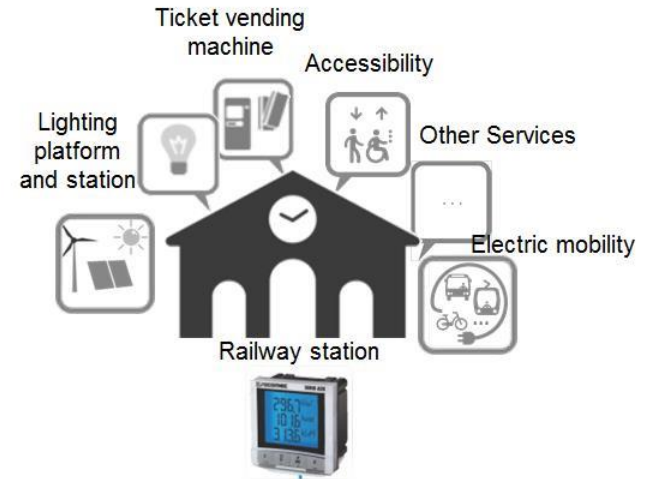
TO SMARTER STATIONS AND BUILDINGS

➤ The demand response is a **Temporary reduction of consumption** to respond external demand (RTE).

- Temperature of travelers' waiting area,
- Variation of the lighting of platforms,
- Etc.

➤ How to proceed?

- Add local energy management and controllable component (consumers)
- Add energy sources
 - Integration of **renewable energies**;
 - Integration of **Energy Storage Systems**;
 - Stationary ESS like batteries,
 - Electric vehicles (V2G).



RAILWAY STATION FLEXIBILITY

TO SMARTER STATIONS AND BUILDINGS

➤ 2 real tests :

- Besancon TGV – building automation and acceptability studies
- Aix-en-provence TGV – microgrid development

Aix-en-provence TGV



Besancon TGV



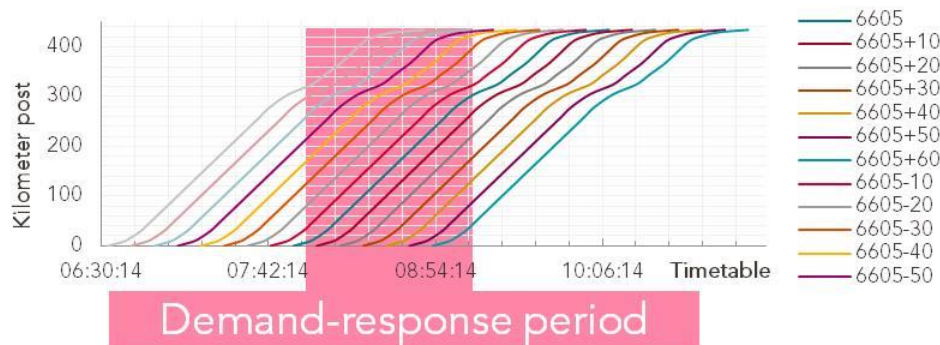
ROLLING STOCK FLEXIBILITY

ROLLING STOCK INVOLVEMENT



Parameters

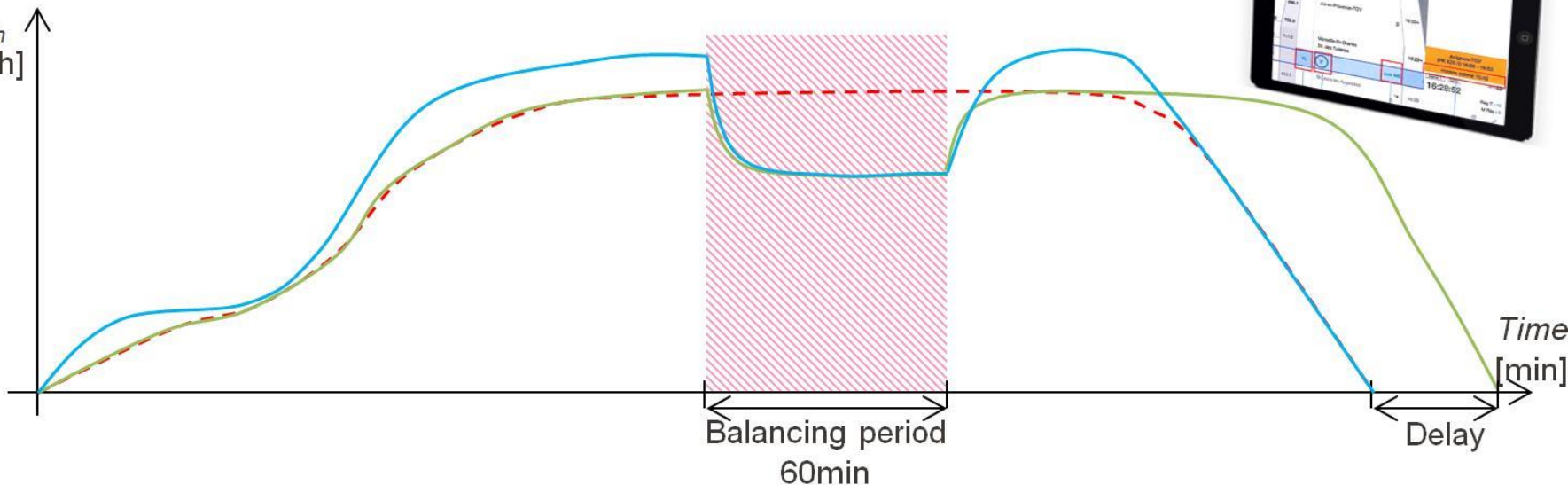
- LN1 Paris Lyon
- 15 HST Duplex on morning rush hour with 10min delay



ROLLING STOCK FLEXIBILITY

ROLLING STOCK INVOLVEMENT

V_{veh}
[km/h]

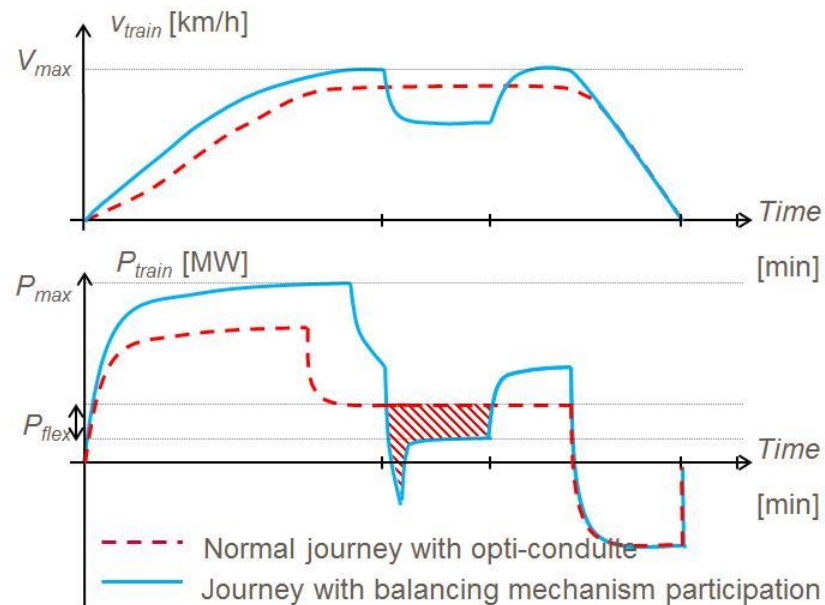
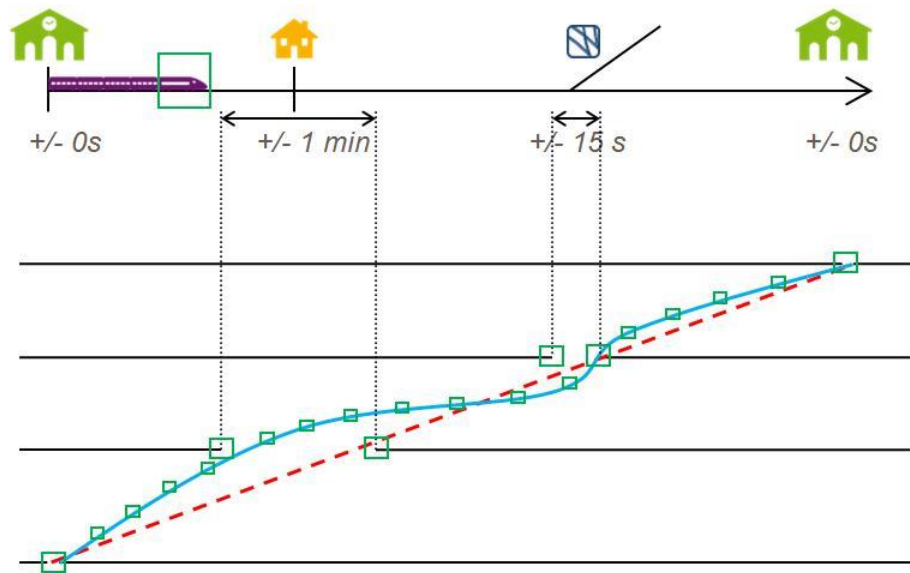


- Normal journey
- Journey with balancing mechanism participation
- Journey with balancing mechanism participation with help of opti-conduite

ROLLING STOCK FLEXIBILITY

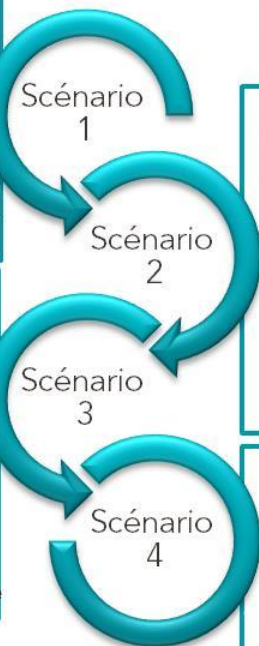
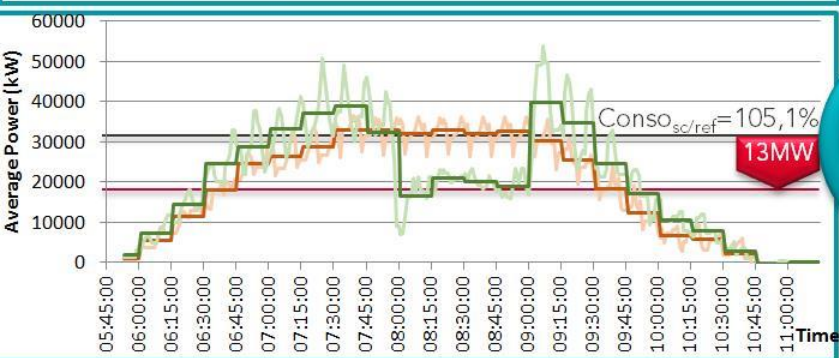
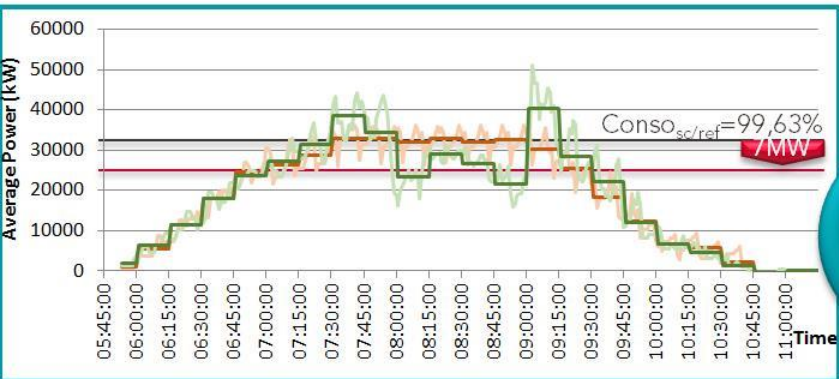
ROLLING STOCK INVOLVEMENT

One train study

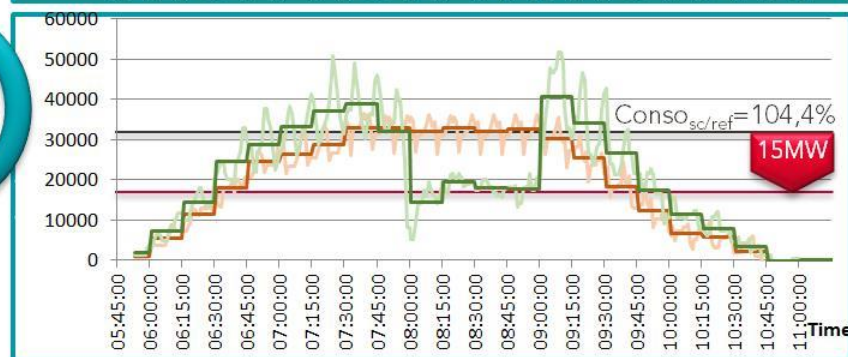
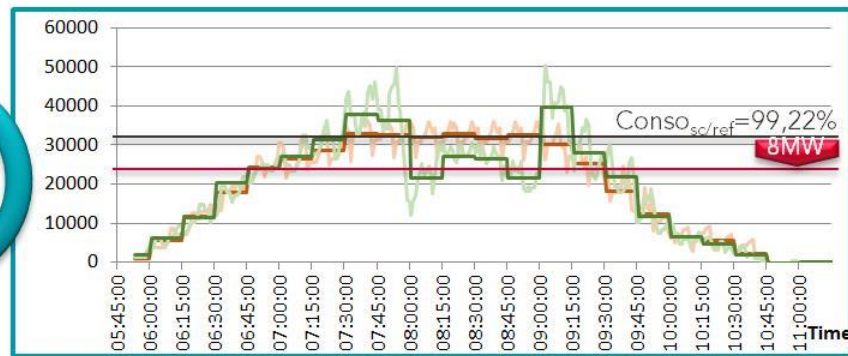


ROLLING STOCK FLEXIBILITY

ROLLING STOCK INVOLVEMENT



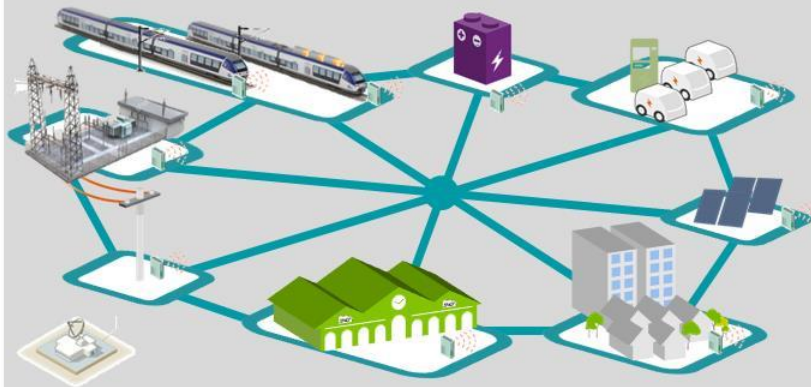
- Original power
- Original Average Power
- Scenario power
- Scenario Average power



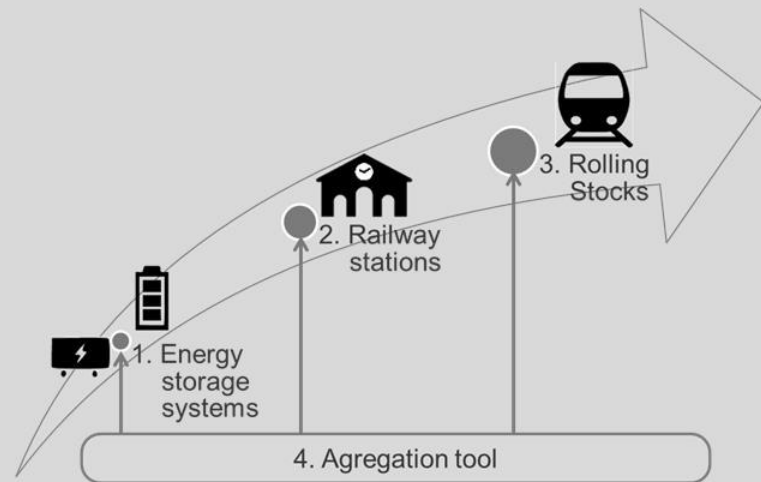
OUTLINE

OUTLINE

RAILWAY SMARTGRID



FLEXIBILITY PROGRAM



CONCLUSION AND DISCUSSIONS

CONCLUSION & DISCUSSIONS

CONCLUSION

- **Societal responsibility meet economic** aspects:
 - A new degree of freedom to reduce **carbon footprint and energetic consumption** all over SNCF group
 - New technologies for **new businesses** : benefits up to M€/an
 - Increase the **profitability of ESS** that can be valuable for railway services (signalling emergency services, catenary voltage control, etc.) and may accelerate investments in storage systems

CONCLUSION & DISCUSSIONS

DISCUSSIONS

- **Railway advantage** for risk mitigation in flexibility operations
- **Regulation** may rule out diesel generators
(too cost efficient in comparison to cleaner businesses)
- **Uncertainty** of return over investment due to market rules evolving
- **Regulators should consult** to take into account railway specificities

RAILWAY SYSTEM CONTRIBUTION TO NATIONAL ELECTRICITY SUSTAINABILITY

