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**Welcome to the best practice workshop**

# TRACKSIDE ENERGY STORAGE

Proposed by
the UIC Energy efficiency and $CO_2$ Emissions Sector

**Organised by the Sector's Chairpersons:**


Bart Van der Spiegel, Infrabel,
Gerald Olde Monnikhof, ProRail.
Philippe Stefanos, UIC


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# TRACKSIDE ENERGY STORAGE

- Please change your ID as [Company-Name Surname]
- The meeting will be recorded.
- Please remain on **mute** while the speaker is active.
- Please keep your **camera off** while the speaker is active.

# Workshop timeline

| | | | |
|---|---|---|---|
| 10 h | **First part: Overview, research and innovation** | | |
| | • European Battery Alliance (EBA) | **Johan Soderbom** | |
| | • Dutch railways: ProRail and NS | **Herman Sibbel** | **Martijn Wolf** |
| | • Railway Technical Research Institute (Japan Railways) | **Takeshi Konishi** | |
| 11 h | **Second part: Application** | | |
| | • SNCF | **Tony Letrouvé** | **Hervé Caron** |
| | • East Japan Railway Company (JR East) | **Koji Kasai** | |

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# EUROPEAN BATTERY ALLIANCE


**Johan Soderbom**
Thematic Leader Smart grids & Energy Storage

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# EUROPEAN BATTERY VALUE CHAIN

## Market outlook and application examples

**Johan Söderbom**
Thematic Leader Smart Grid and Energy Storage

# Topics

- Why talk about batteries?
- Market development
- European Battery Alliance
- Applications

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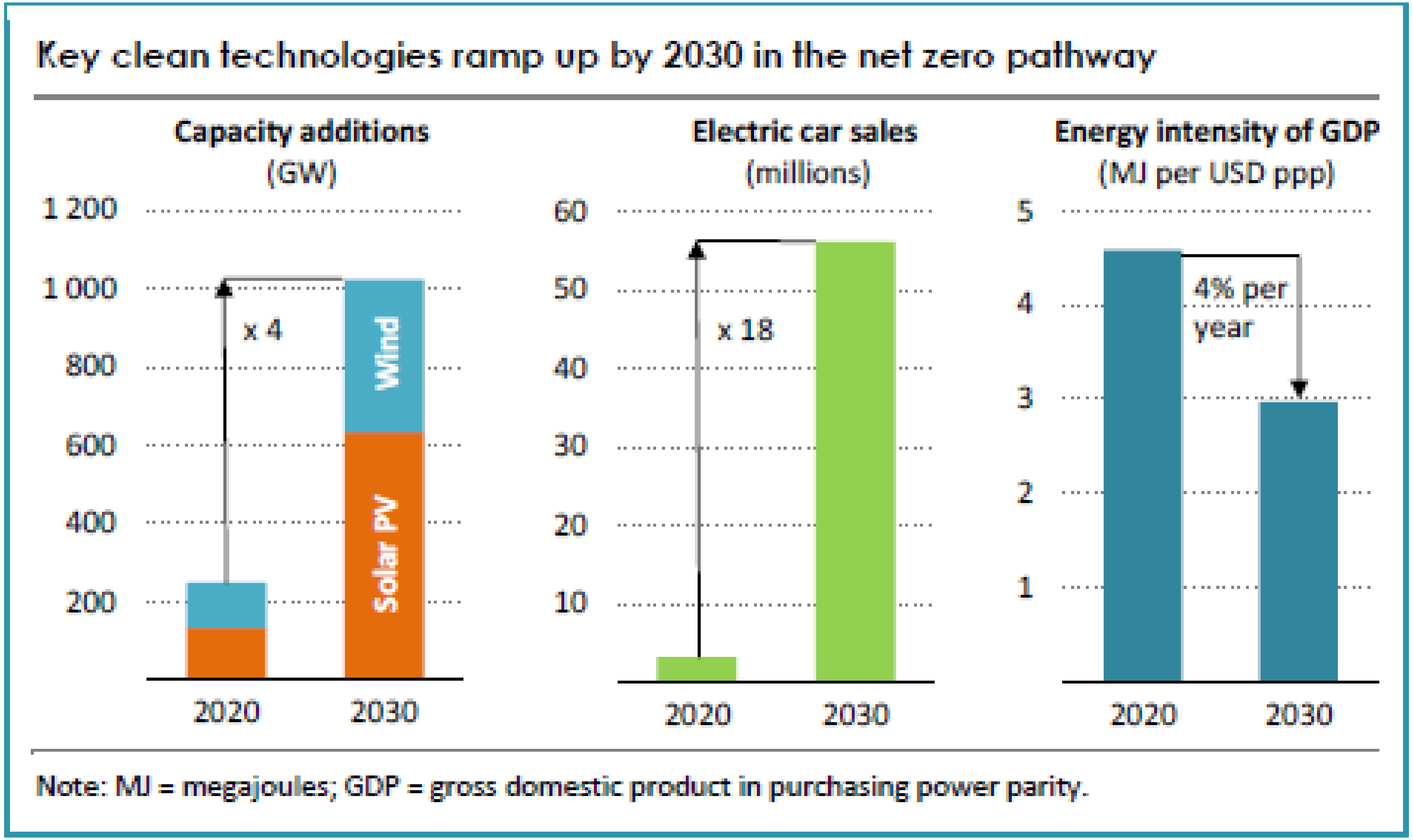
- Why talk about batteries?
- Market development
- European Battery Alliance
- Applications

# Why energy storage?



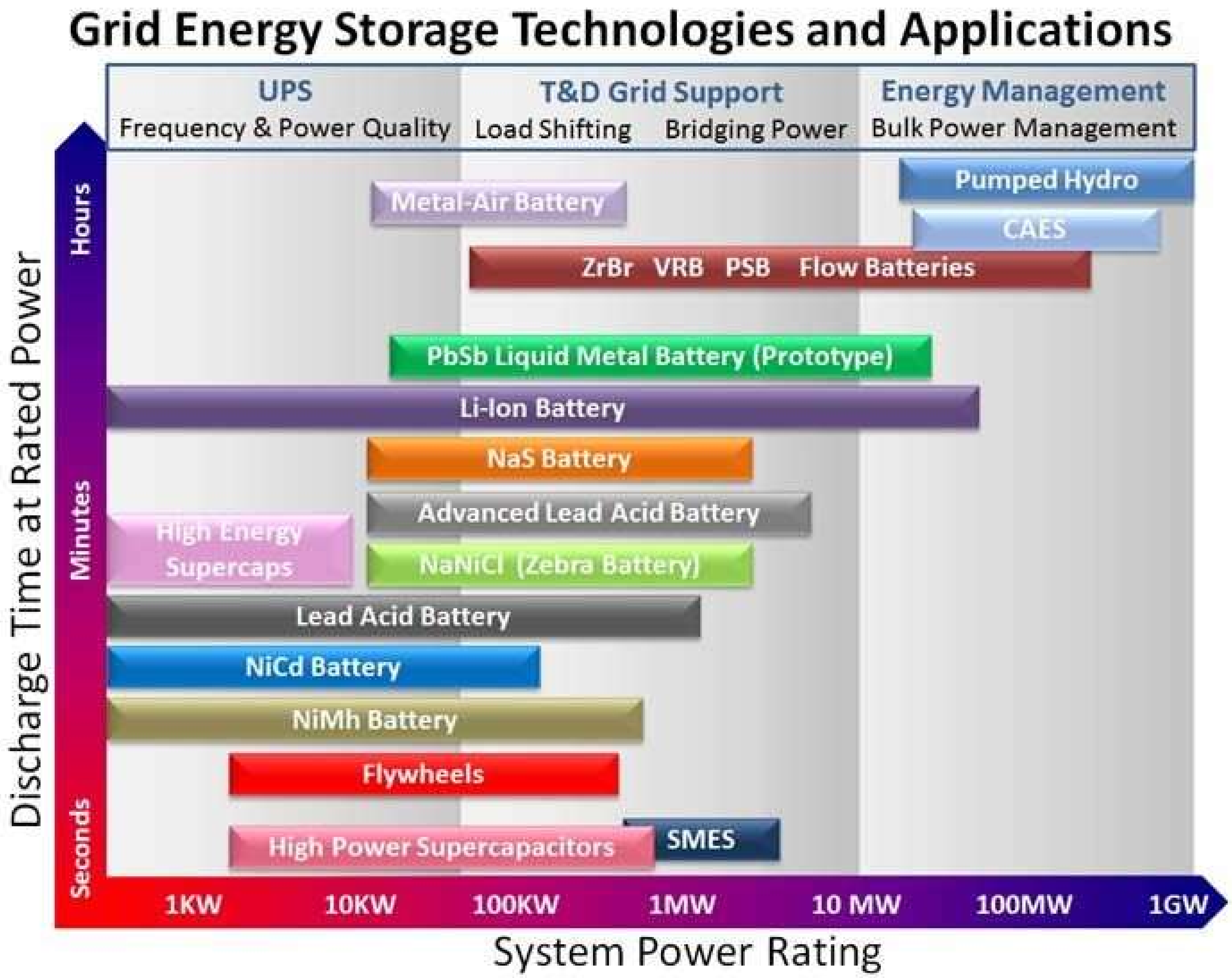


International Energy Agency

Extremely tough measures in order to achieve the target

- Dispatchable RES
- Low carbon generation
- Energy Storage

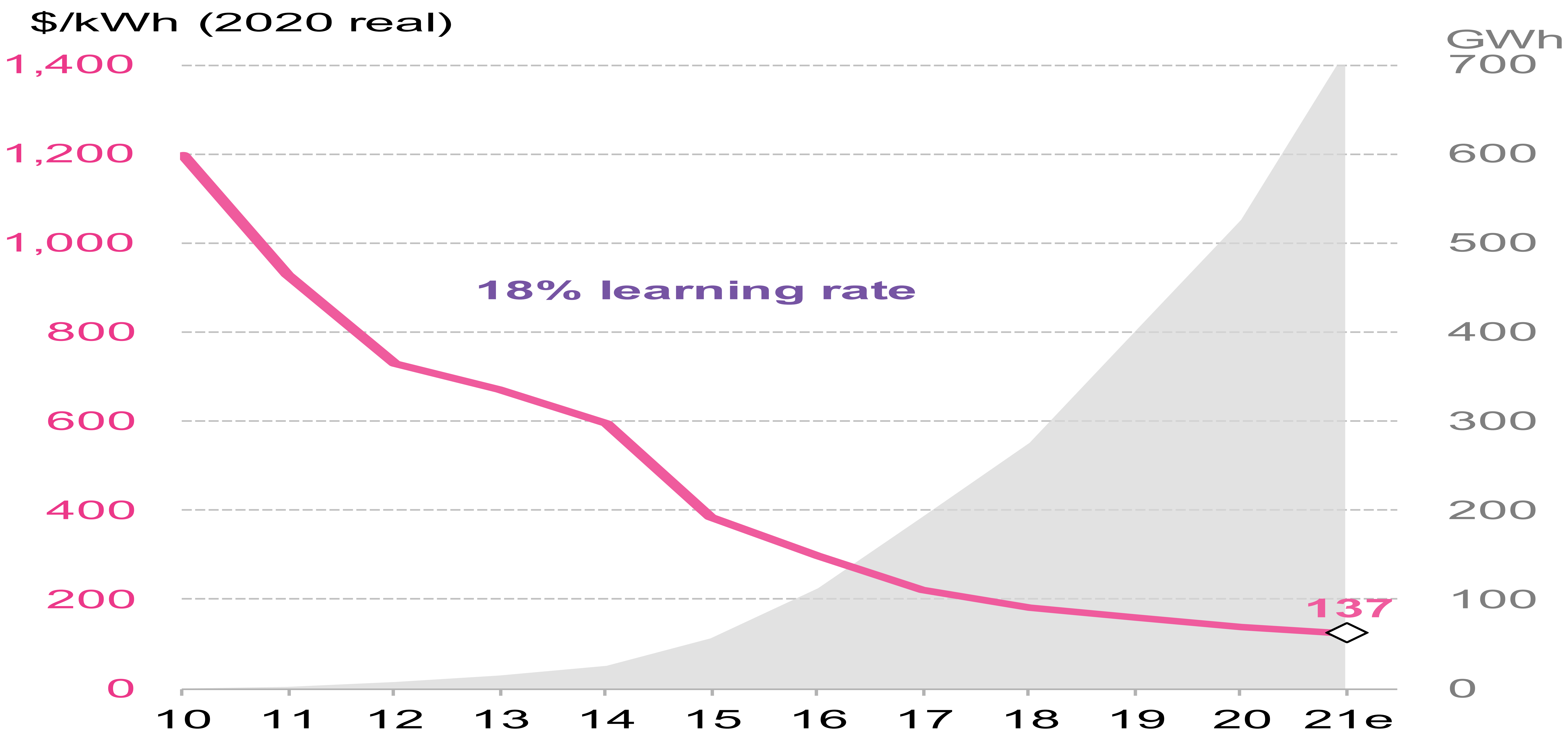
# Why focus on Li-Ion Batteries?




- Covering a large power and energy span
- Mature technology
- Automotive industry is pushing the limits regarding cost and performance

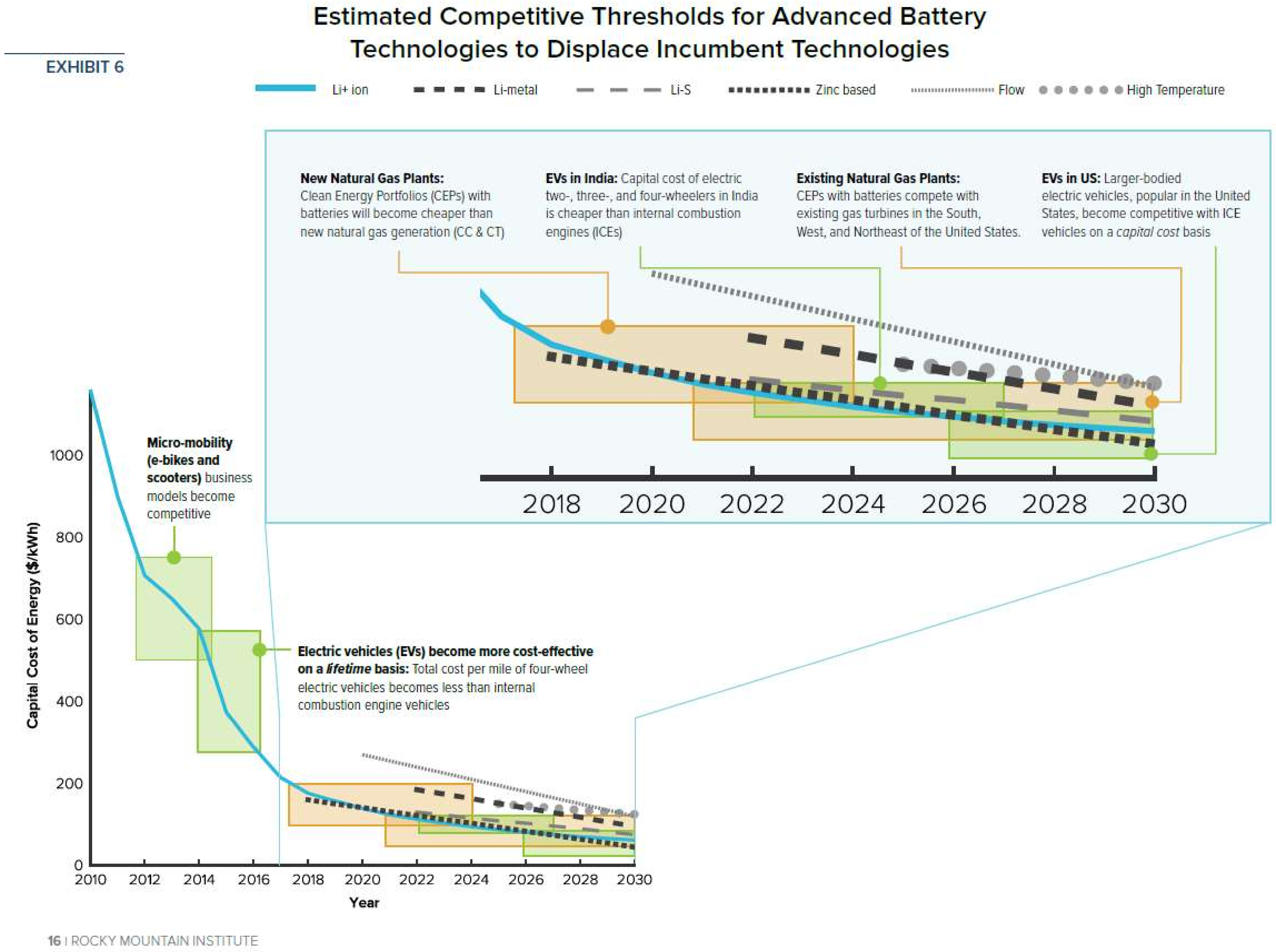
# Lithium-ion battery pack prices and cumulative deployment





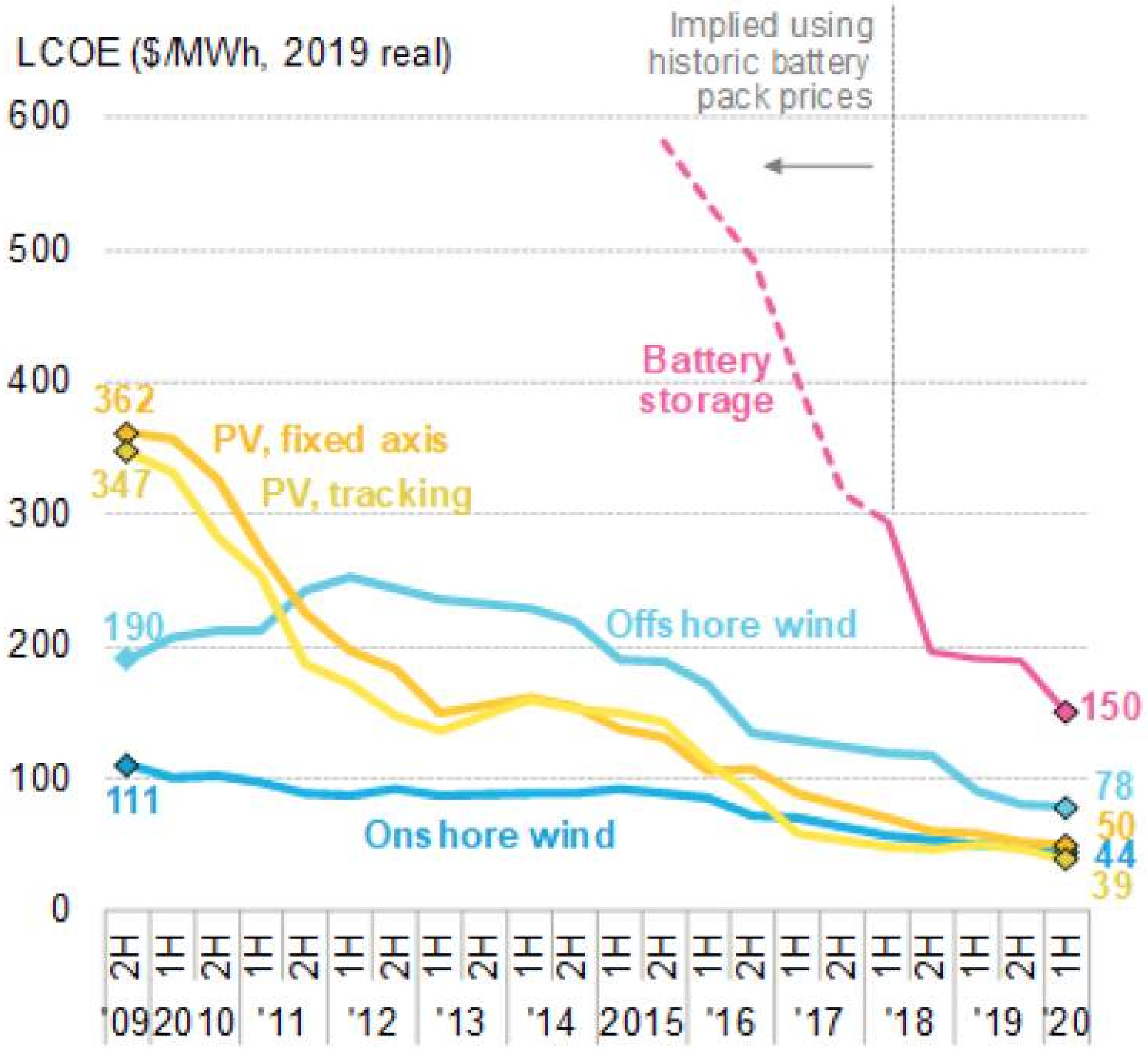

Source: BloombergNEF. 2020 Lithium-Ion Battery Price Survey

# Li-Ion will be competitive in several applications




- Lithium Ion is becoming more and more competitive in different applications
- No other battery technology seems to be able to catch up

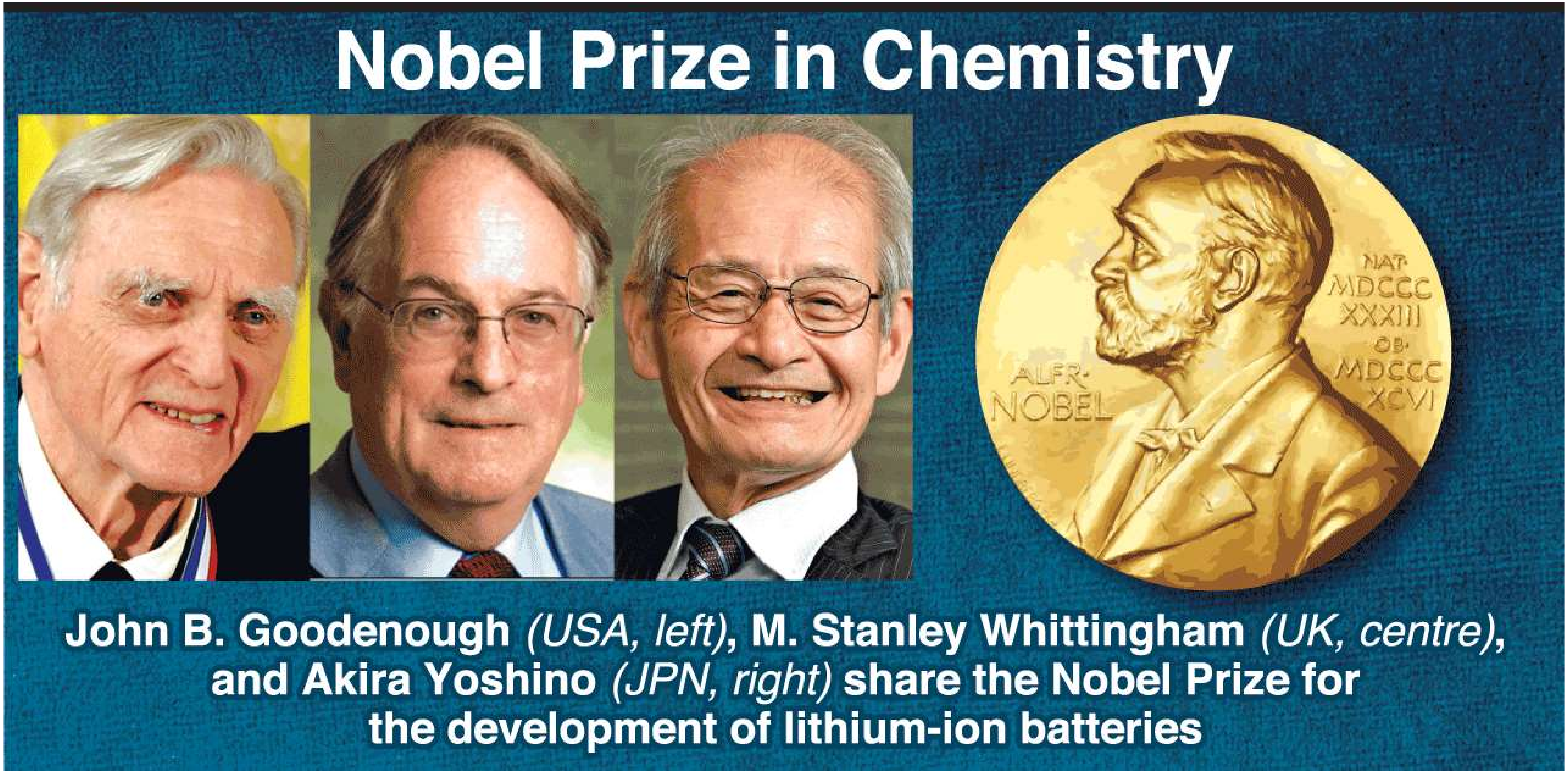
# Batteries has the fastest falling cost in the Power System




Bloomberg NEF:

"Already cheaper to install new-build battery storage than peaking plants"

# The time for Lithium-Ion is here



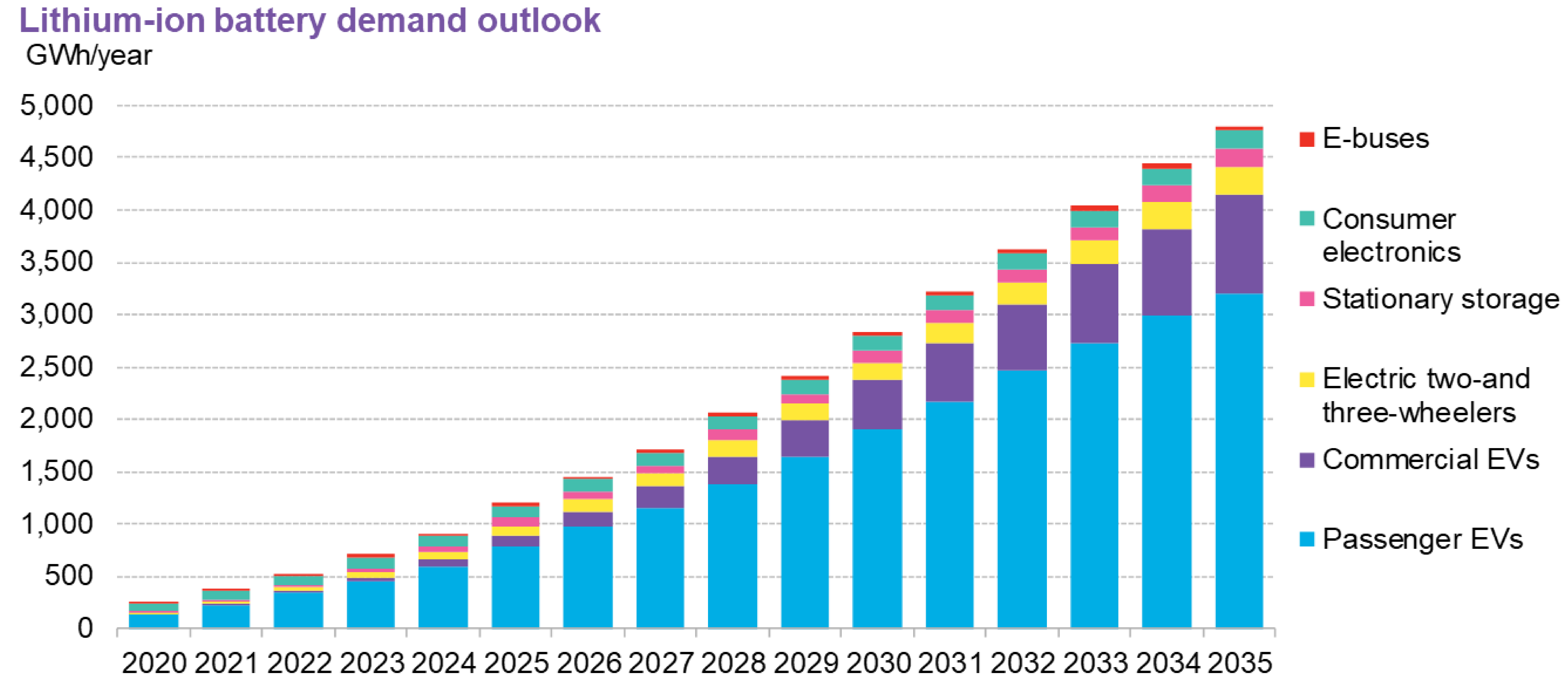

2019

# Topics



- Why talk about batteries?
- Market development
- European Battery Alliance
- Applications

# Annual lithium-ion battery demand by application

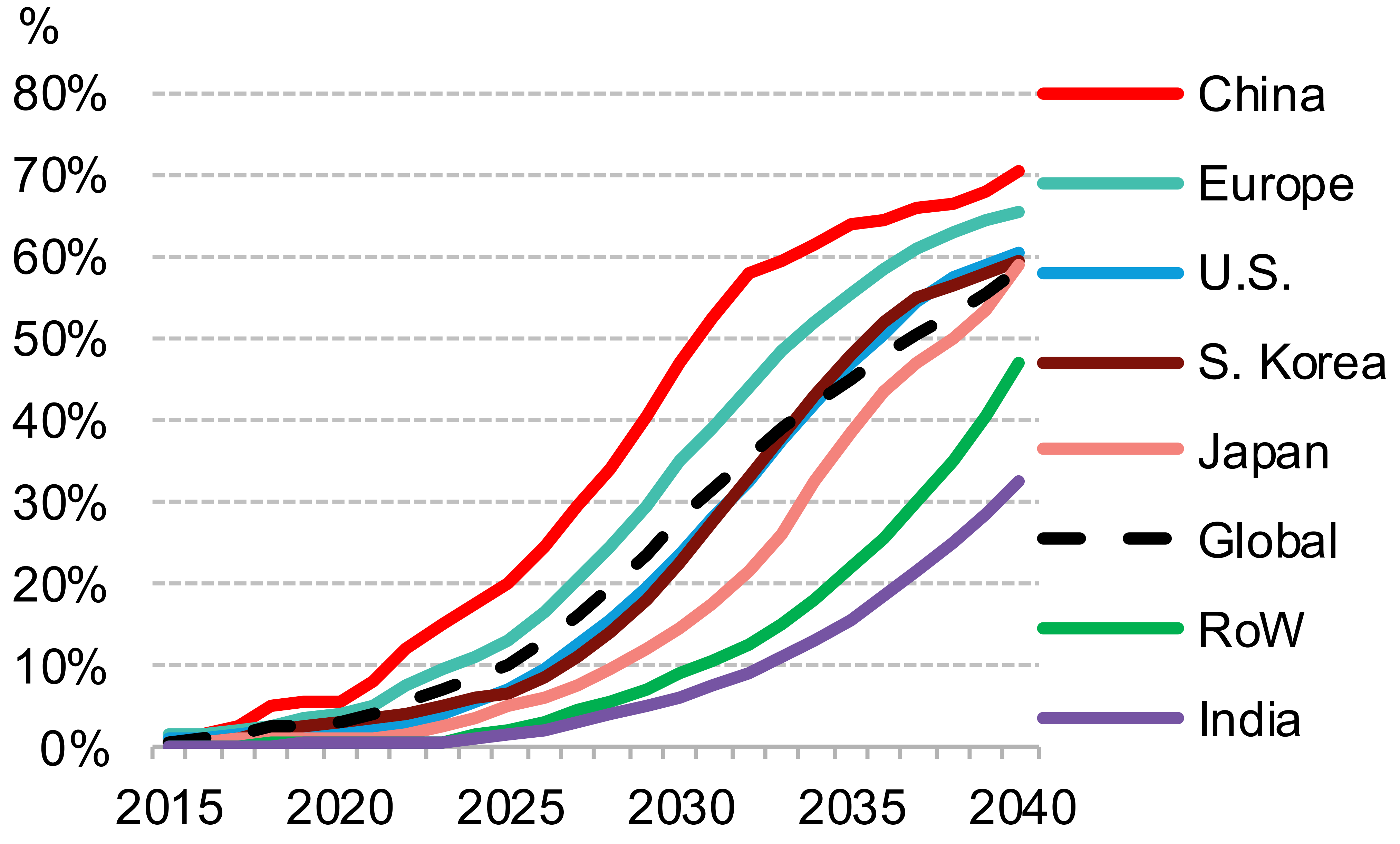



*Source: BNEF, Bloomberg, ACEA, China Automotive Information Network.*

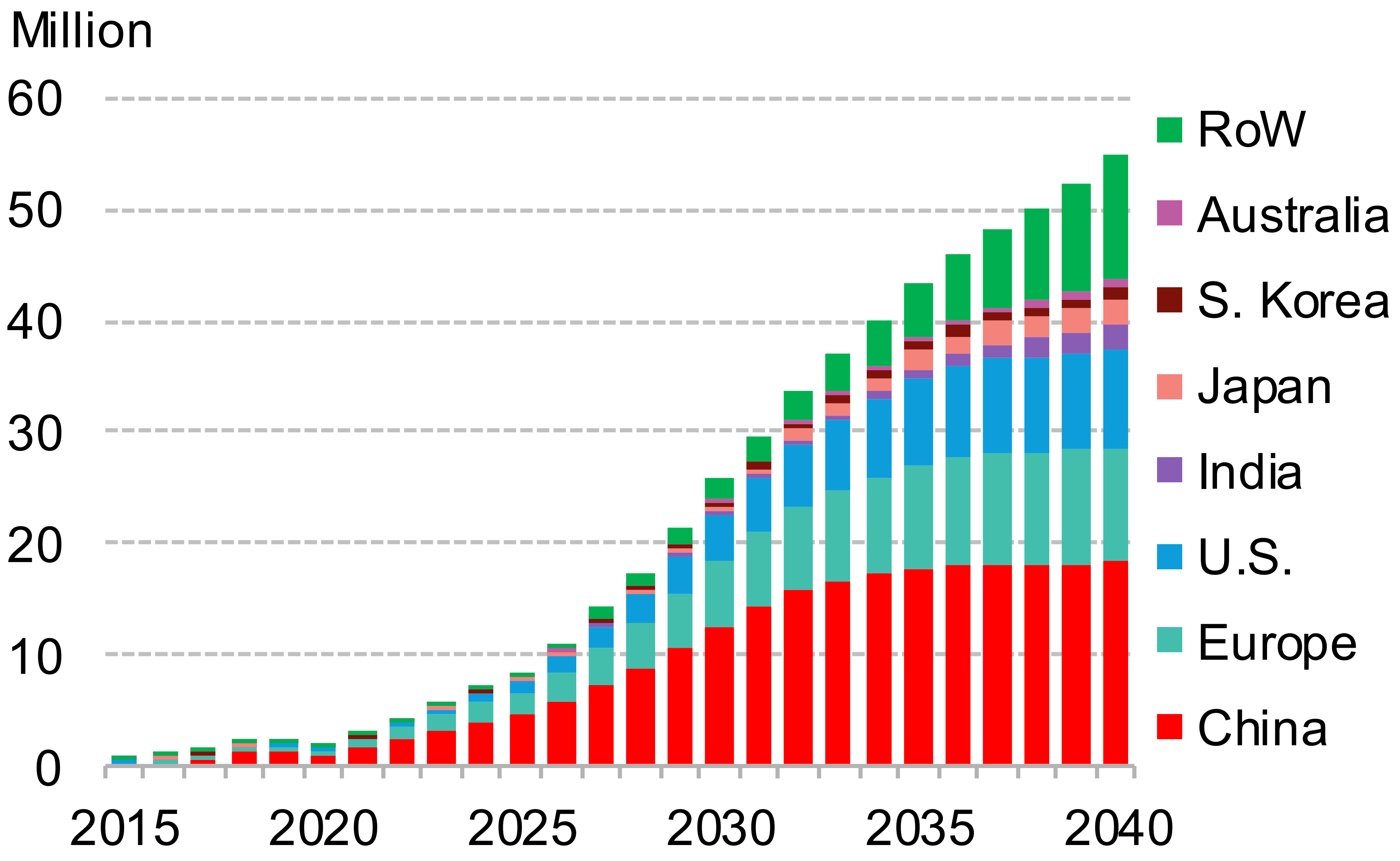
Most probably an understimation!

# Growth of electric vehicles

Global EV share of new passenger vehicle sales by region

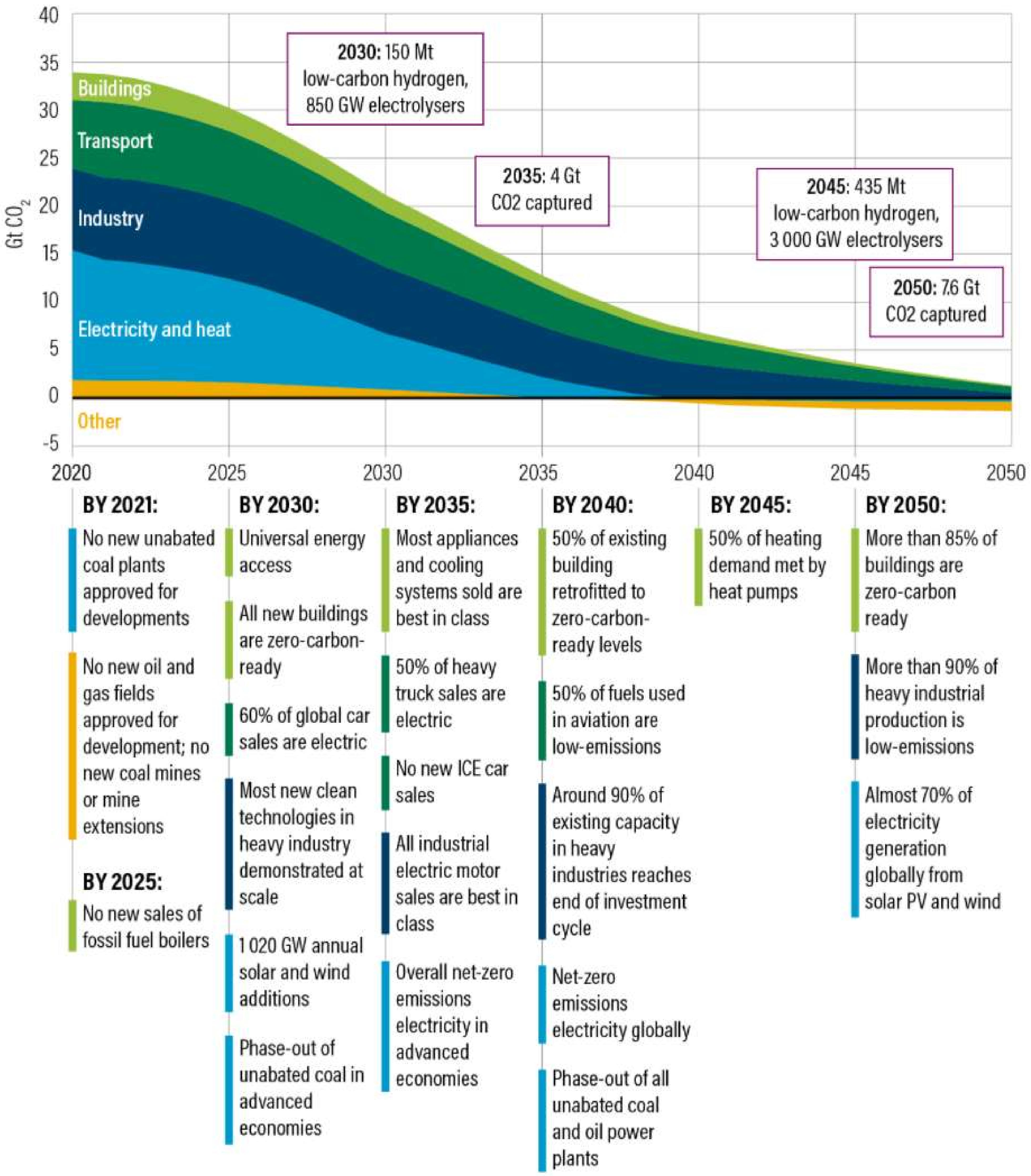



Annual passenger EV sales by region

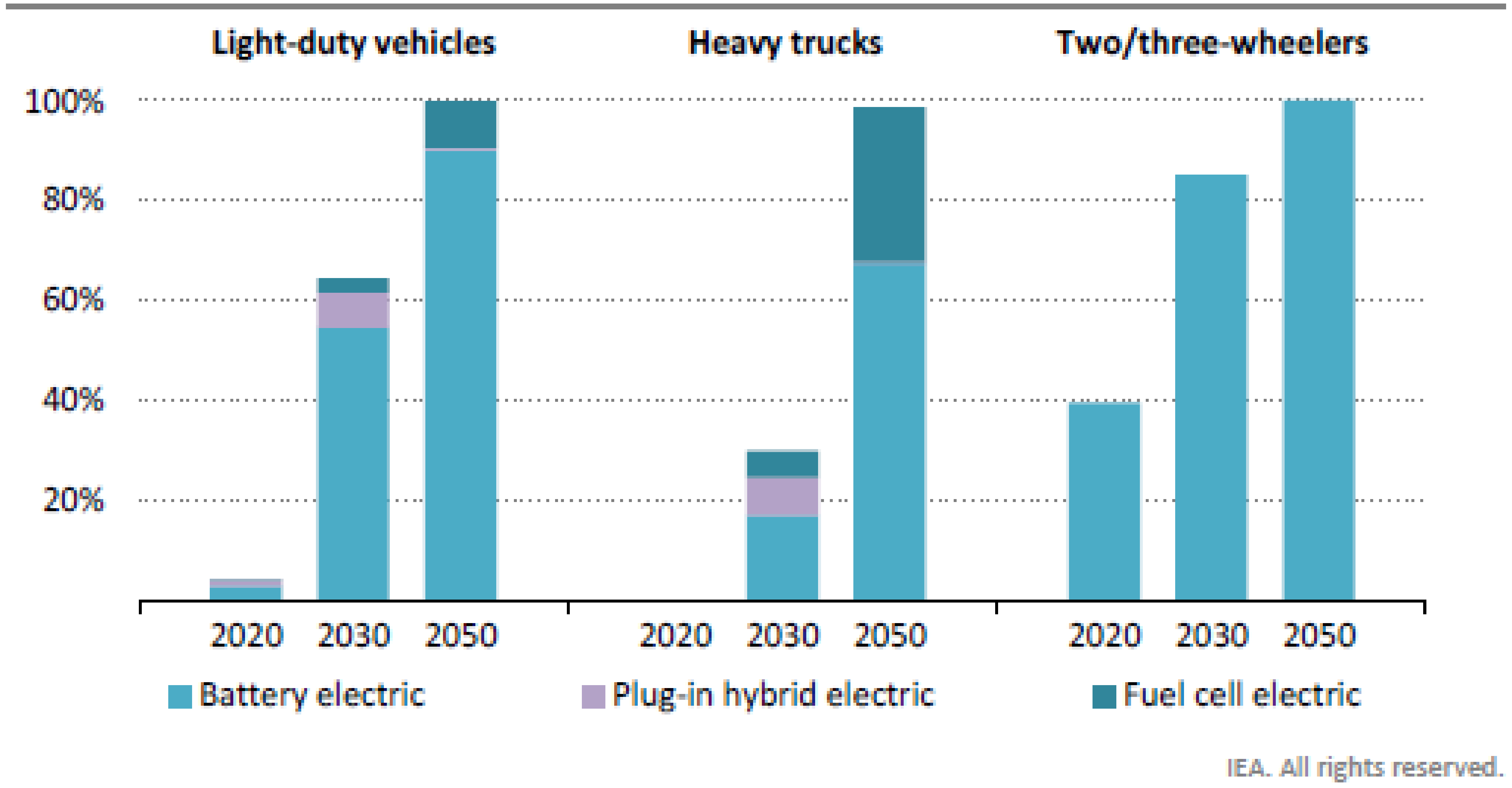


# Growth of electric vehicles

Key Milestones to IEA's Pathway to Net Zero







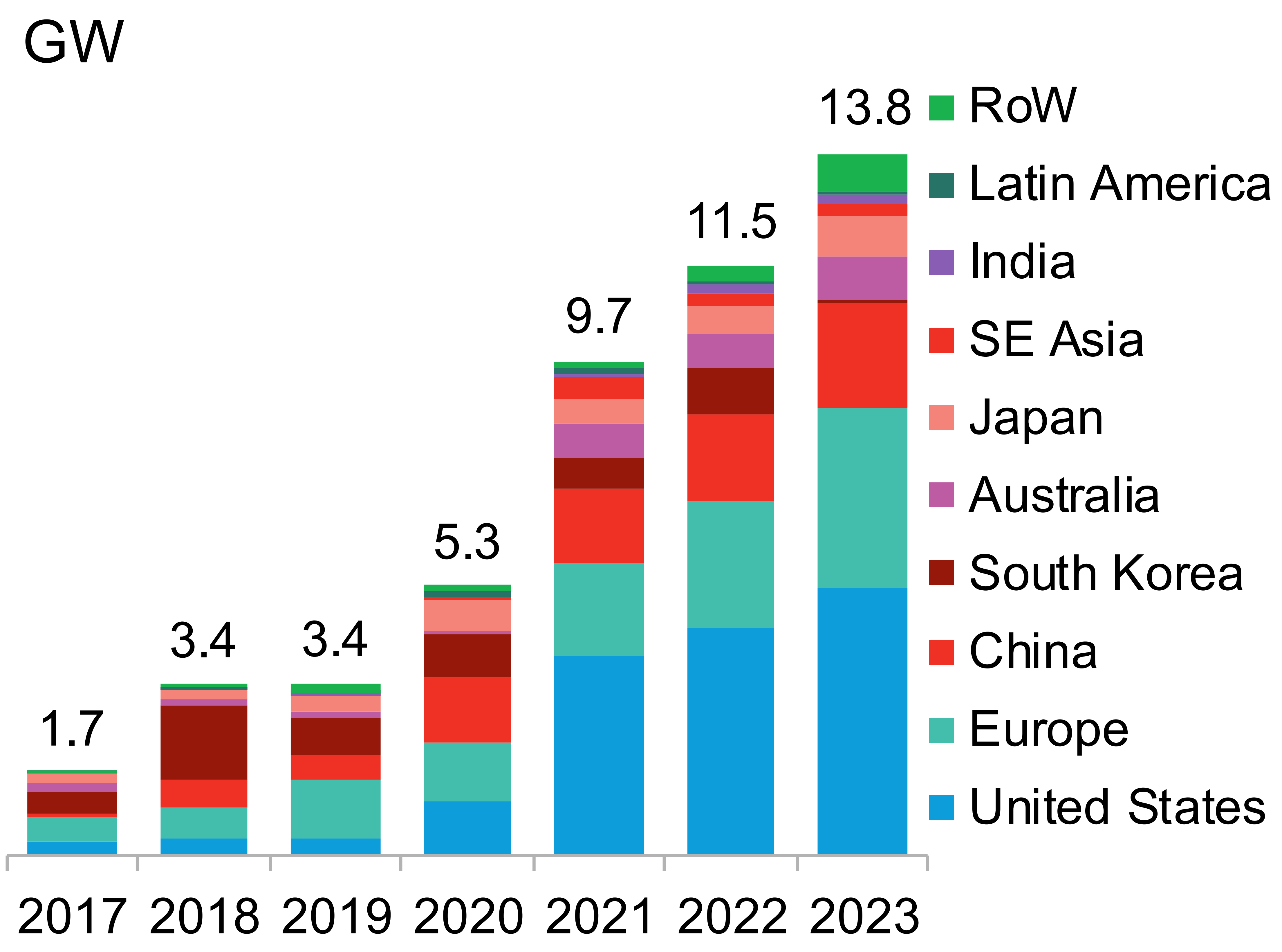



*Sales of battery electric, plug-in hybrid and fuel cell electric vehicles soar globally*

# Stationary storage

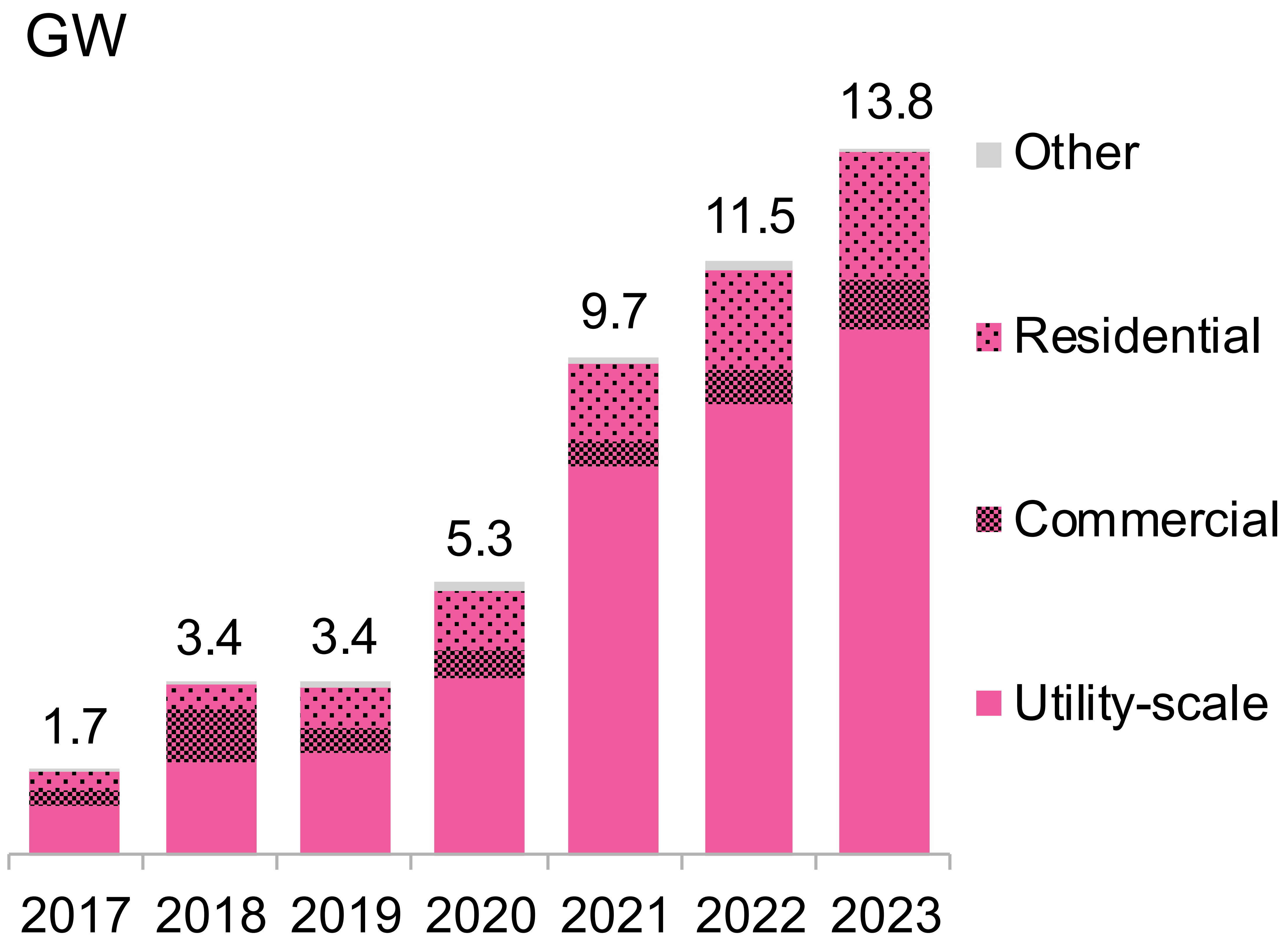
## Utility dominates, US fastest growing market

Global energy storage build by country




Source: BloombergNEF. Note: SE Asia = Southeast Asia, RoW = Rest of the World.

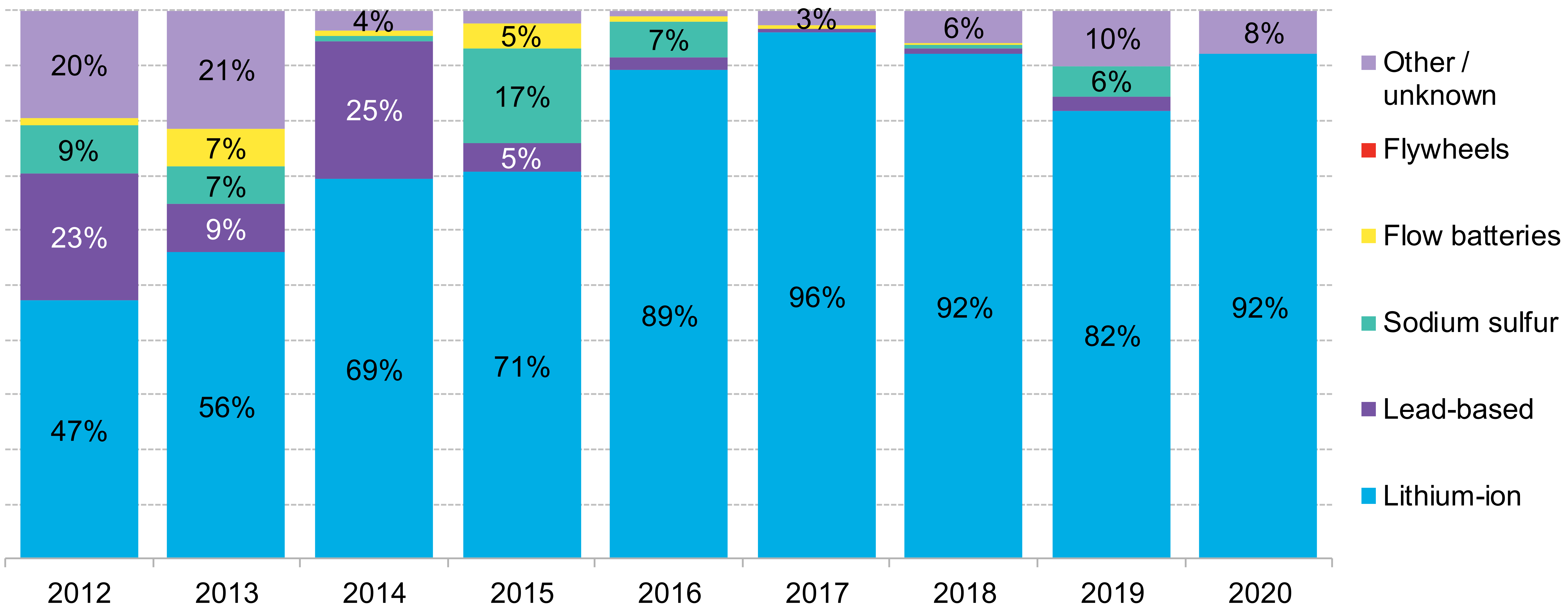
Global energy storage build by segment




Source: BloombergNEF.

# Lithium-ion dominating the market

## Technology mix of commissioned utility-scale storage projects based on power output

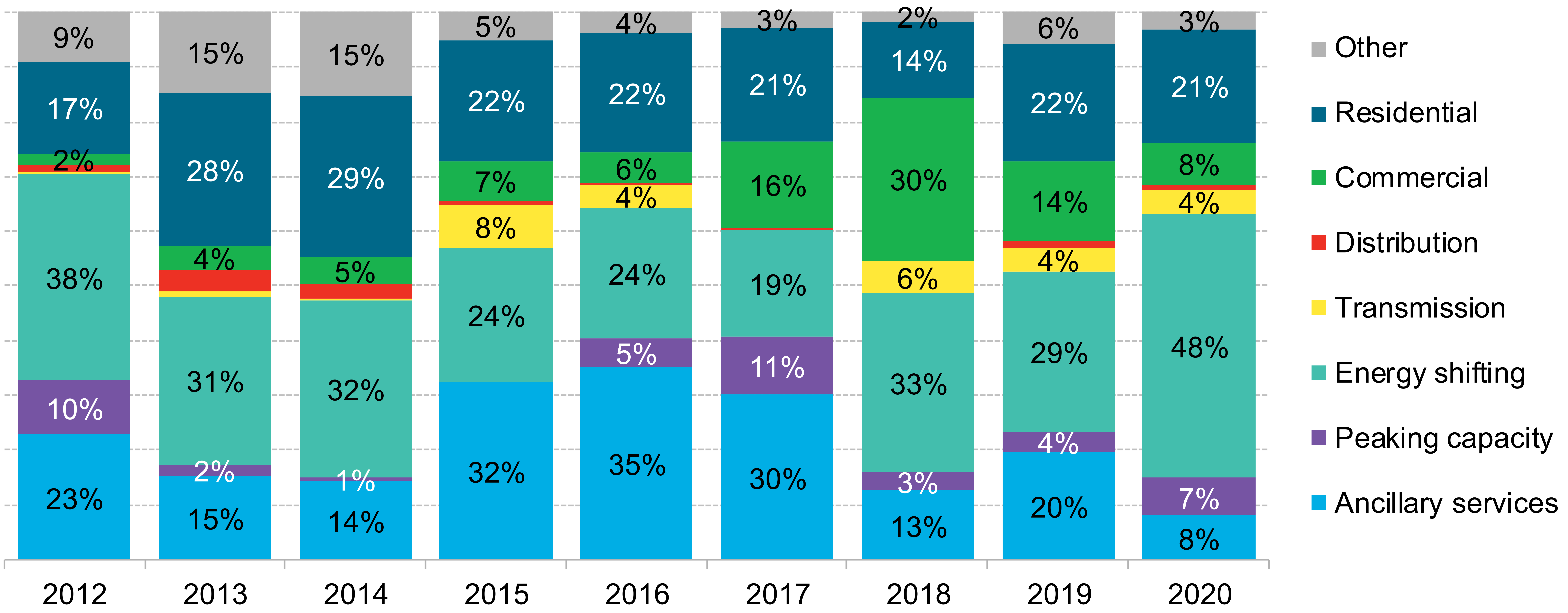



Source: BloombergNEF. Note: Excludes pumped hydro and compressed air energy storage projects. If multiple applications are selected, the capacity is divided equally amongst them.

# Energy shifting largest application



## Application mix of commissioned energy storage projects based on power output




Source: BloombergNEF. Note: Excludes pumped hydro and compressed air energy storage projects. If multiple applications are selected, the capacity is divided equally amongst them. This chart includes behind-the-meter + utility-scale capacity.

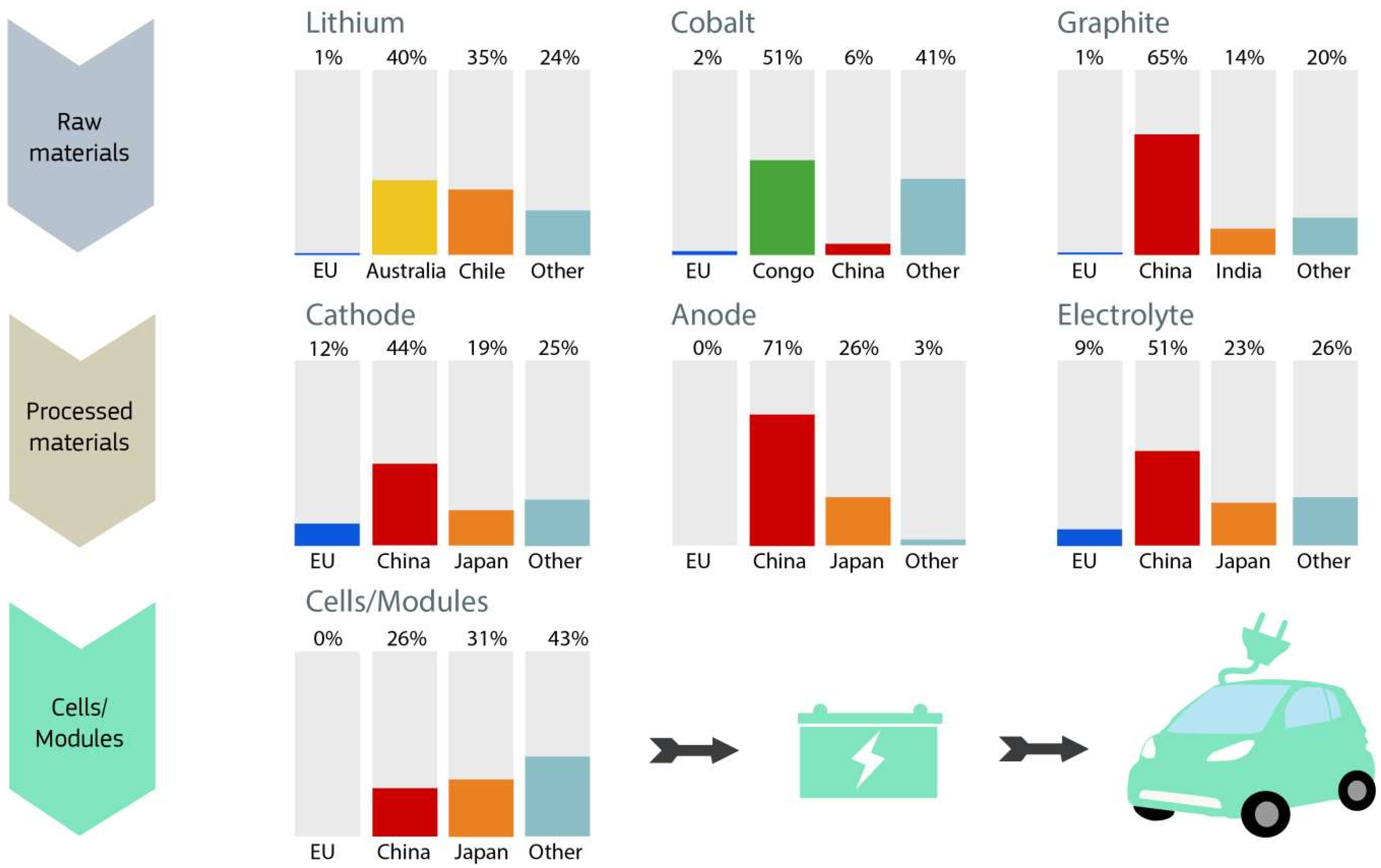
# Topics

- Why talk about batteries?
- Market development
- European Battery Alliance
- Applications

# Situation 2017

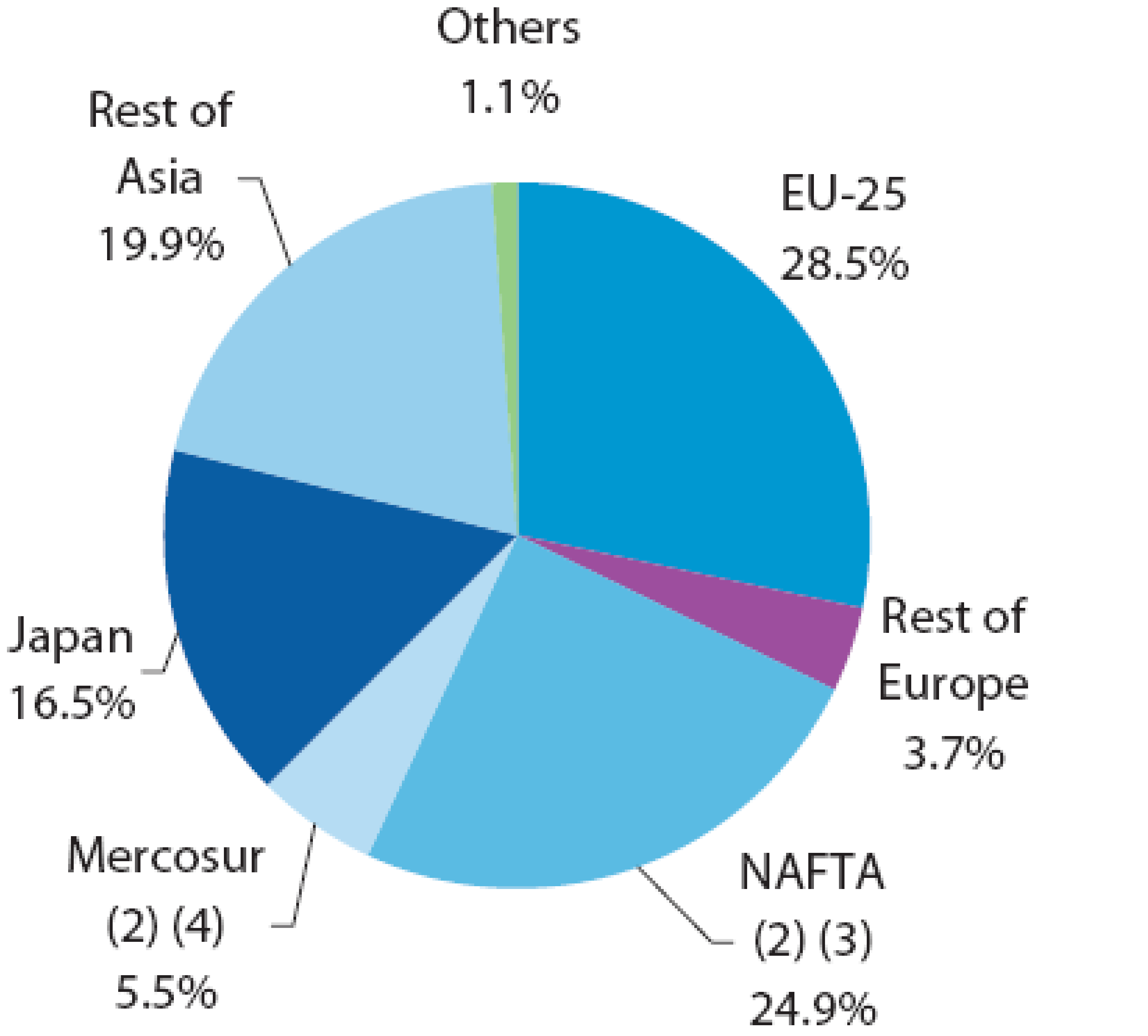


## Global battery value chain




Sources: Roskill, Peteves et al., World Resource Forum 2017, European Commission

## Global car manufacturing




(1) Including interim or estimated figures.
(2) Including light trucks.
(3) North American Free Trade Agreement covering Canada, the United States and Mexico.
(4) Southern Common Market covering Argentina, Brazil, Paraguay and Uruguay.

*Source:* VDA, http://www.vda.de

# Ecosystem approach in Europe



## **Boom in battery production in Europe** catalysed by concerted policy and investment effort

### Securing Access to Raw Materials

- Communication on critical raw materials
- Raw Materials Alliance with a focus on upstream supply chain elements

### Accelerate R&D Innovation

- Various programs such as Horizon 2020, Batteries Europe, Horizon Europe, Battery 2030+ promoting technology leadership

### Sustainability Focus

- Battery Regulation Proposal (Dec 2020) as part of a Circular Economy Action Plan

### Supporting Cell Manufacturing

- Important Projects of Common European Interest to the tune of €3.2bn (Dec 2019) and €2.9 BN (Jan 2021) launched and funded

### Securing Skilled Workforce

- Dedicated projects such as ALBATTS, DRIVES, and COSME
- Automotive Skills Alliance launched (Nov 2020)

EBA ACADEMY

### Policy Consistency

- Aligning broader frameworks like EU's trade policy, clean energy strategy, mobility packages, and Green Deal

*Sources: European Commission, Oliver Wyman*

# EBA250 – The industrial development programme of the European Battery Alliance



EUROPEAN BATTERY ALLIANCE | EBA250

This cooperative ecosystem gathers the European Commission, interested EU countries, investment institutions and key industrial, innovation and academia stakeholders

EIT InnoEnergy has been trusted by the European Commission to drive forward and promote EBA250 activities, acting as network manager and project facilitator

## 700+ members


**60+** Research and associations active in large parts of the value chain

**10+** European Commission Services

**50+** Financial Institutions

# The European Battery Alliance – overview



The European Battery Alliance

**EU and Member States providing the supportive framework**

- EU = Strategic Action Plan on Batteries
- EU = Sustainable Batteries Regulation
- Other legislative & funding initiatives at EU and national level

EUROPEAN BATTERY ALLIANCE EBA250

**The industrial workstream of the Battery Alliance led by EIT Innoenergy**

- Open and inclusive platform for the entire battery ecosystem
- Policy insight
- Accelerating battery projects → Business Investment Platform BIP

**R&I Networks and initiatives**

BATTERIES EUROPE
EUROPEAN TECHNOLOGY AND INNOVATION PLATFORM

- Batteries R&I strategies and short to medium term technology roadmaps
- Coordination of battery initiatives
- Drive forward SET-Plan action on batteries

BATTERY 2030+

- Long-term technology roadmaps

**Battery Partnership (BEPA)**
Battery specific programmes under Horizon Europe

Other partnerships
Battery downstream work programmes under Horizon Europe

Other R&I activities

Two Battery IPCEIs

Interregional partnership on advanced battery materials (ERDF/Smart specialisation)

National and bilateral R&I activities

**Capture a new market worth 250B€/year in 2025**

A cpmpetetive and sustainable European battery vaölue chain!

# Ongoing and Planned Battery Cell Factories in Europe

I would take out this since it is repeated in next slide



**FREYR**
Announced, planned start 2023, up to 15 GWh

**NORTHVOLT ETT**
Under construction, Start 2021, up to 40 GWh

**NORTHVOLT Labs**
In operation, 0,5 GWh

**MORROW**
Announced, planned start 2021, up to 32 GWh

**ENVISION AESC**
In operation, 1,9 GWh

**BRITISHVOLT**
Announced, planned start 2021, up to 30 GWh

**ACC (France)**
IPCEI project, Start 2022, up to 24 GWh

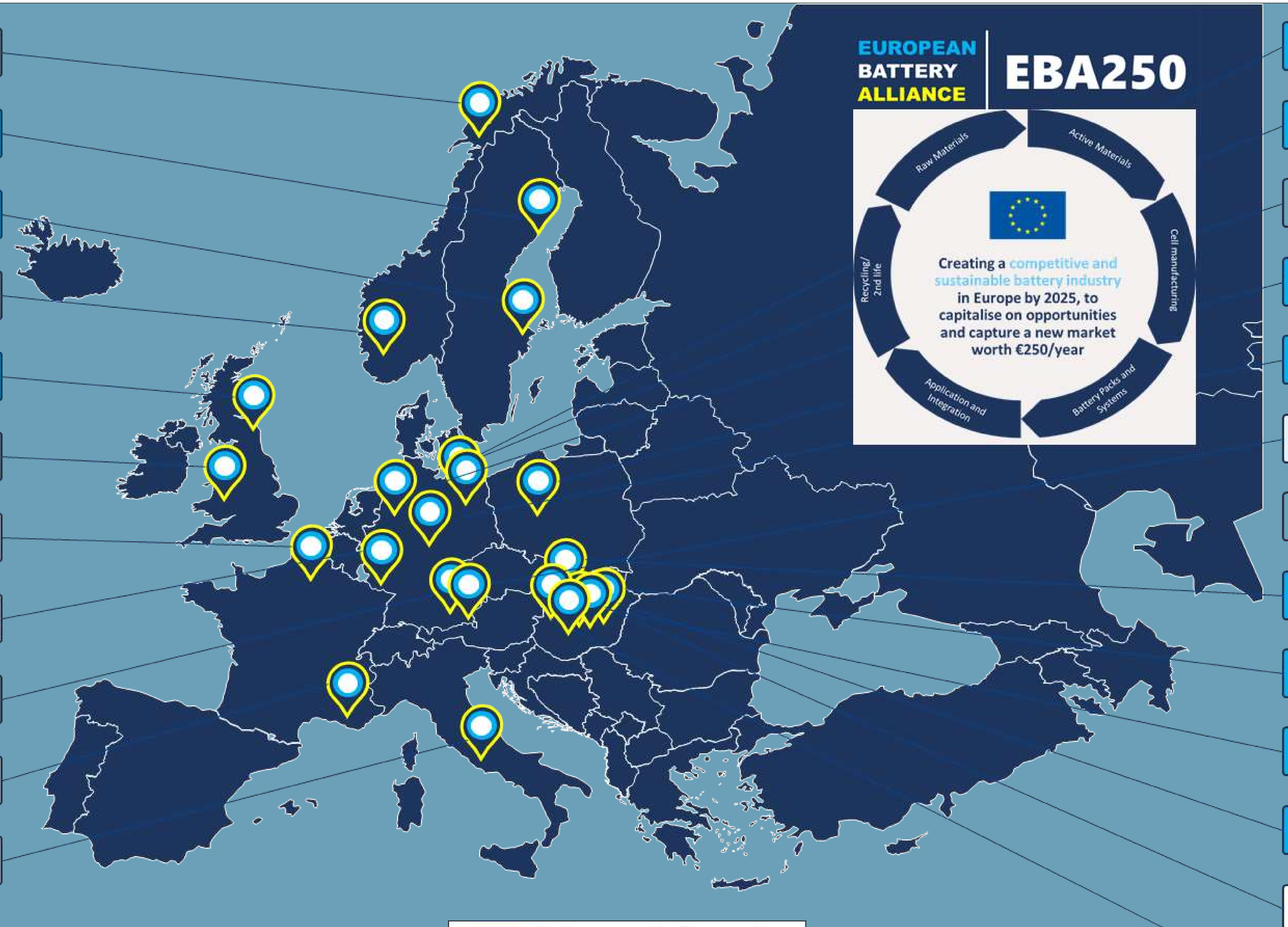
**ACC (Germany)**
IPCEI project, Start 2021, up to 24 GWh

**BMZ**
Announced, 4 GWh with possible ramp up to 28 GWh

**VERKOR**
Start 2023, 16GWh with plans to ramp-up to 50 GWh

**FAAM/LITHOPS**
Production started small scale, up to 10 GWh

**Volkswagen**
Additional 4 gigafactories à 40 GWh




**CATL**
Start 2022, up to 80 GWh

**TESLA**
Start 2022, up to 150 GWh

**CELLFORCE**
Announced, up to 1 GWh

**LG CHEM**
Start 2018, up to 67 GWh

**Volkswagen**
Start 2021, up to 40 GWh

**VARTA**
IPCEI project, Start 2021, up to 5 GWh

**FARASIS**
Announced, up to 15 GWh

**MES**
Start 2020, up to 15 GWh

**SAMSUNG**
Start 2018, up to 30 GWh

**SK Innovation**
In operation, 7,5 GWh

**SK Innovation**
Start 2021, up to 9,8 GWh

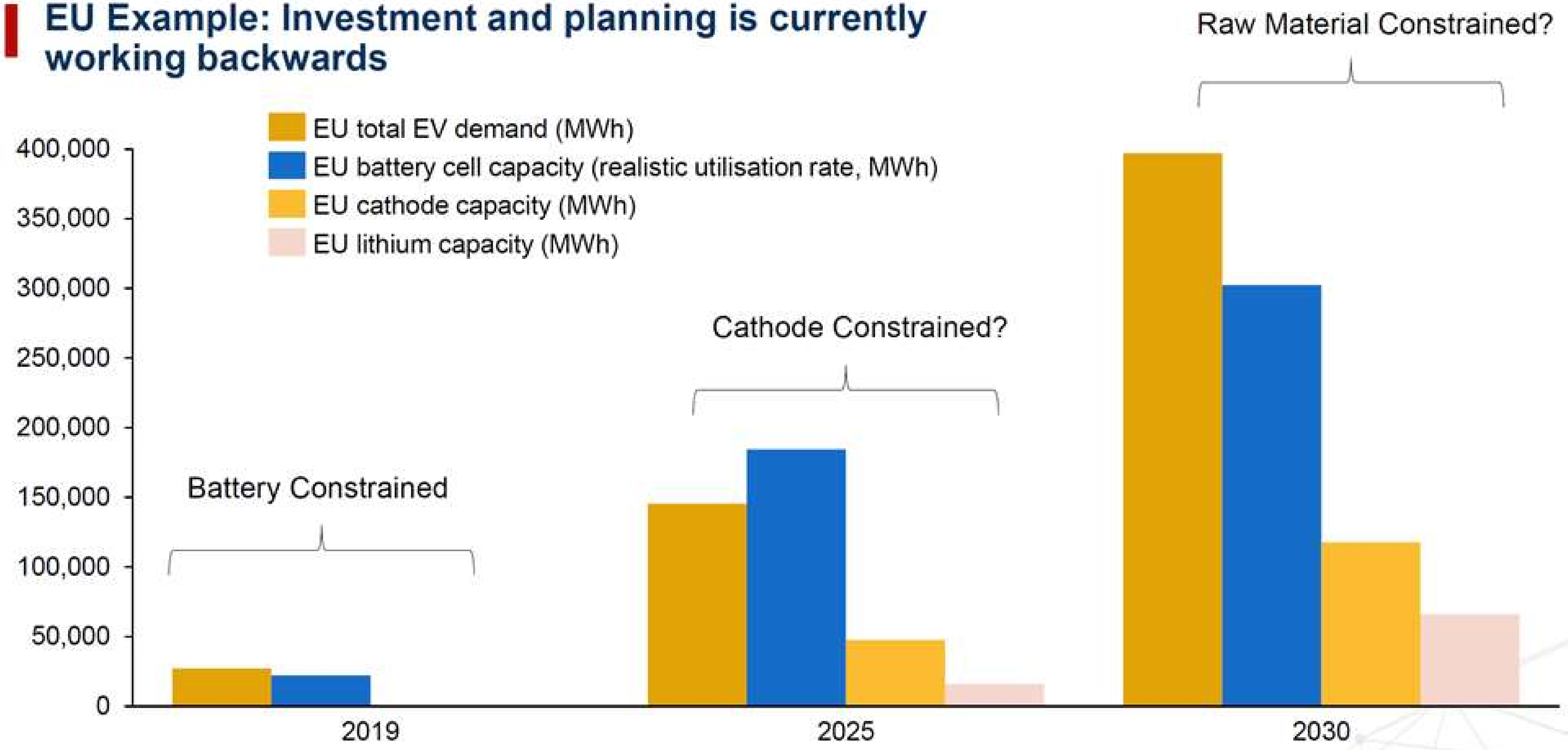
**SK Innovation**
Announced, start 2028, up to 30 GWh

**INOBAT**
Under construction, up to 10 GWh

Under construction/ in operation
Planned, partially financed
Announced, financial status unclear

# Bottlenecks in the value chain

## EU Example: Investment and planning is currently working backwards




Note: Above shows announced plans as of June 2020, not a forecast of capacity in each year.

Source: Benchmark Mineral Intelligence

BENCHMARK MINERAL INTELLIGENCE

9

# Examples of projects along the European value chain

## Mines, active materials, recycling

**SKALAND GRAPHITE**
Graphite Anode Production
Start 2021, Ramp Up 2023

**KELIBER**
Lithium Mine
2021 (Capacity 12500t/a)

**REVOLT (NORTHVOLT)**
Recycling Pilot Plant
Start 2020

**FORTUM & BASF & NORNICKEL**
Recycling Centre
Announced

**BASF**
Cathode Material Plant
Start 2022

**UMICORE, NYSA**
Cathode Material Plant
Start 2021

**REVOLT (NORTHVOLT)**
Full-Scale Recycling Plant
Start 2022

**BASF & SCHWARZHEIDE**
Cathode Material Plant
Start 2020

**ELKEM**
Battery Graphite Pilot Plant
Start 2020

**PROMOBIUS**
Recycling Plant
Start 2021

**VOLKSWAGEN & SALZGITTER**
Recycling Pilot Plant
Start 2020 (Capacity 1200t/a)

**CINOVEC**
Lithium Mine
(Capacity 22500t/a)

**VULCAN ENERGY**
Lithium from Brine
Start 2021

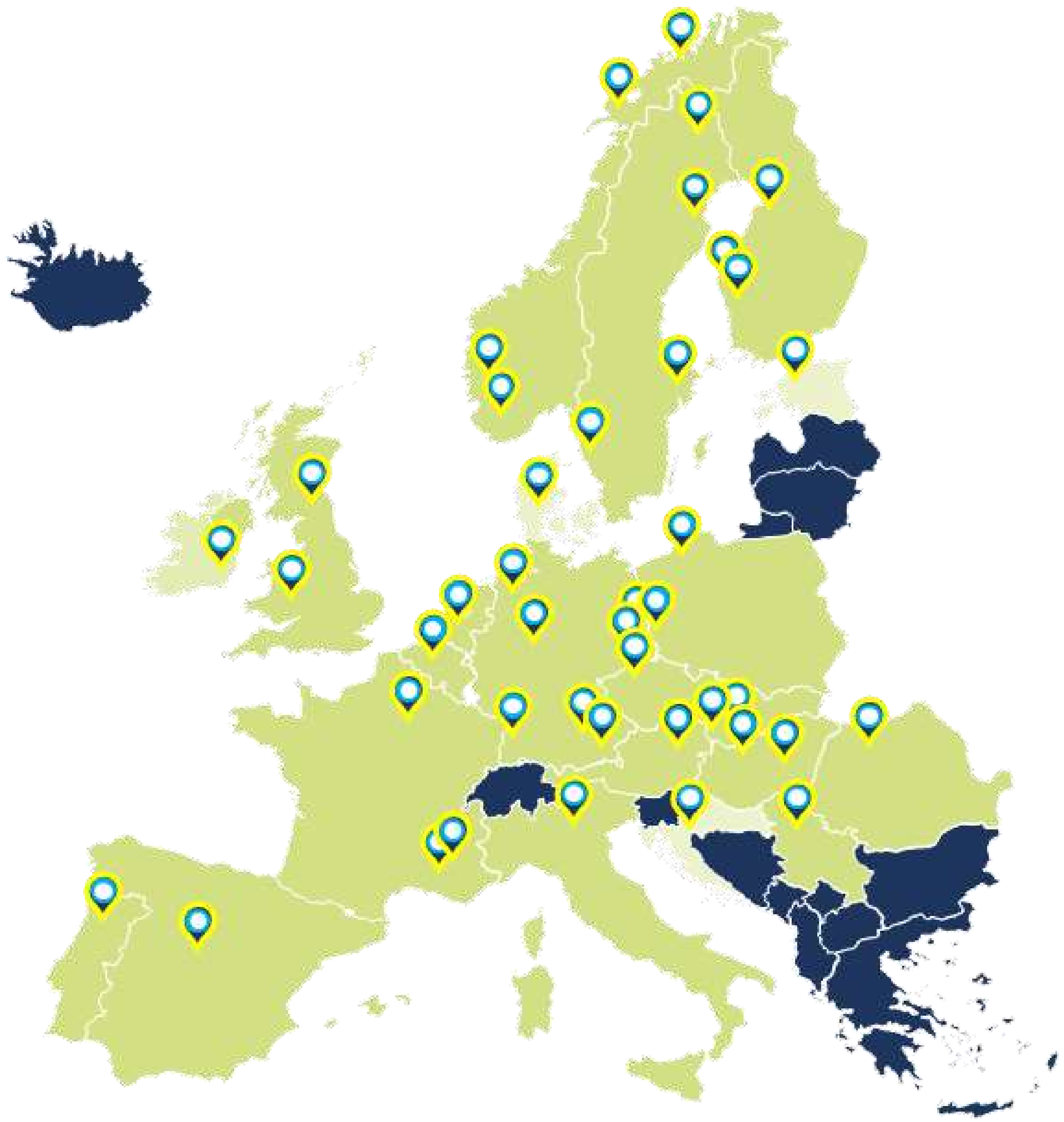
**EURO MANGANESE**
Manganese from Tailings, Start 2020 (Capacity 1.2 Mt)

**SAVANNAH RESOURCES**
Lithium Mine
Start 2021

**RIO TINTO & JADAR**
Lithium Mine
Start 2022

**INFINITY**
Lithium Mine
Start 2021 (Capacity 15000t/a)

**SNAM & HONDA**
Recycling Project
Announced



**2020**
**~ 26 GWh Capacity**

**2030**
**> 500 GWh Capacity**

## Giga Factories

**FREYR**
Start 2023
Up to 32 GWh

**CATL**
Start 2022
Up to 70 GWh

**NORTHVOLT ETT**
Start 2021
Up to 40 GWh

**TESLA**
Start 2021
Up to 40 GWh

**NORTHVOLT Labs**
Start 2020
Up to 0,5 GWh

**CELLFORCE**
Announced
Up to 1 GWh

**MORROW**
Start 2021
Up to 32 GWh

**LG CHEM**
Start 2018
Up to 67 GWh

**ENVISION AESC**
Start 2021
Up to 32 GWh

**NORTHVOLT ZWEI**
Start 2021
Up to 20 GWh

**BRITISHVOLT**
Start 2021
Up to 32 GWh

**VARTA**
Pilot Plant
Start 2021

**ACC (France)**
Start 2021
Up to 24 GWh

**FARASIS**
Start 2021
Up to 15 GWh

**ACC (Germany)**
Start 2021
Up to 16 GWh

**MES**
Start 2020
Up to 15 GWh

**BMW**
Pilot Plant
Start 2021

**SAMSUNG**
Start 2018
Up to 30 GWh

**VERKOR**
Start 2021
Up to 50 GWh

**SK Innovation**
Start 2021
Up to 18 GWh

**LITHOPS**
Start 2021
200 MWh

**INOBAT**
Start 2021
Up to 10 GWh

# Topics

- Why talk about batteries?
- Market development
- European Battery Alliance
- Applications

# Electric roads

- Electricity from either overhead lines or from the road
- Several tests in the world not the least in Europe
- Can reduce the need for large batteries
- Requires substantial investments over many years


# Battery powered heavy vehicles, does it make sense?

- Several OEMs on their way
- Driving regulation (Europe)
  - Maximum driving time 4,5 hours
  - Mandatory rest of 45 minutes
  - Ideal for charging intervals
- Driving
  - @ average 80 km/h: 500 kWh battery required (Tesla spec.)
  - Add 25% for safety: ~ 620 kWh
  - Tesla mod 3 battery ~5 kg/kWh
- Approx 3 100 kg of battery added to a total vehicle weight of 40 tonnes

# Battery powered heavy vehicles, How to charge?

- High power charging
  - New standards under development
- High demand on the local grid
- Buffer battery ("Trackside")
- Already an existing solution

# Trackside energy storage for trains

**(An amateurs view)**



- Ultracaps as an option
- Collecting braking energy at station
- Delivering acceleration energy at station
- Fast charging of battery electric trains from buffer battery at station
- PV + batteries along the track

# Questions

# Discussion

Johan Soderbom
Thematic Leader Smart Grid and Energy Storage

**Thank you for your attention.**

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# DUTCH RAILWAYS


**Herman Sibbel**
**Martijn Wolf**

# Workshop timeline



| | | |
|---|---|---|
| • Dutch railways: ProRail and NS | **Herman Sibbel** | **Martijn Wolf** |

*The presentation is based on research on the use of energy storage for different purposes.*
*NS and ProRail are the founders/sponsors of the research.*

| | |
|---|---|
| **Herman Sibbel**<br><br>**Movares**<br>Energy and rail market Business manager/senior consultant | **Martijn Wolf**<br><br>**Ricardo Rail**<br>Senior consultant |

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# TRACKSIDE ENERGY STORAGE

## The Dutch situation

**Herman Sibbel (Movares), Martijn Wolf (Ricardo Rail)**

# Content

- Background of the project
- Applications for trackside energy storage
- Matching possibilities with sustainability goals
- Review energy storage systems
- Conclusions and next steps

# Background of Trackside energy storage project



- Team

# Background of Trackside energy storage project

Sustainability goals NS (railway operator) and ProRail (rail infrastructure manager)

ProRail

- Energy neutral in 2030 by making use of self-generated sustainable electricity
- Increase energy efficiency with 30% in 2050 compared to 2010

- In 2040 NS will be fossil fuel free (100% sustainable energy sources and no fossil fuel backup)
- Increase energy efficiency with 10% for traction and 20% for utilities in 2030 vs 2020
- In 2030 an additional 30 MW sustainable electricity will be self-generated compared to 2019

**How can trackside energy storage supports these goals?**

# Background of Trackside energy storage project

## Project Goals

Investigate how trackside energy storage can improve the sustainable energy and reliability goals and objectives of NS and ProRail by assessment of the technical and financial feasibility

# Applications for trackside energy storage



Nine applications for the use of energy storage have been identified

1. “Bringing home” function if a major power failure occurs
2. Contribution to national frequency containment reserve (primary reserve)
3. Contribution to peak shaving at network connections for traction
4. Optimising of overhead line voltage
5. Hourly Matching (match between time of generation and time of use)
6. Storage of self-generated sustainable electricity
7. Replacement of fossil fuel emergency power generators
8. Contribution to energy/mobility hub
9. Storage of regenerative braking energy

# Matching applications with the sustainability goals

- Combining of applications is financially the best option
- But very complex to decide how to combine (many parameters)
- First: the number of applications to analyse are reduced by matching with the sustainability goals:
    - Hourly matching
    - Storage of self-generated energy
    - Storage of regenerative energy

- Combined with applications with highest financial returns
    - Primary reserve
    - “Bringing home” function
    - Energy/mobility Hub

# Review energy storage systems

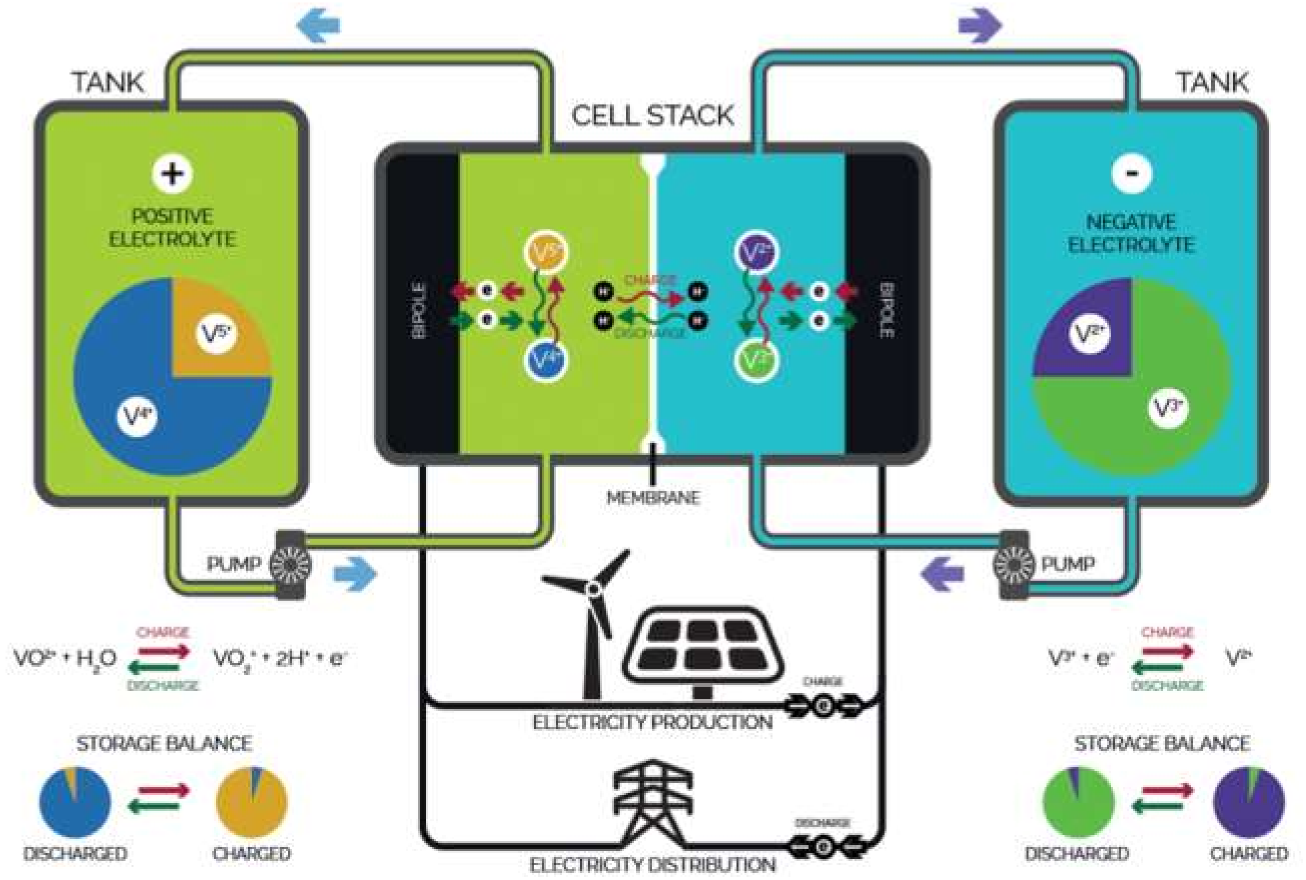


- Which technical solutions are feasible?
- Examples:
    - Chemical batteries, e.g. Pb battery, NiCd battery lithium-titanate-oxide battery
    - Chemical flow batteries, e.g. Vanadium Redox flow Battery
    - Electromagnetic, e.g. (super) capacitor, Superconducting magnetic energy storage
    - Thermal energy storage
    - Mechanical energy storage, e.g. flywheel, compresses air energy storage (CAES), water reservoirs

# Review energy storage systems

Two solutions identified

- Vanadium Redox flow Battery (VRB) and lithium-titanate-oxide battery (LTO):
  - Combination of maximum capacity/power, Charge/ Discharge cycles, relatively low costs, acceptable size




[Source: https://vrbenergy.com/]

[Source: www.leclanche.com]


[Source:https://www.global.toshiba/ww/products-solutions.html]

# Review of energy storage systems

Preliminary financial results:

- Investment costs are relatively high and income not significant. Examples:
  - Lower energy costs
  - Lower substation network connection costs
  - Lower CO2 emissions
  - Reduced operational costs
  - Income via primary reserve
  - Reduced costs for emergency power generators.

→ Payback period varies between 5 years (regenerative braking energy) to decades (improvement of hourly matching)

However:

- Combination of applications decreases the payback period
- The payback period depends strongly on the valuation of items such as hourly matching, CO2 reduction, sustainable transport etc. (important matters for society). This can increase significantly the coming years due to recent and new climate agreements.

# Conclusions and next steps

Conclusions

- Technical it seems feasible to make use of trackside energy storage in the railways
- Combining energy storage applications is essential for a positive business case
- Sustainability should be valued more highly and considered in the business case

Next steps

- Setup a business case with combination of possibilities
- Determine juridical impact: e.g. is an infrastructure manager allowed to deliver electricity? Who owns recuperated energy? etc.
- Determine risks: financial, EMC, fire safety, space occupancy etc.
- Setup of a pilot

# For questions you can contact: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# Questions

# Discussion

Herman Sibbel
Martijn Wolf

**Thank you for your attention.**

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# RTRI


**Takeshi Konishi**
Lead Design Engineer & OCL expert

# OUTLINE OF TRACKSIDE ENERGY STORAGE SYSTEM IN JAPAN

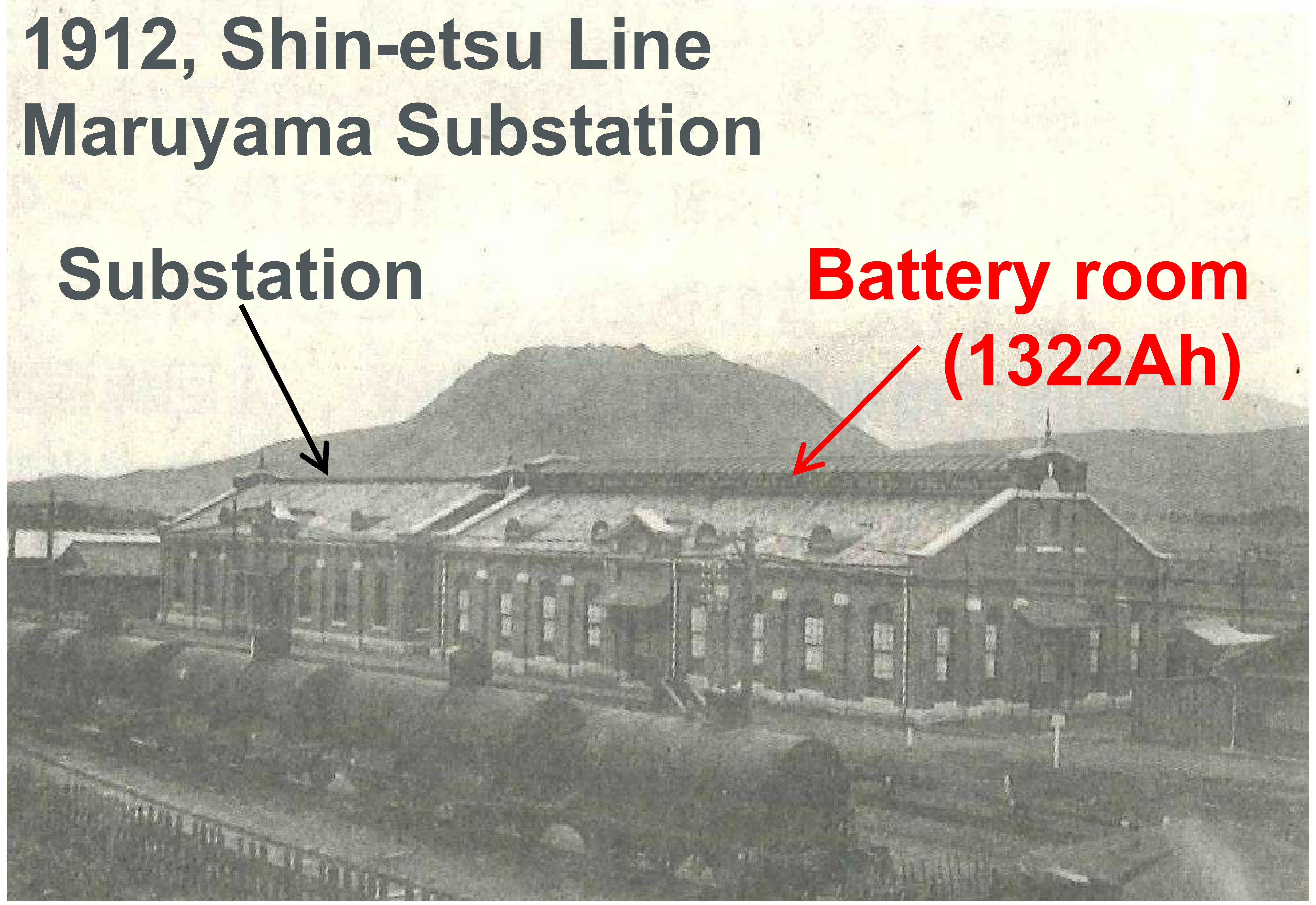
Takeshi Konishi
Railway Technical Research Institute

# Outline of this presentation

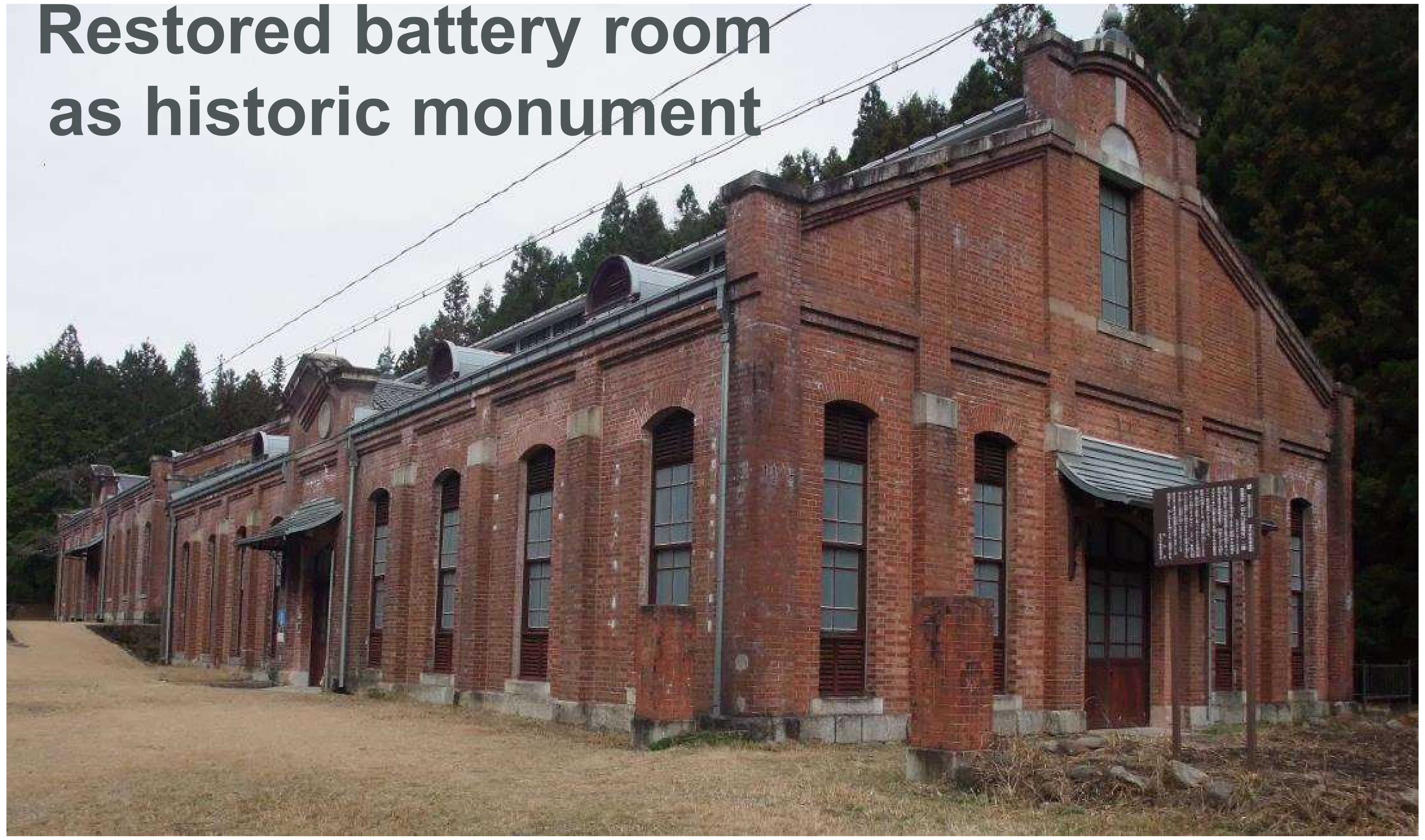
Trackside Energy Storage System (TESS)

- Introduction status in Japan
- Constitution
- Control methods
- Recent topics

# Traditional Trackside Energy Storage System




Reference:RRR, vol.75, No.3, pp.28-31, 2018.3 (in Japanese)



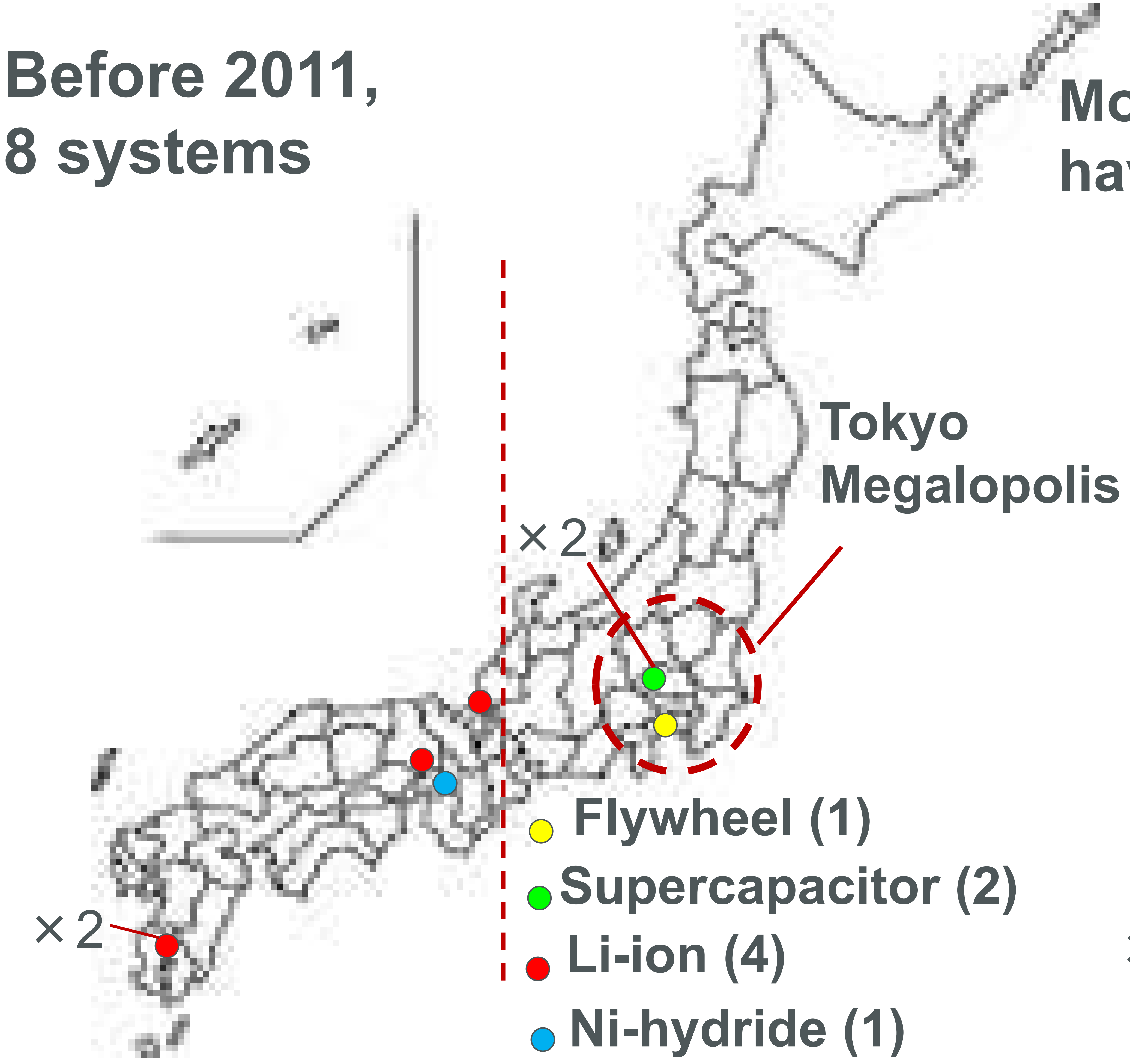

Reference:RTRI REPORT, vol.33, No.5, pp.39-42, 2019.5 (in Japanese)

**Purpose: Peak Shaving, Supplementary power supply**

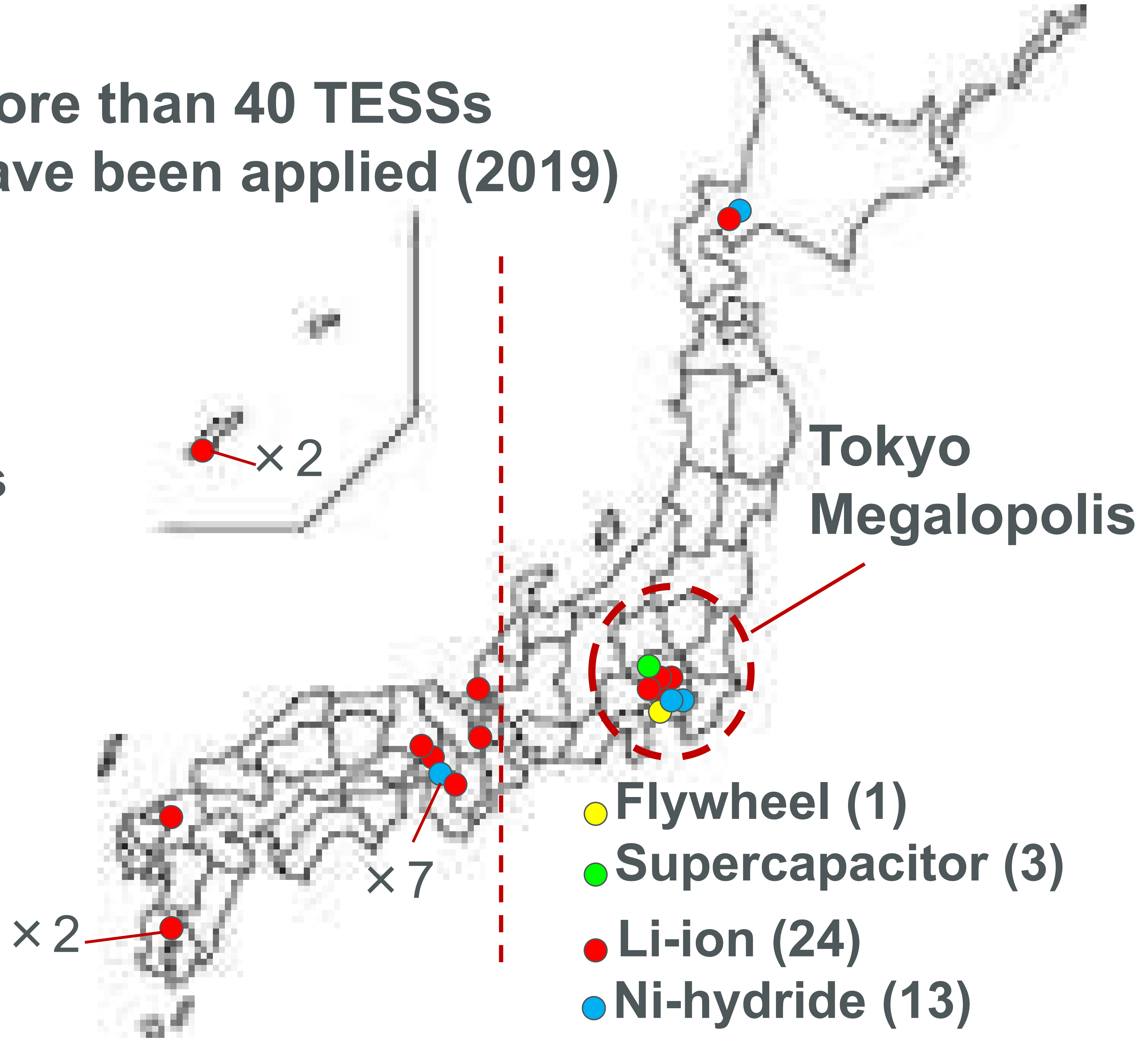
**Before 1928, such batteries (Lead-acid) had been installed also in Tokyo metropolitan area (ex. Keihin-Tohoku line)**
**All the batteries have been abolished by 1941 in Japan.**
**TESSs in Japan have been revived since 1988.**

# TESS application status in Japan

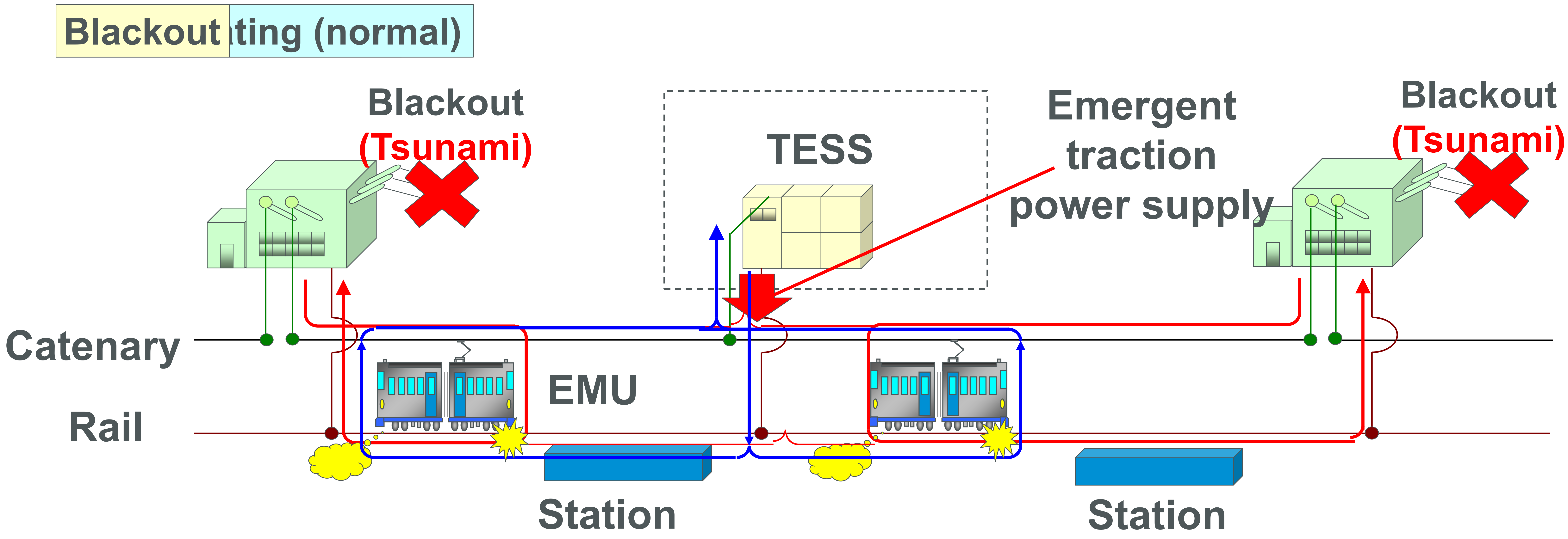
Before 2011,
8 systems




More than 40 TESSs
have been applied (2019)



# Recent increase of TESSs in Japan




The Great East Japan Earthquake in 2011 has influenced tremendous shock of energy policy for Japanese railway.
TESSs have been installed for the purpose of two reasons.

Energy Saving

Emergency traction power supply
(especially subway and monorail)

# Specifications of various type of TESSs

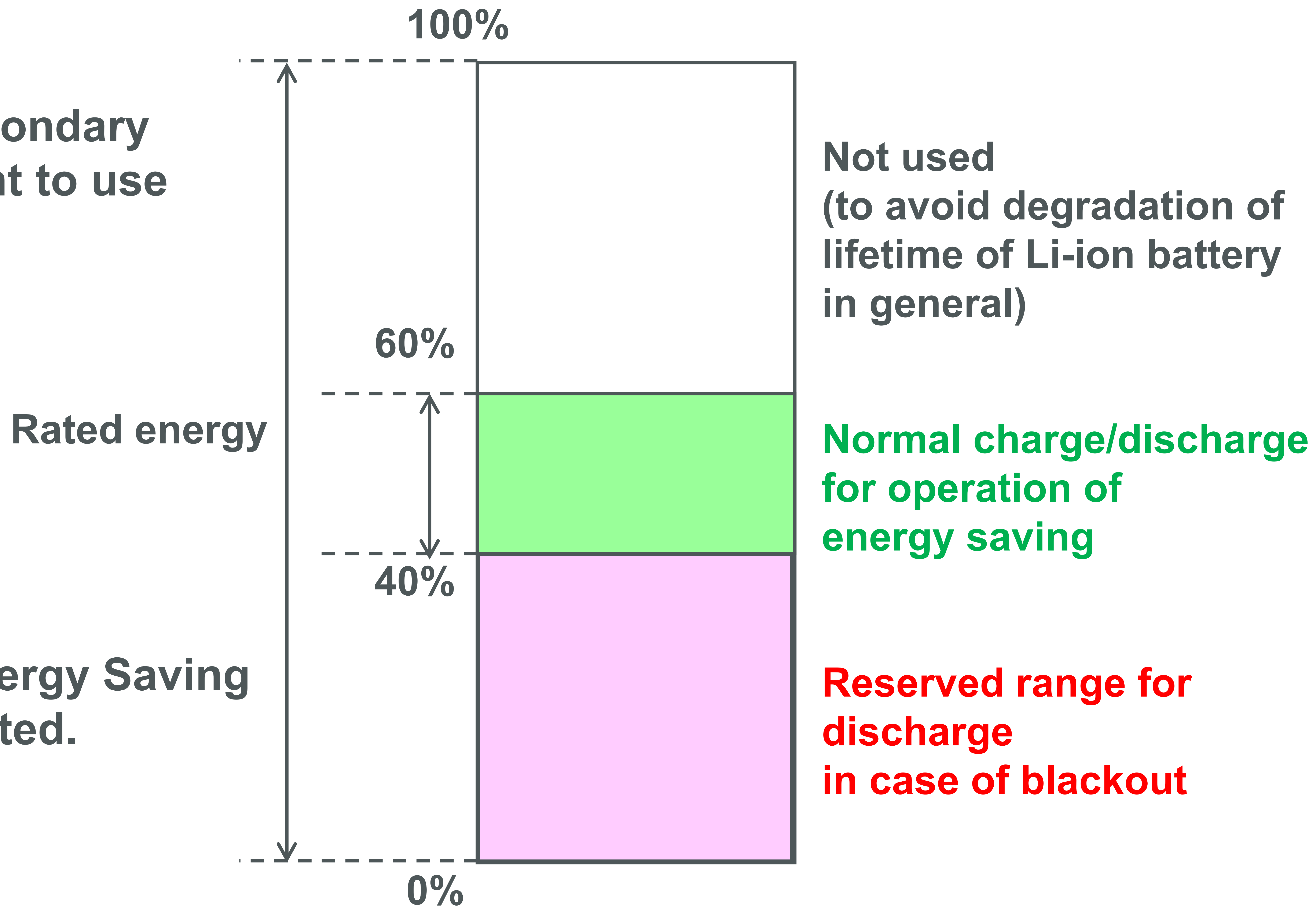
| Energy Storage Unit | Rated Power (kW) | Rated Energy (kWh) |
|---|---|---|
| Flywheel | 3000 | 25 |
| Supercapacitor | 2000 – 2600 | 7 - 17 |
| Lithium-ion Battery | 250 - 3000 | 18 - 600 |
| Nickel-metal hydride Battery | According to the internal resistance | 100 - 1000 |

**Flywheel, Capacitor: Capable of deep-cycle charge/discharge**

**Secondary Batteries: Deep-cycle charge/discharge is generally not recommended to avoid fast degradation of lifetime (dependent on chemical design of each battery)**

# SOC range control of secondary batteries (Li-ion)

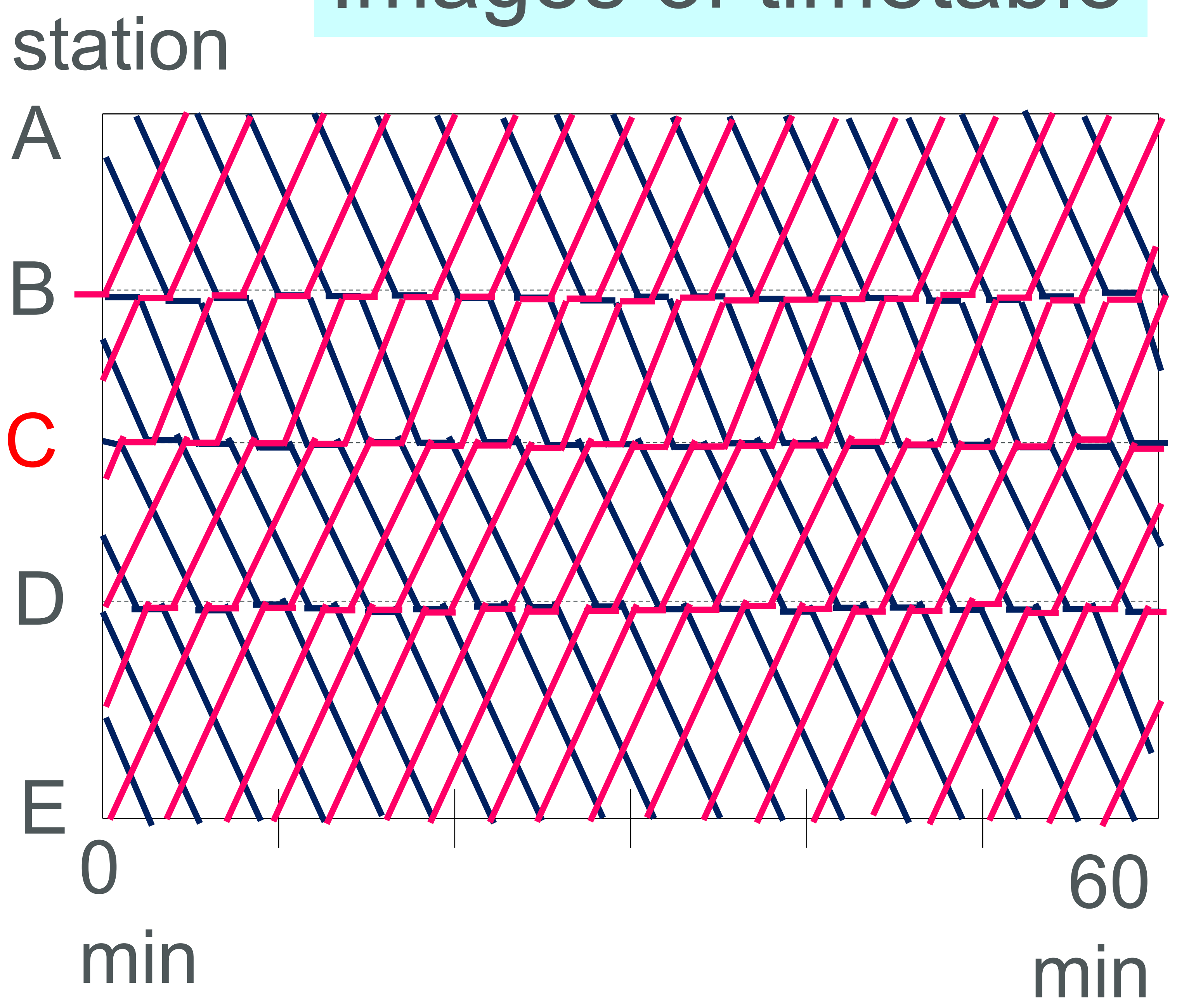
SOC range control of secondary batteries is very important to use TESSs for long years.



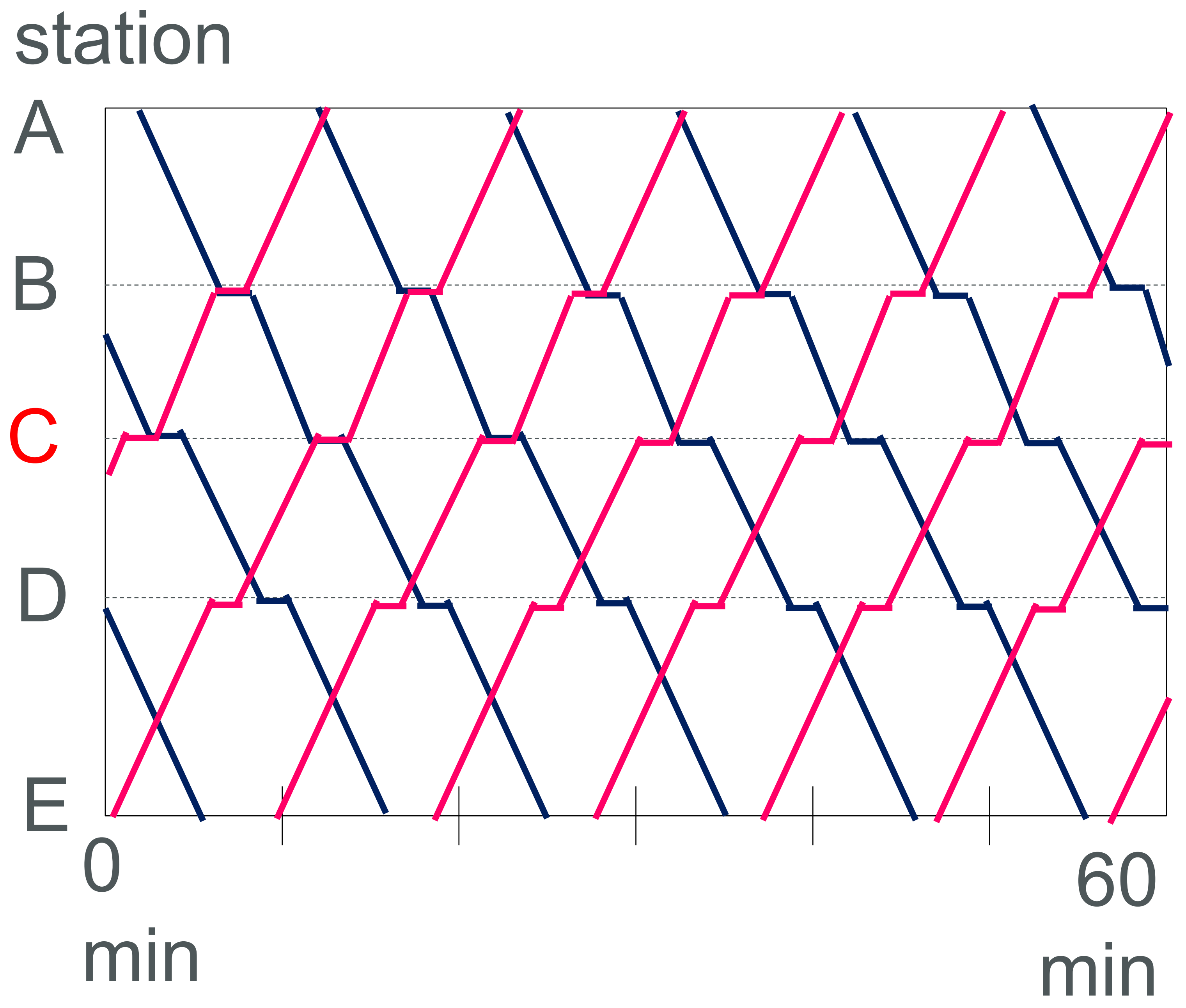

Usable SOC range for Energy Saving in normal use is very limited.

# Suitable application area of TESSs for Energy Saving

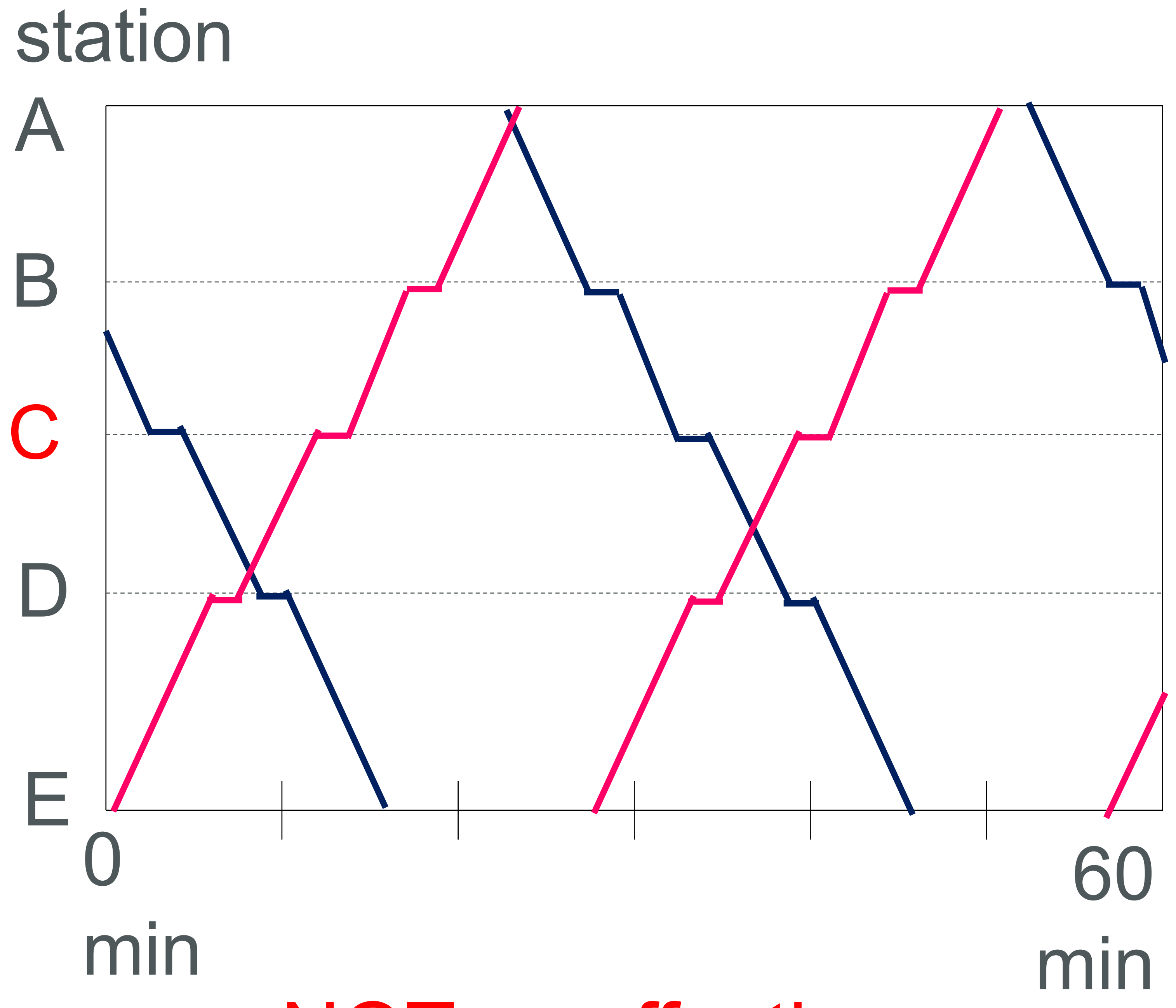
Images of timetable




NOT so effective
(metropolitan area)




Suitable
(suburban area)




NOT so effective
(countryside area)

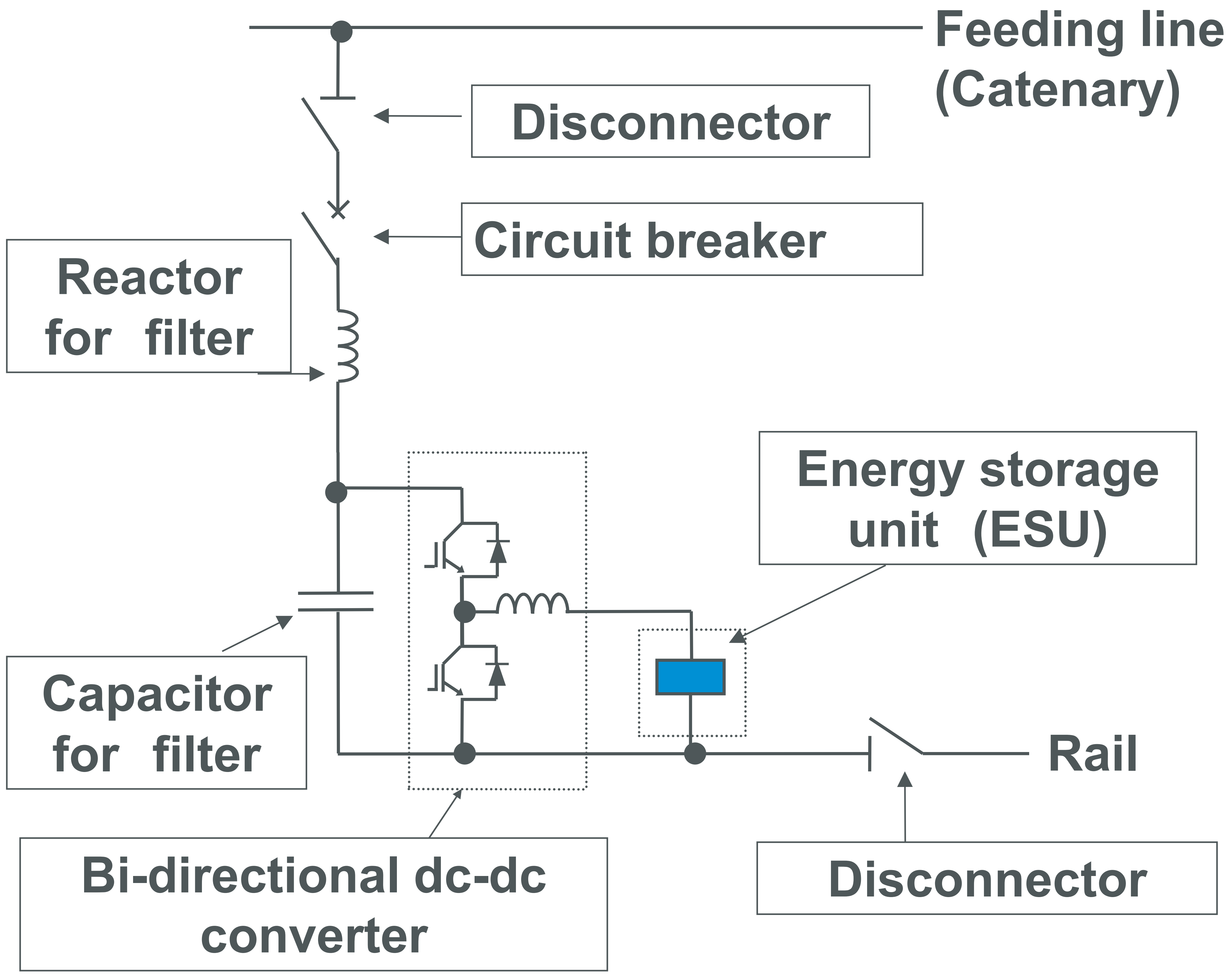
Regenerative energy can be easily transferred to and reused by other powering trains via contact line system.

Pretty well amount of regenerative energy is expected but transfer it via contact line system is slightly difficult due to distance.

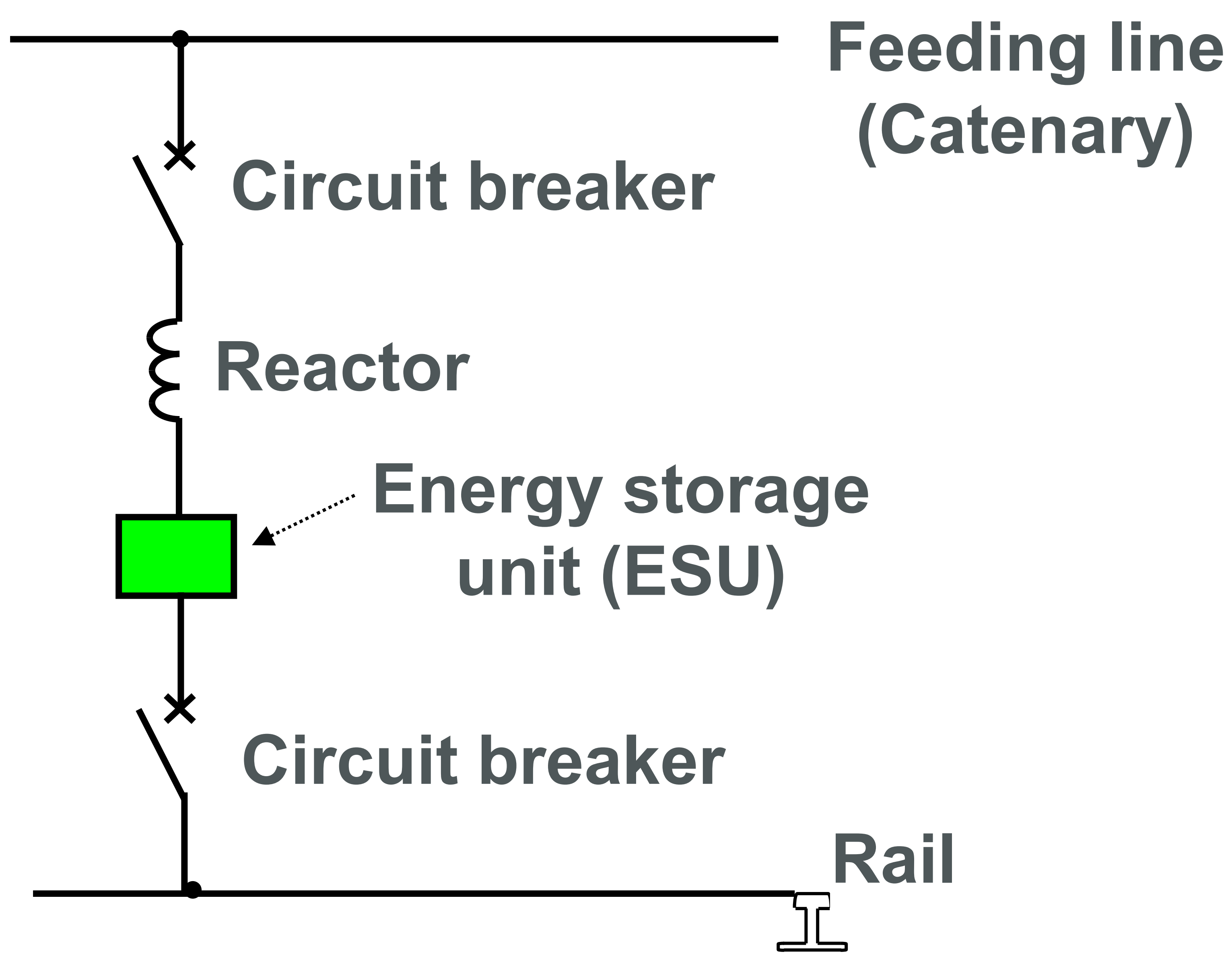
Too little amount of regenerative energy is expected.

# Fundamental Constitution of TESSs in Japan





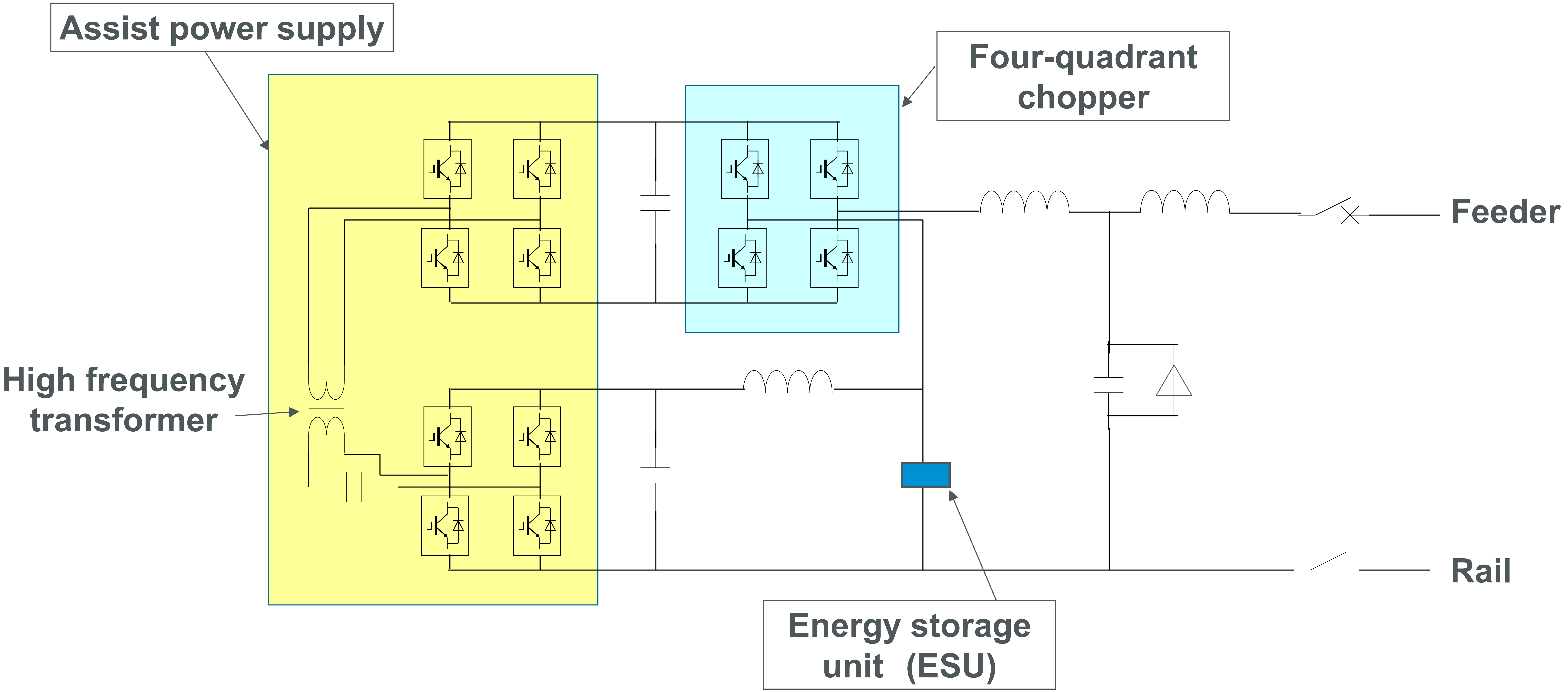

TESS with electronic power converters




TESS without power converter

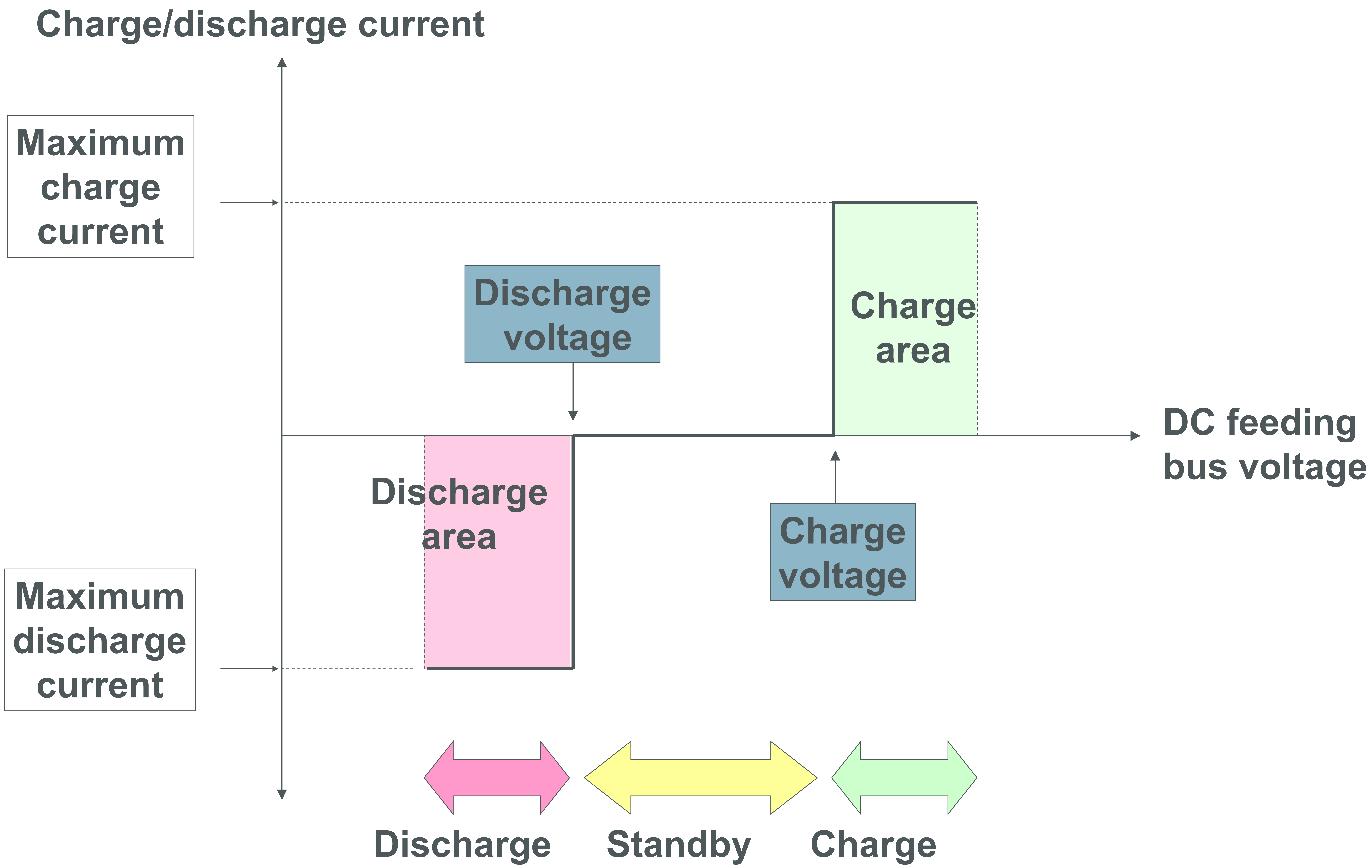
# Constitution (New Type)

Reference: IEEJ Transactions on Industry Applications vol.141, No.8, pp.654-660-31, 2021.8 (in Japanese)

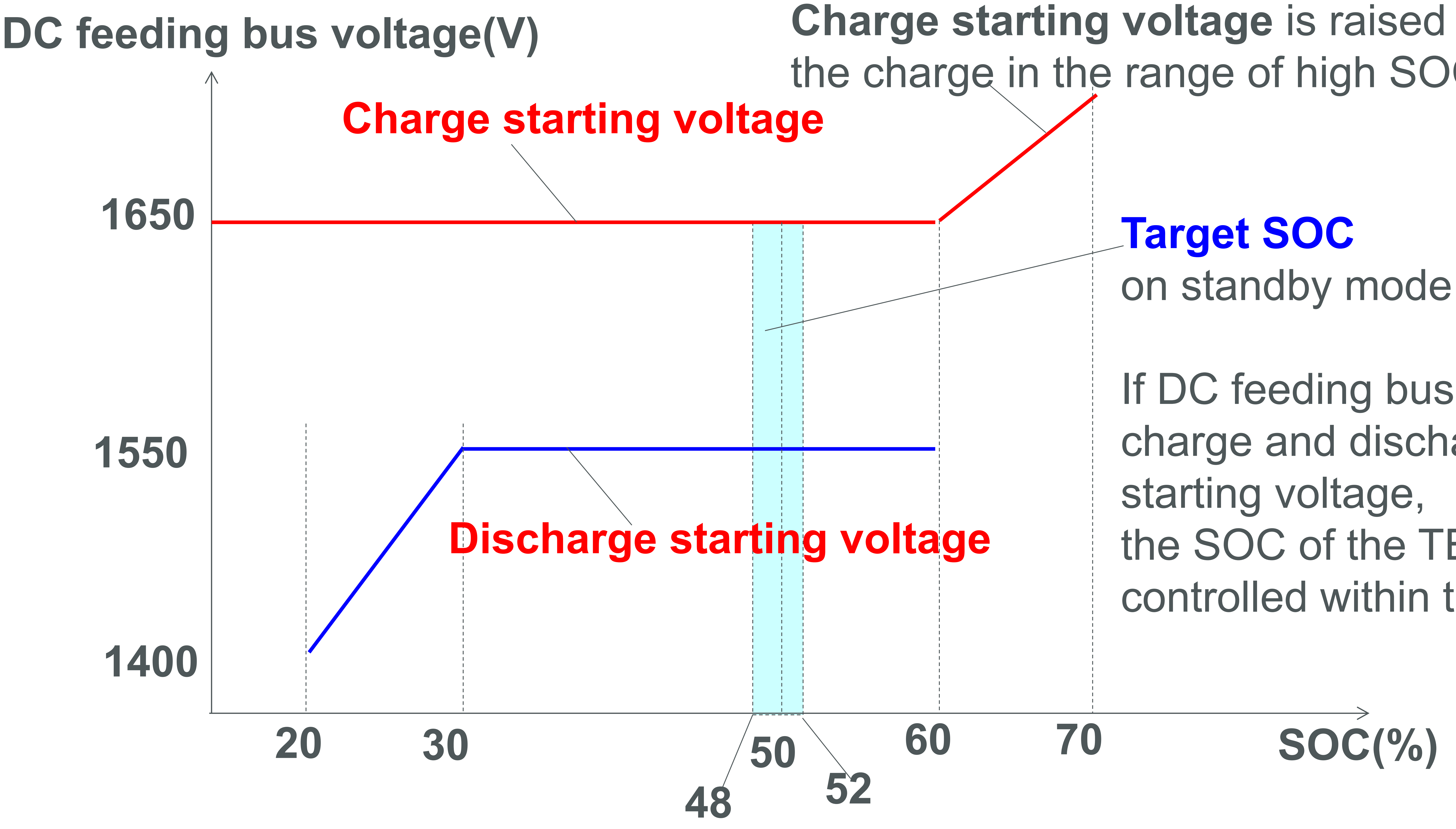



This circuit configuration allows the outer shape of TESS to be reduced.

# Fundamental control of TESS

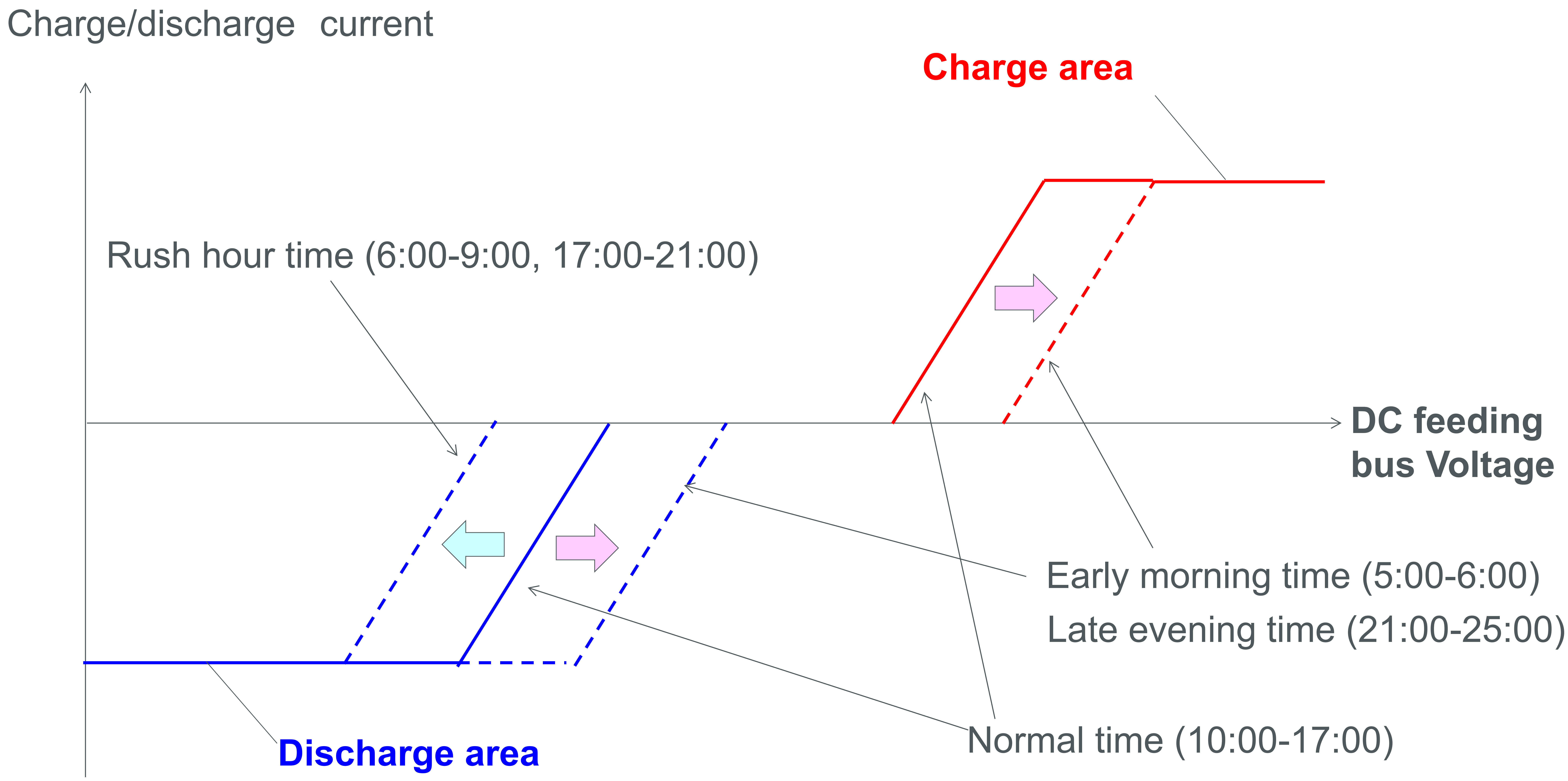


# Example of charge/discharge strategy (A)



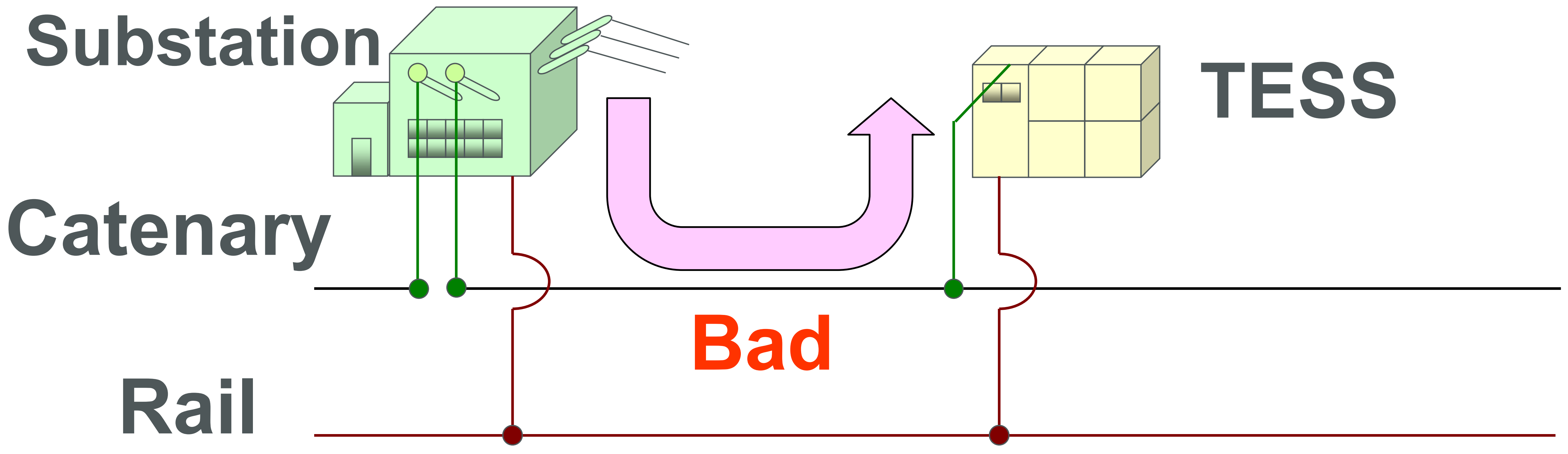

If DC feeding bus voltage is between charge and discharge starting voltage, the SOC of the TESS is controlled within this target range.

# Example of charge/discharge strategy (B)

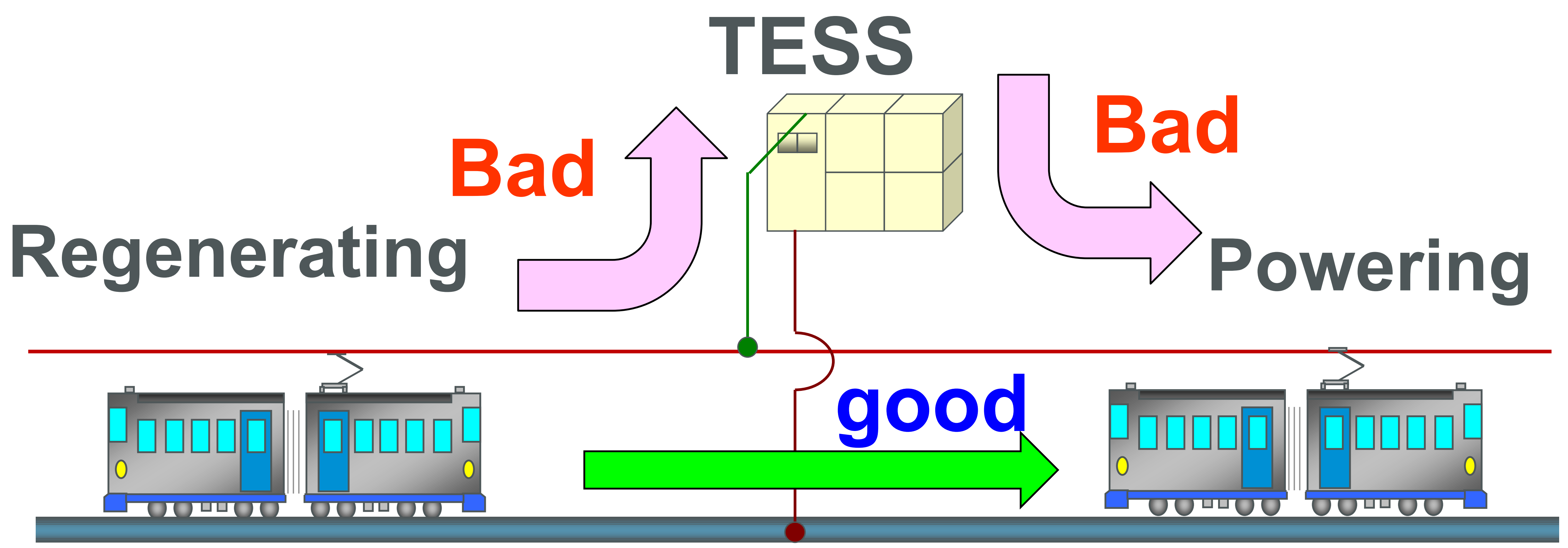


# Problem of introducing TESSs

(A) Direct charge from rectifiers




(B) Unnecessary charge




If the charge voltage setting(s) of the TESS is inappropriate, unnecessary charge occurs

~~Energy Saving~~

Increasing energy !

- Regenerative energy is reused between two trains → Good!
- Unnecessary / undesired charge/discharge by the TESS → Bad!

~~Energy Saving~~

Increasing energy !

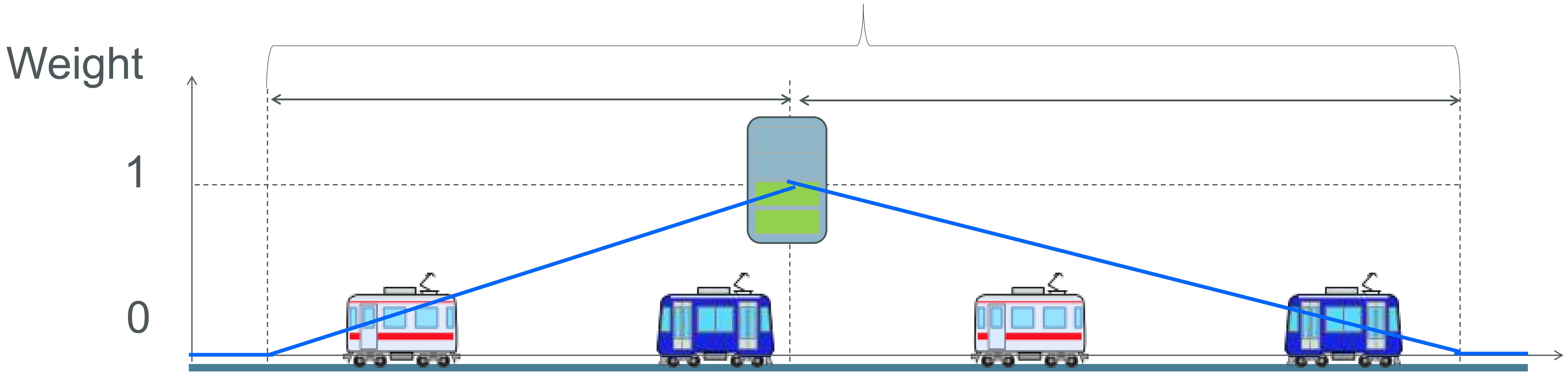
# New control without the information of feeding voltage



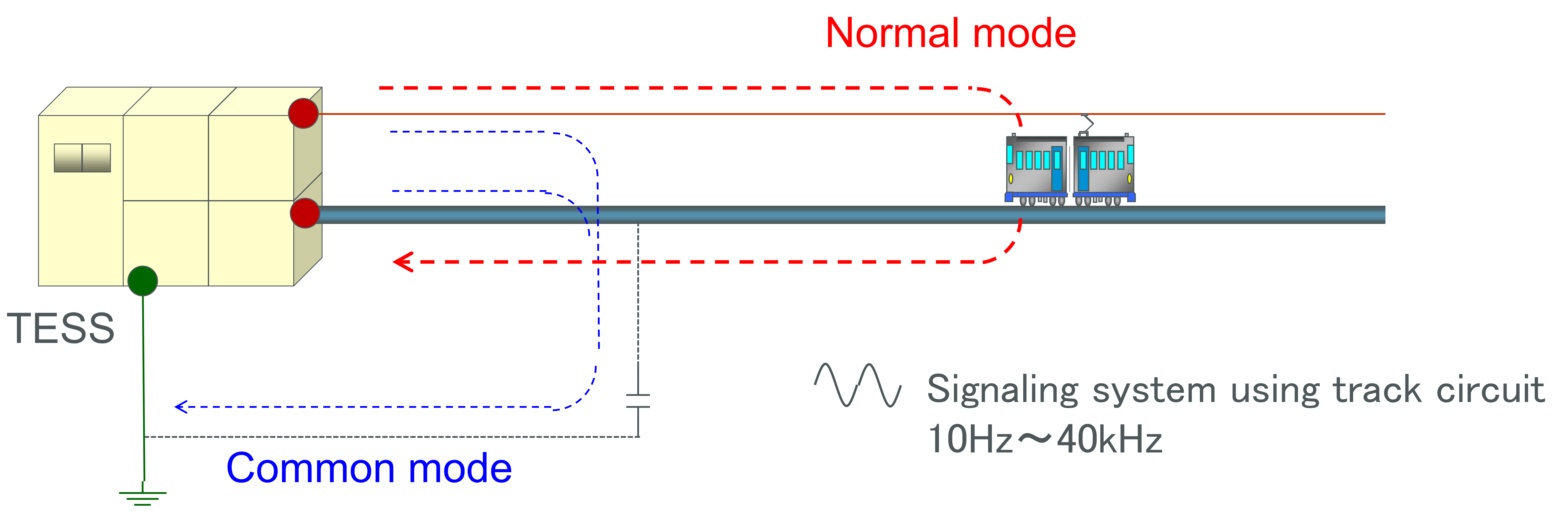
Control Method based on Train Energy

Train energy = kinetic energy + potential energy
Calculating the sum of the weight for the train energy
Increasing discharge, decreasing charge

Calculation the sum of weight



# Problem of high frequency switching noise




Obtaining the characteristics among feeding circuit, rail, and earth is important to grasp the level of switching noise.

# Conclusions and New topics for Carbon Neutral



More than 40 TESSs for energy saving or emergency compensation in Japan.

Each rated energy is less than 1 MWh. → Too small impact for carbon neutral !

In 2019, in Kintetsu Railway Co. Ltd., TESS (7.1MWh) has been installed for the virtual power plant (VPP)

It will be indispensable to install large capacity of TESSs to charge/discharge renewable energy.

The coordination between power supply companies and railway companies will be also important to operate large capacity of TESSs effectively.

Thank you for your attention !

Merci

ありがとうございました

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OF RAILWAYS

# Questions
# Discussion

Takeshi Konishi
Lead Design Engineer & OCL expert

**Thank you for your attention.**

# Break

# Break

*Railways and UIC members are invited to join the*

**UIC project:**

**"H2TR - Operating hydrogen powered trains"**

*In partnership with the IEC*

*If interested, please reach out to stefanos@uic.org*

*Resuming at 11h12*

# Break

## *Resuming at 11h12*

## *New UIC Sustainability projects:*

- NOise and VIbration Technical Advice (NOVITA)
- Routes out of Homelessness: Addressing Homelessness on the Railway (ROOH)
- Zero Waste Railway workshops - circular economy best practice workshops
- International guidance for managing risk of human trafficking and modern slavery in rail

## *Previous workshops:*







# Break

## *Resuming at 11h12*

## *New UIC Rail system projects:*

- Harmonized methodology for drone / UAV use for plain track inspections (D4R-PT, DPT)
- Heavy Rain. REsilient RAilways facing Climate Change. Operation Management and Impact on Infrastructure (RERA-Rain)
- Robotic based Inspection Sensor Monitoring (ROB-Inspection)
- Digital Automatic Coupling (DAC)
- Future Railway Operations and Traffic Control Center
- LL shoes behaviour in a locked brake situation
- Operational Use Cases of 5G for Rail
- New methods for safety demonstrations
- IRS 50553 – Functional requirements for HVAC systems
- Publication funding of rolling stock IRSs standards for the year 2022
- Non-craneable semi-trailers suitable for rail-road CT
- Updating of general provisions for passenger vehicles

# Now resuming

## Second part: Application

| | | |
|---|---|---|
| • SNCF | **Tony Letrouvé** | **Hervé Caron** |
| • East Japan Railway Company (JR East) | **Koji Kasai** | |

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OF RAILWAYS

# SNCF

## Energy storage system at SNCF réseau



Hervé CARON
Tony LETROUVE

# SNCF

Energy storage system at SNCF Réseau

Specification of ESSs for an IM and first experiments in the French railway network.


| | |
|---|---|
| **Hervé CARON**<br><br>**SNCF Réseau**<br>Group leader in energy innovation and sustainable development | **Tony LETROUVE**<br><br>**SNCF Innovation and Research.**<br><br>Energy project manager |

# ENERGY STORAGE SYSTEM AT SNCF RÉSEAU

## Learning and experiments

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**H. CARON & T. LETROUVE**
SNCF Réseau & SNCF I&R

# OUTLINE



1. ESS why and when?

2. Specification of ESS for railway infrastructure

3. Simulation results and tests in industrial laboratories

4. Conclusions & outlooks

# ESS – WHERE AND WHY?

# SMART INFRASTRUCTURE PROJECT



Definition of different solutions that can be coupled to switch to an active and multidirectional DC network


* Power Electronic

# TRACKSIDE ENERGY STORAGE SYSTEM

A response to the challenges and needs of SNCF Réseau



## Operation

- Reinforce the catenary voltage (ensure the transport plan)
- Add more flexibility
- Resilience

## Sustainable development

- Improve the receptivity of the infrastructure to reduce emissions of fine particles due to mechanical braking

## Energy

- Reduce the financial impact of electrical losses on the network (consumption and variation)
- Develop braking energy recovery
- Add more services like demand-response (railway smart grid project)

# TRACKSIDE ENERGY STORAGE SYSTEM

For what uses? What are the criteria?

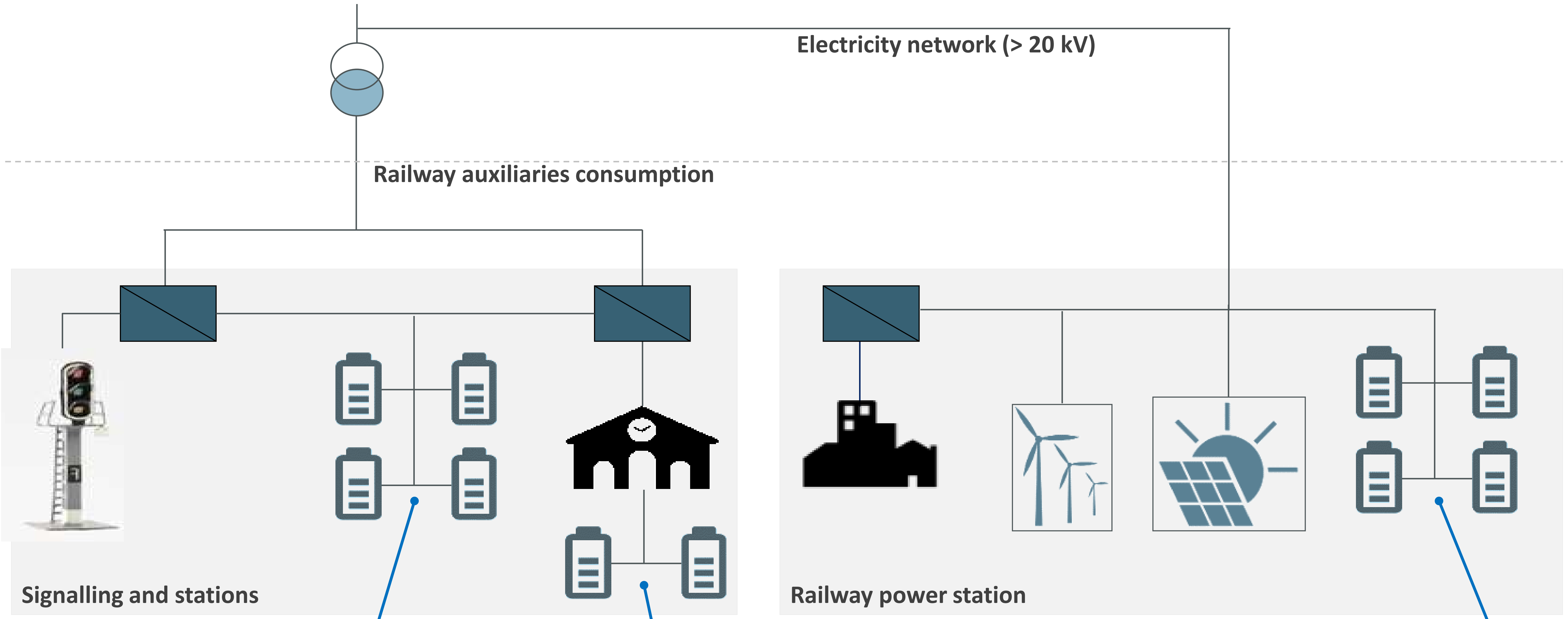


| | Paralleling station | Classic DC substation | Trackside ESS |
|---|---|---|---|
| implementation schedule? (increase traffic, temporary reinforcement) | 2 to 3 years | 3 to 5 years | Time divided by 2 compared to a classic SS |
| Cost / availability of land? | 5 to 20 m² (land price) | 300 to 500 m² (land price) | Installed in the railway trackside |
| Distance from the upstream supply network? | 0€ | 150 to 170 k€/km (excluding reinforcement of the electric network's substation) | 0€ |
| Power? | 0 MW | 2 to 10 MW | 2 to 3 MW |
| Modularity, mobility | No | No | Yes<br>Without traffic interruption |

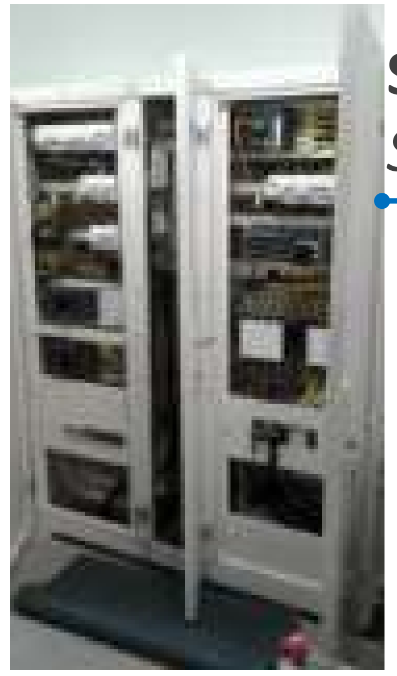
# TRACKSIDE ENERGY STORAGE SYSTEM

## For what uses? What are the criteria?



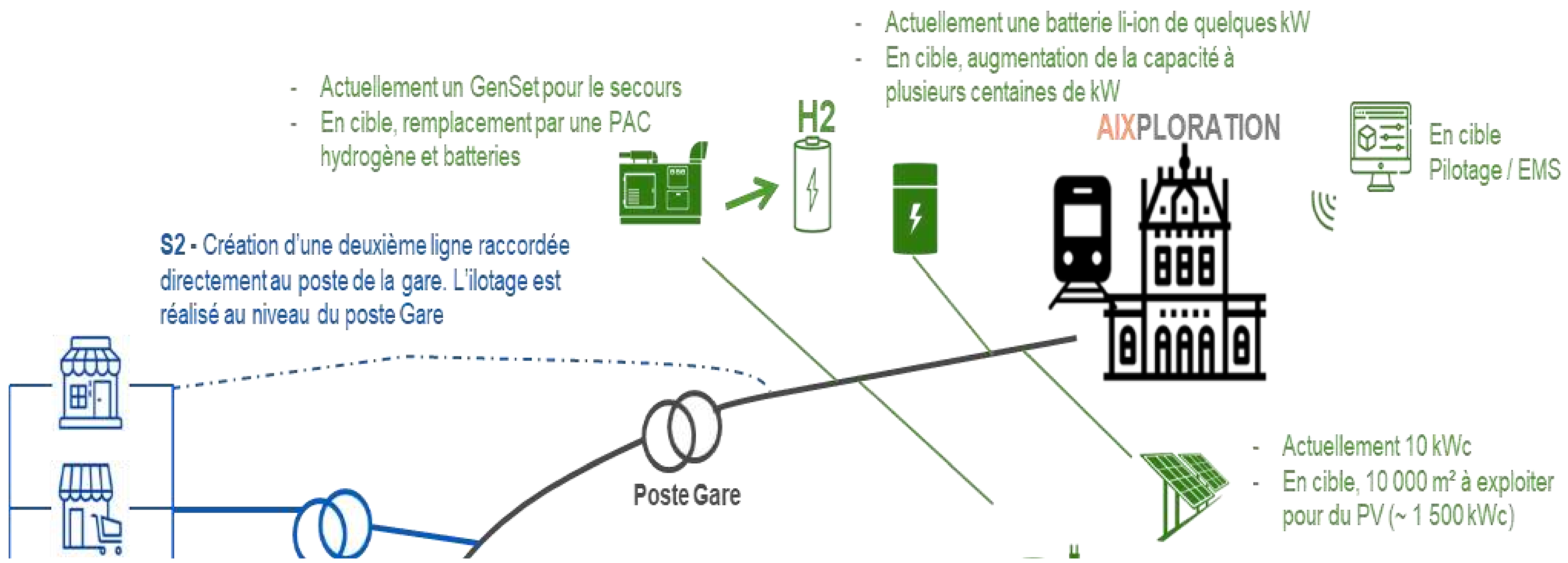



- Peaks shaving in consumption, optimizing the energy bill
- Emergency power supply for railway signalling and the station,
- Voltage and frequency support for the upstream electric network
- Establishment of a demand response service to reduce the return on investment of batteries



**SIGALI**
*Sarcelles*

**SMART GARE**
*Aix-en-Provence TGV*



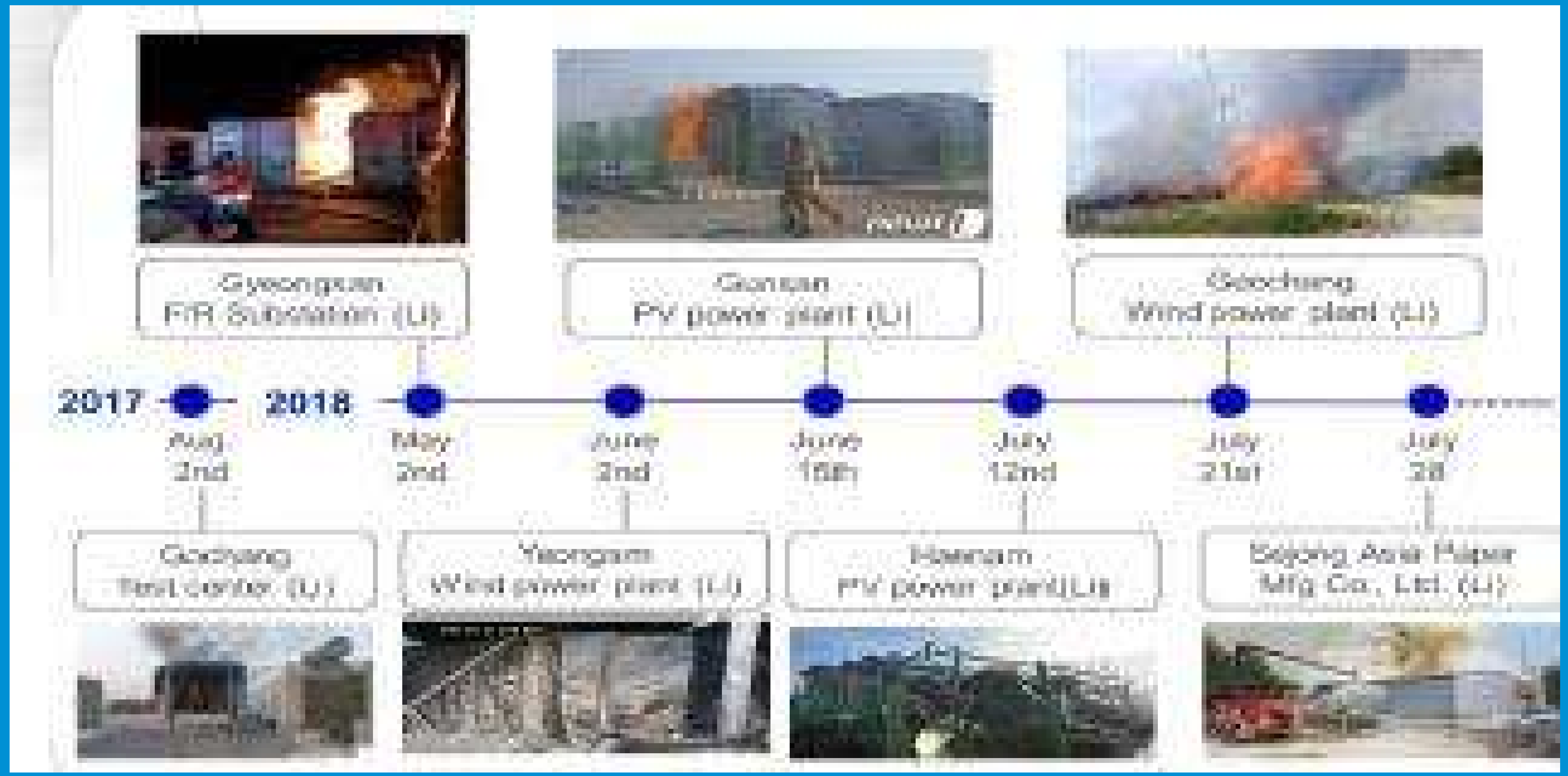

**TRACKSIDE ENERGY STORAGE SYSTEM**

# SPECIFICATION OF ESS FOR RAILWAY INFRASTRUCTURE

# SPECIFICATION OF ESS FOR INFRASTRUCTURE
Safety first

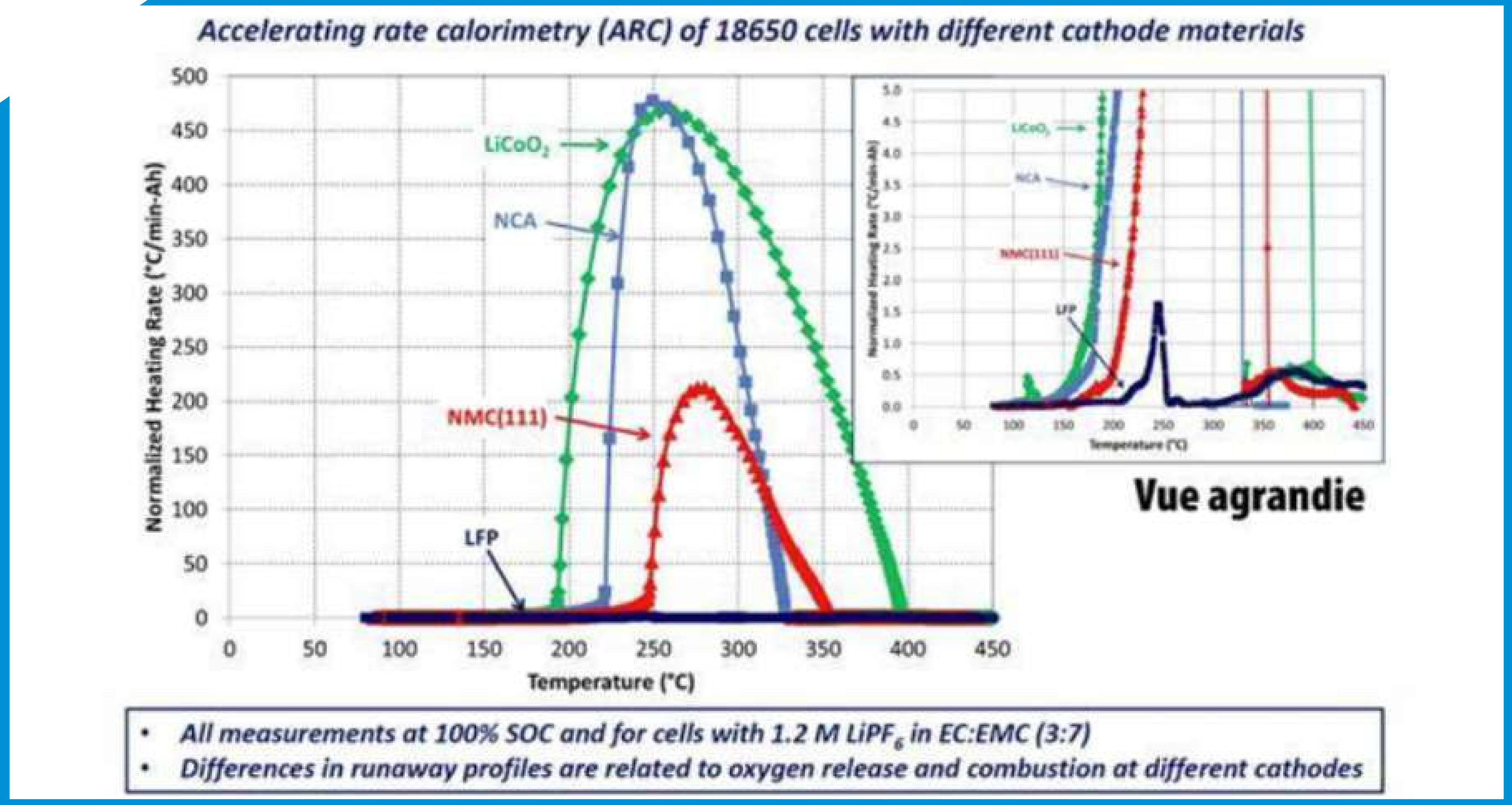


## ESS incident survey




## Preliminary risk analysis

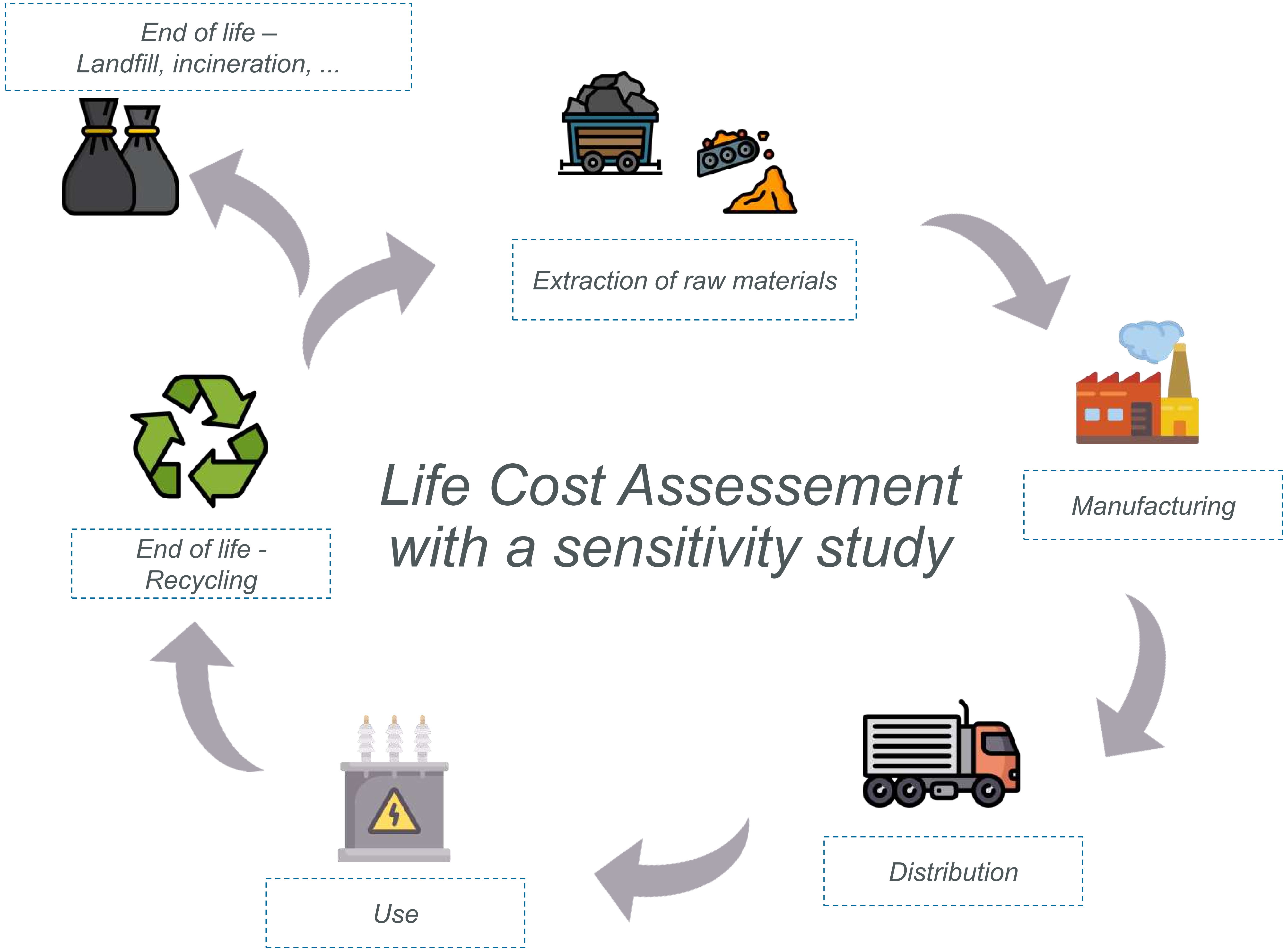
- Battery technology : thermal runaway
- Power electronic failure
- Climatic environment



# SPECIFICATION OF ESS FOR INFRASTRUCTURE

## Auxiliaries' consumptions and a high efficiency






**For the Manufacturing phase :**

- impose high recycling rates
- Rationalize the use of impacting materials

**For the use phase:**

- Closely monitor all energy consumption and losses
- Converter efficiency
- Battery efficiency
- Consumption of the cooling system and its optimization

# SPECIFICATION OF ESS FOR INFRASTRUCTURE

## Conclusion



Safe connection with the electric environment

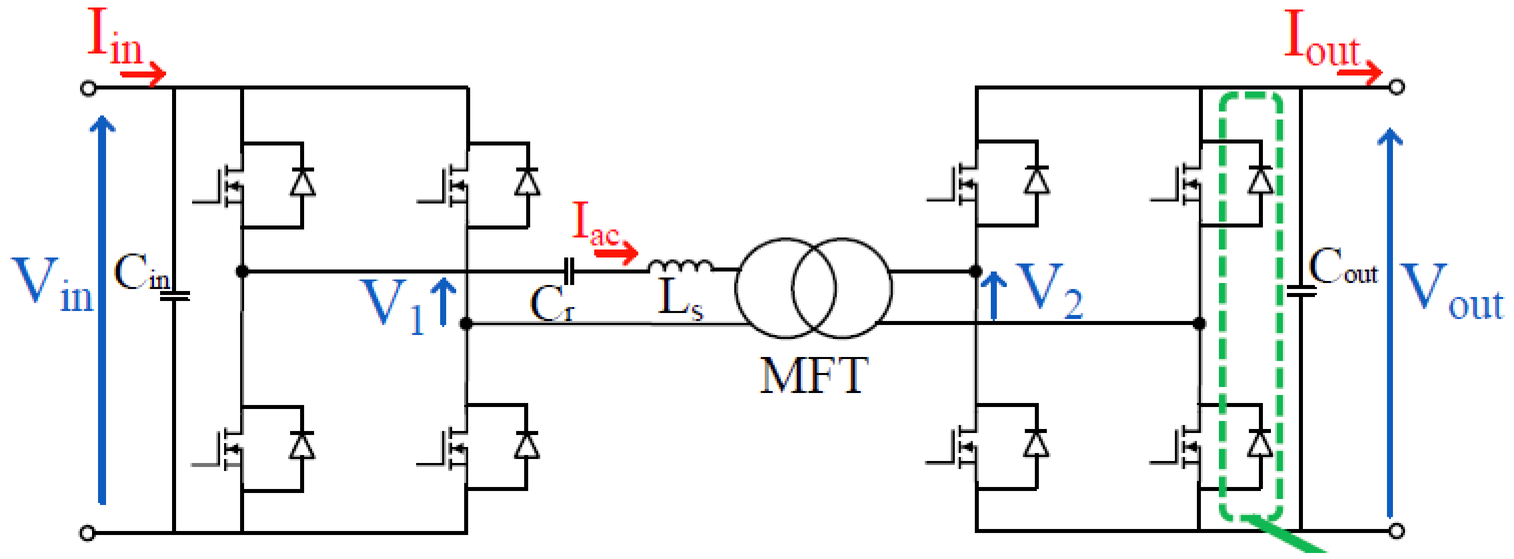
Recyclable and safe component (incl. battery cells) chemistry

High efficiency

A lower price than the conventional substation

Lithium Iron Phosphate Technology

MFT with SiC component



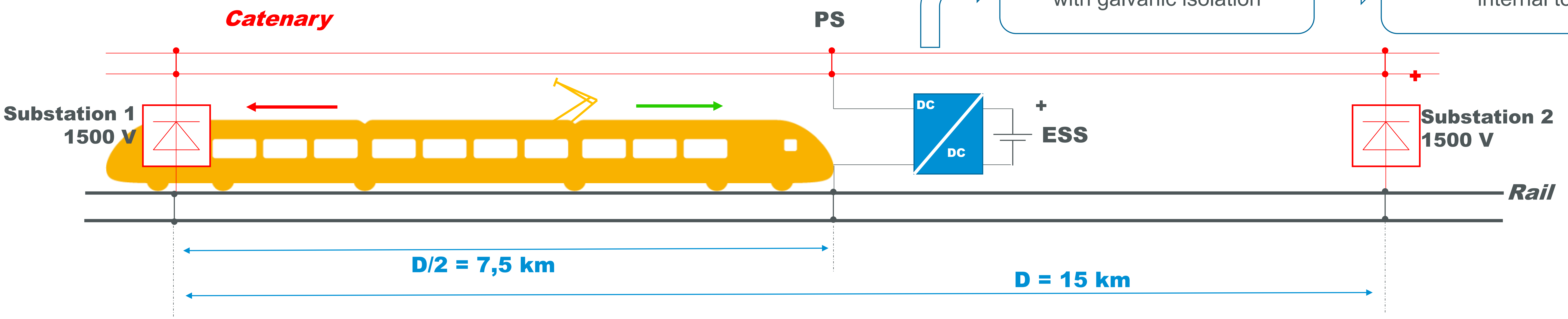
# SIMULATION RESULTS AND TESTS IN INDUSTRIAL LABORATORIES

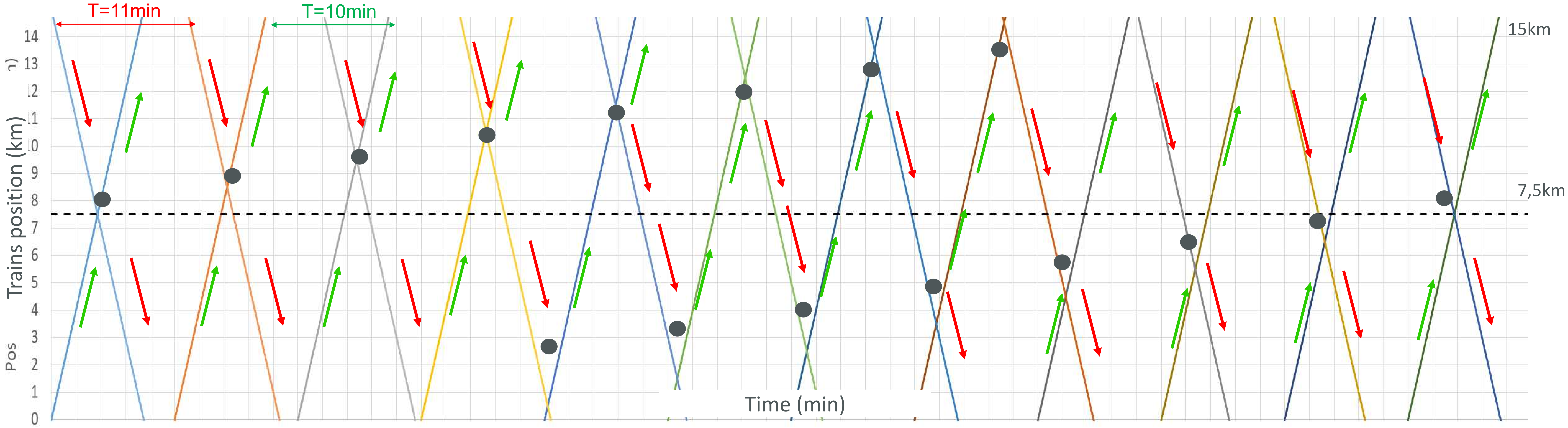
# VALIDATION IN A SIMULATION ENVIRONMENT

## Model under PLECS of a sector with traffic grid

Developed DC / DC converter with galvanic isolation

ESS has been sized using internal tools



# VALIDATION IN A SIMULATION ENVIRONMENT

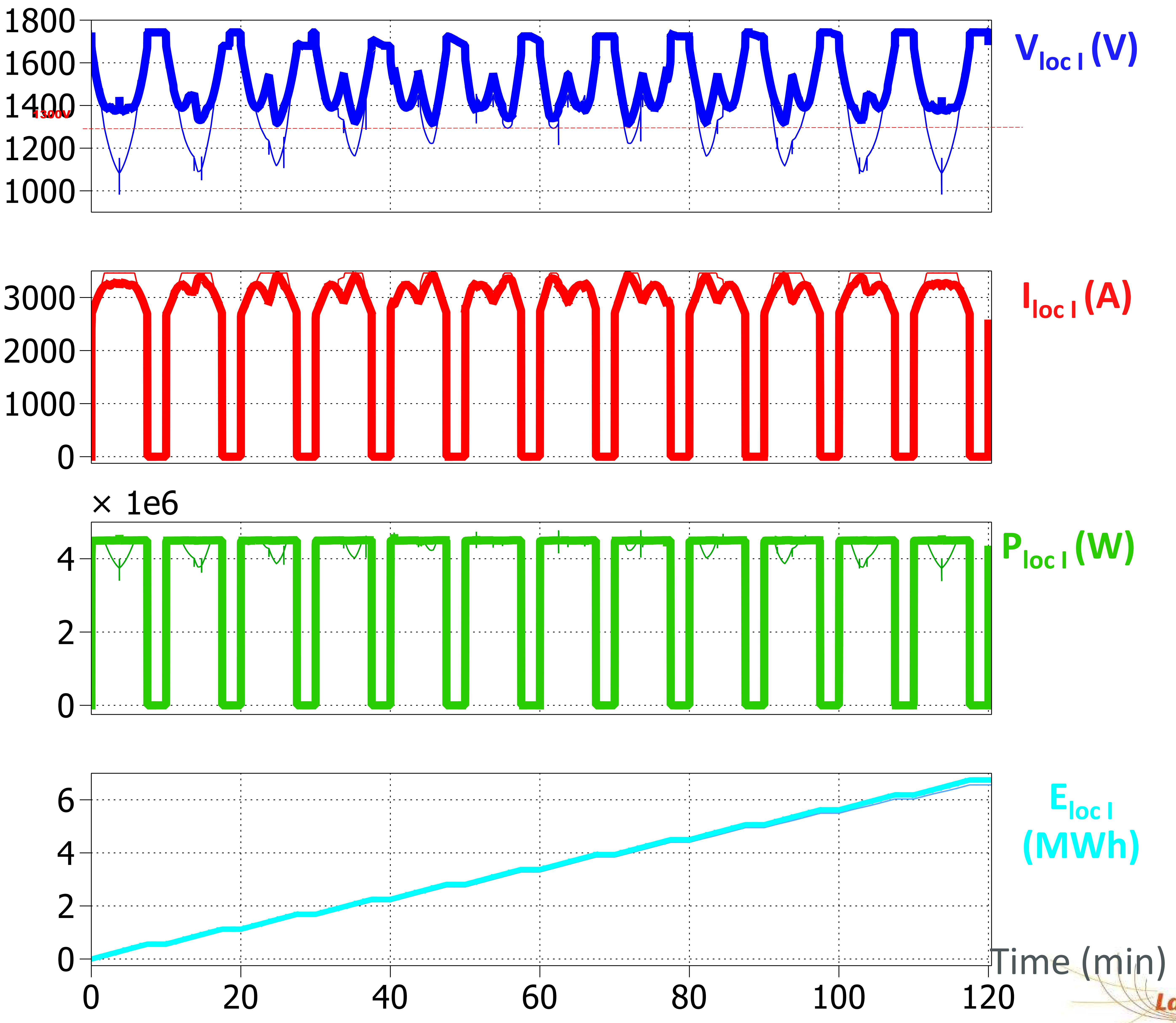
## Simulations results : Measurement from trains with and without ESS



**Hypothesis :**

| | |
|---|---|
| Catenary section (S) | 630 mm$^2$ |
| Distance between substations(D) | 15 km |
| Trains power | 4,5 MW/train |
| Energy storage system size | 16 elementary blocks in parallel |

If the storage device is not present, $V_{train}$ drops below 1300V (the trains are restrained in power).




Laplace SNCF

# VALIDATION IN A SIMULATION ENVIRONMENT

## Simulations results : Conclusion



| Energy (MWh) | $E_{substation\ 1}$ | $E_{substation\ 2}$ | $E_{trains\ I\ (IMPAIR)}$ | $E_{trains\ P\ (PAIR)}$ | $E_{batt}$ (in source convention: negative in charge and positive in discharge) |
|---|---|---|---|---|---|
| **Without ESS (2h)** | **7,769** | **7,769** | **6,563** | **5,998** | **0** |
| | **$E_{substation\ 1\ +\ 2}$ = 15,538** | | **$E_{trains\ I\ et\ P}$ = 12,561** | | |
| **With ESS (2h)** | **6,472** | **6,472** | **6,749** | **6,186** | **1,910 (depth of discharge 81,2%)** |
| | **$E_{substation\ 1\ et\ 2}$ = 12,944** | | **$E_{trains\ I\ et\ P}$ = 12,936** | | |
| **With ESS (2h Without train trains, total de 4h)** | **1,021** | **1,021** | **0** | **0** | **-1,984 (battery fully charged in 116 min)** |
| | **$E_{substation\ 1\ et\ 2}$ = 2,042** | | **$E_{trains\ I\ et\ P}$ = 0** | | |

→With these simulation assumptions, it takes 2 hours to reach the maximum depth of discharge that we had set (81.2% here). It will take a little less than 2 hours more without any trains to fully recharge the batteries.

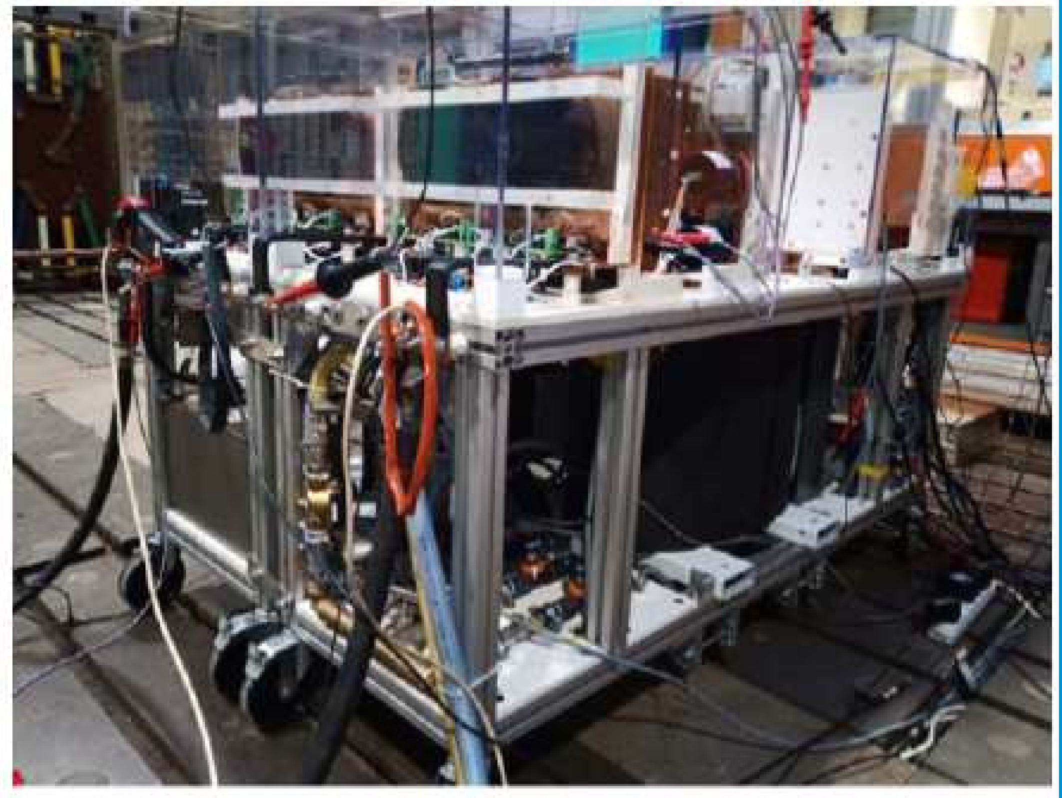
→The efficiency of the installation is improved, it goes here from 80.84% without a storage device to 86.31% with this battery storage device.

# TEST IN INDUSTRIAL LABORATORIES

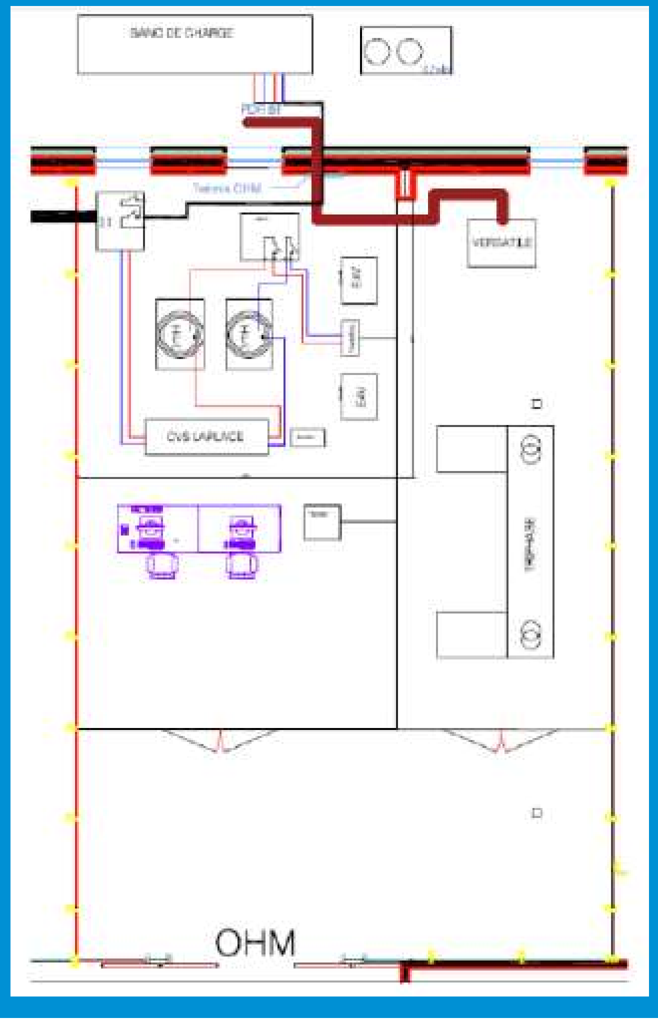
From laboratory hardware to the on-site experiment



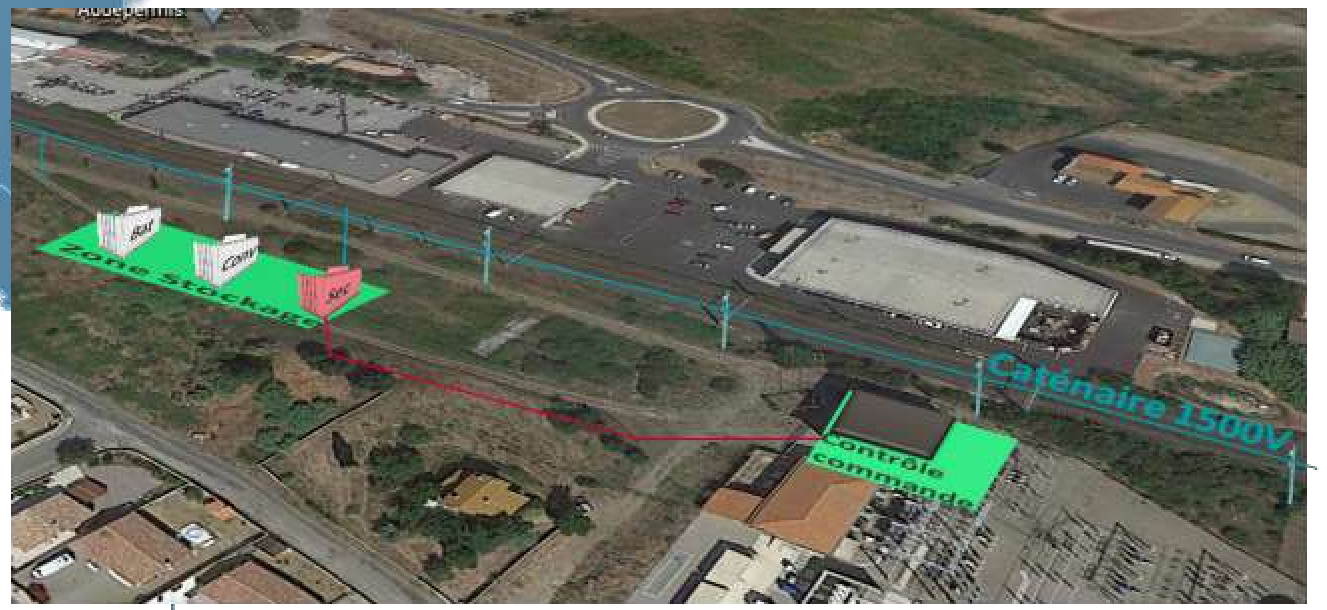
MFT test at full scale at EURAIL TEST



Full system test in emulated environment at SCLE




Test at Lezignan-Corbière railway power station…



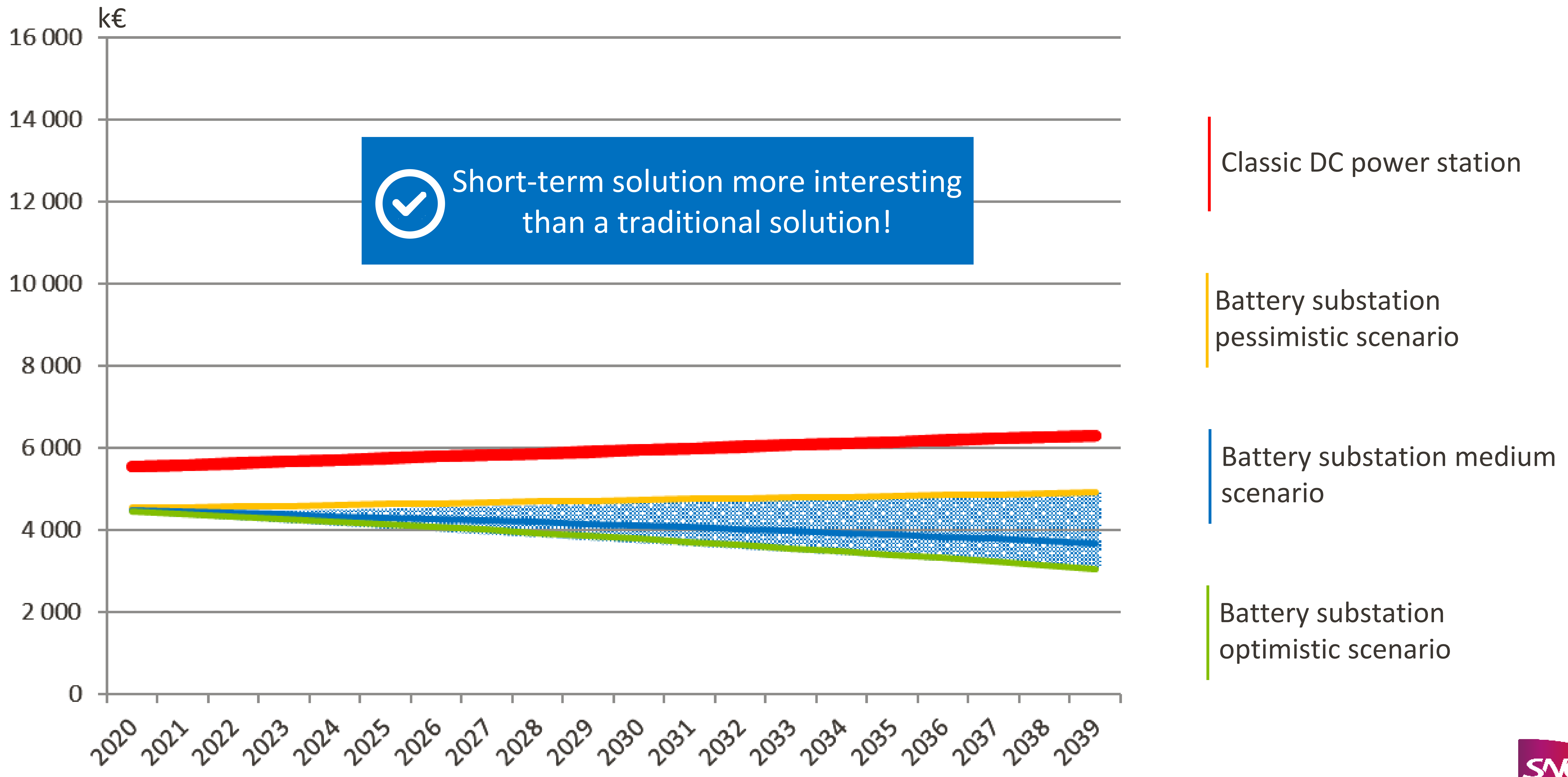

…industrialized by SCLE

# CONCLUSIONS & OUTLOOKS

# Economic studies



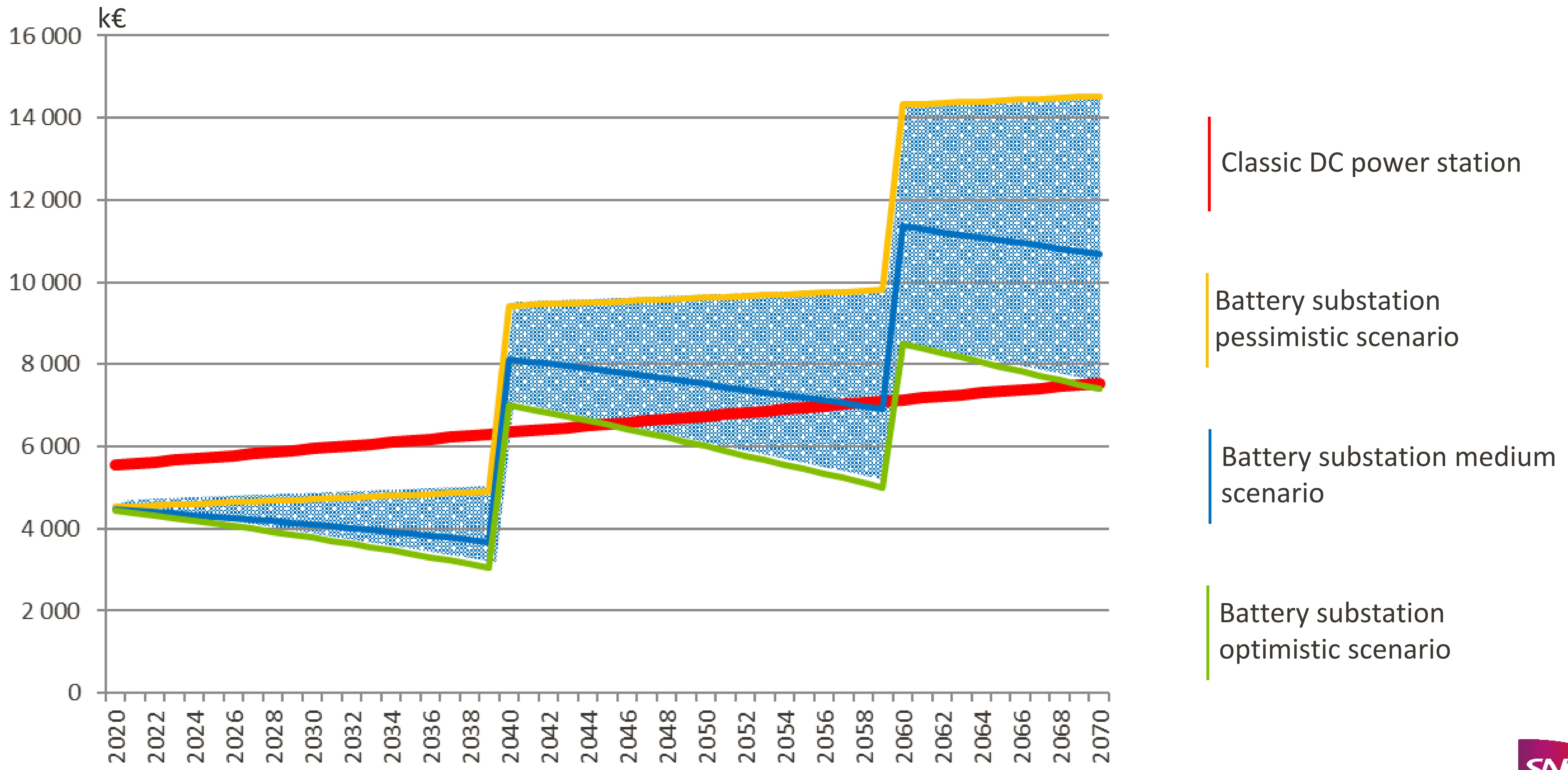
## An economically viable solution in SNCF studies: flashback on the studies



# Economic studies

## An economically viable solution in SNCF studies: flashback on the studies

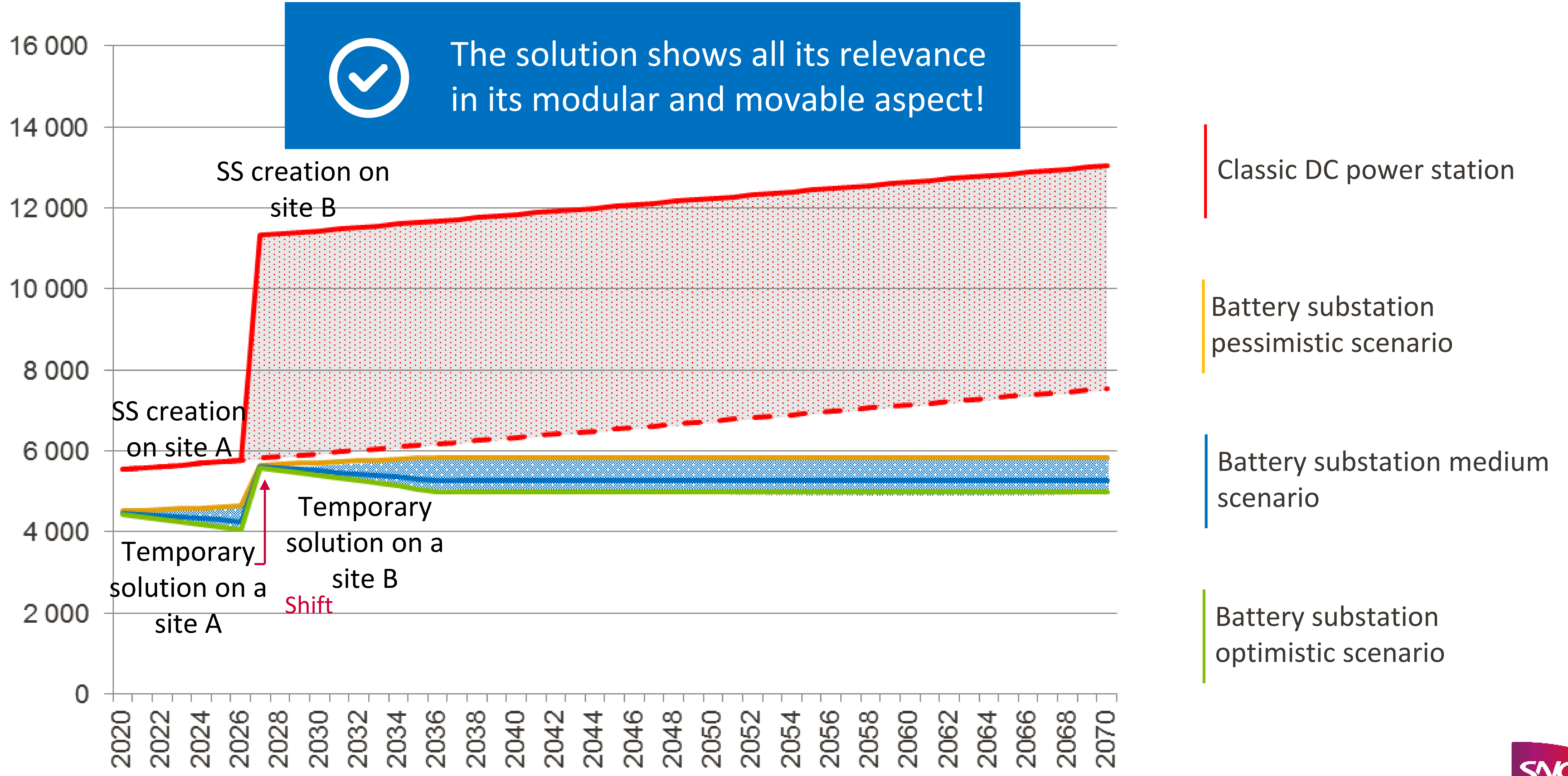




# Economic studies

## An economically viable solution in SNCF studies: flashback on the studies



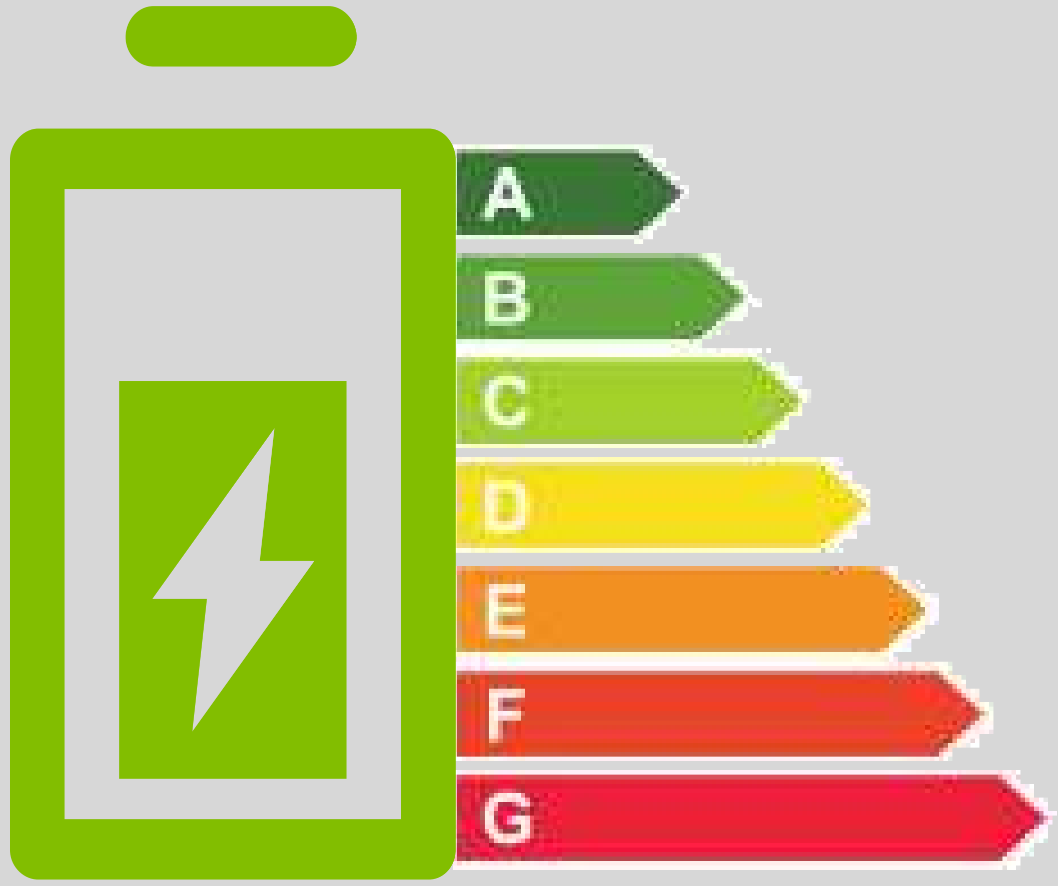


# NEXT STEP

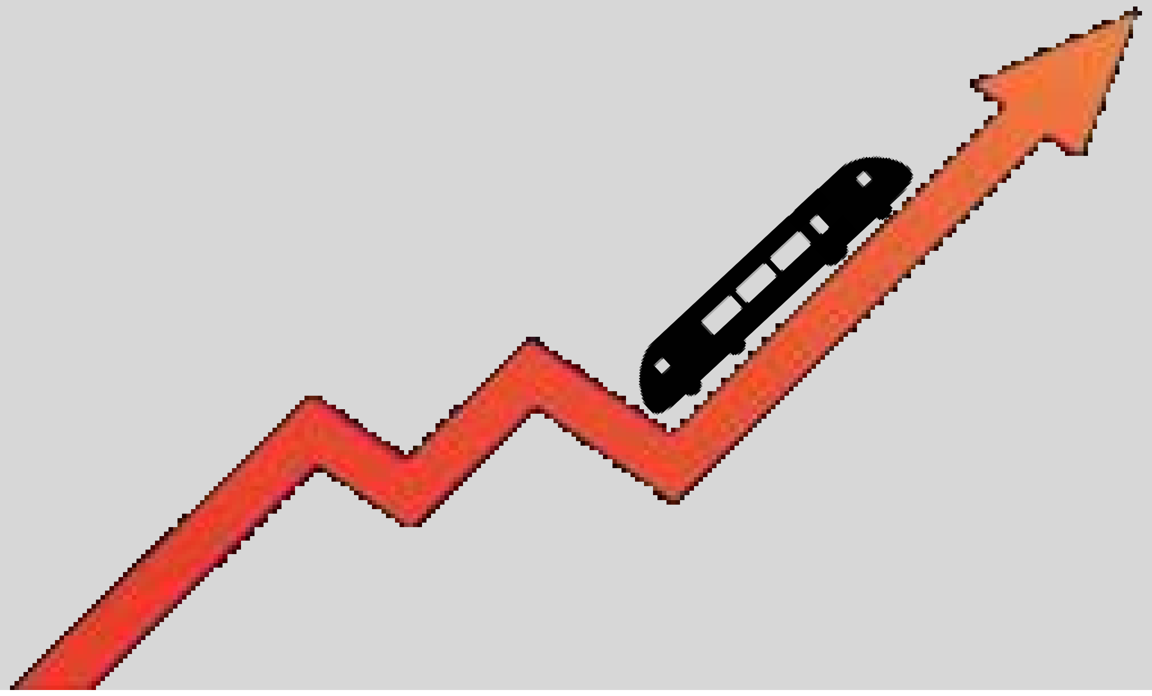
## RACCOR-D* : Get ready for the future of the 1,5kV DC network



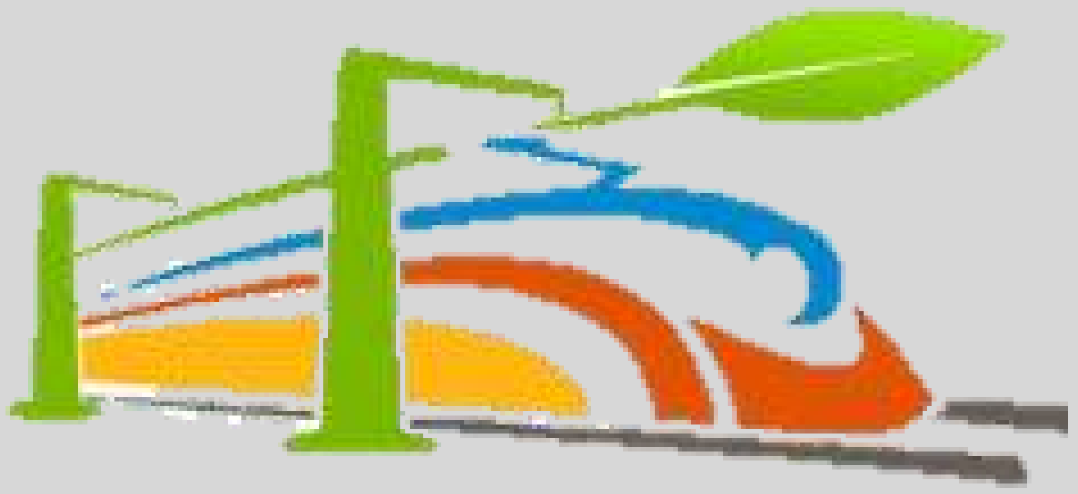
INCREASE ENERGY EFFICIENCY AND ROBUSTNESS OF THE RAIL SYSTEM




COPING WITH THE INCREASE IN TRAFFIC AND MORE POWERFUL TRAINS



DECARBONIZE THE NETWORK AND RATIONALIZE THE USE OF PRIMARY RESOURCES

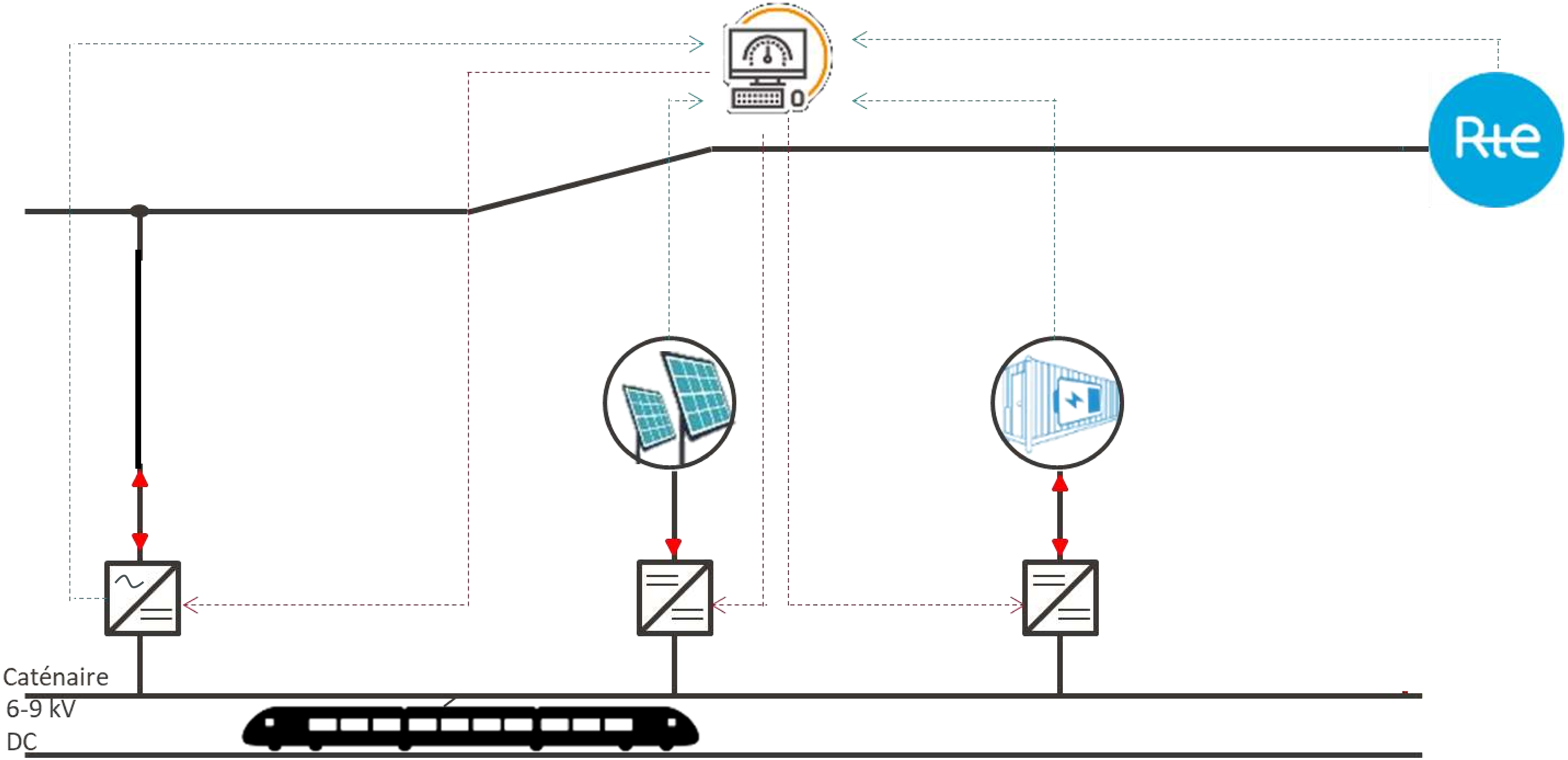


* Project proposed to CORIFER French call of interest

# NEXT STEP

## RACCOR-D* : Get ready for the future of the 1,5kV DC network






* Project proposed to CORIFER French call of interest

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# Stay in touch with UIC:

## www.uic.org

#UICrail


**Contact:**
Hervé CARON – SNCF Réseau
Herve.Caron@reseau.sncf.fr
Tony LETROUVE – SNCF
Tony.Letrouve@sncf.fr


**Thank you for your attention.**

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OF RAILWAYS

# Questions
# Discussion

Hervé CARON
Tony LETROUVE

**Thank you for your attention.**

INTERNATIONAL UNION
OF RAILWAYS

# JR EAST

# Workshop timeline

11 h **Second part: Application**

- East Japan Railway Company (JR East) **Koji Kasai**

Mr Koji Kasai

Deputy General Manager,
Management Planning Department,
Corporate Planning Headquarters
EAST JAPAN RAILWAY COMPANY

JR East's strategy for Energy and Environment

# JR EAST'S STRATEGY FOR ENERGY AND ENVIRONMENT

## Zero-Carbon Challenge 2050

**Koji KASAI**

Deputy General Manager, Corporate Management Planning Department, East Japan Railway/JR East

7th Oct, 2021

# Agenda

## 1 Summary of JR East – 3 Features

## 2 Our Energy and Environment Strategies and Initiatives

# Agenda

## 1 Summary of JR East – 3 Features

## 2 Our Energy and Environment Strategies and Initiatives

# Feature 1 - Vertical Structure

| | |
| --- | --- |
| **Non-Rail Business** | Life-style business<br>IC card |
| **Operation**<br>Various transport models | Trains<br>Buses |
| **Maintenance** | Rolling Stock<br>Infrastructure |
| **Ownership** | Rolling Stock<br>Infrastructure |

We own, operate and maintain all the railway infrastructure as a **fully integrated railway.**

Network: **7,401.7 km**

Trains: approx.**12,300 /day**

# Feature 2 - Horizontal Structure

## WE OPERATE ALL CATEGORIES OF RAILWAY

Metropolitan

High Speed

Regional

Network: **7,401.7km***

No. of Passengers: **17.8 Million /day***

No. of Trains: **12,300 /day*** **(the largest in the world !)**

Annual Operating Revenue: **$ 15.8 Billion****

（ **$ 26.8 Billion*** ）

(no subsidies from the government)

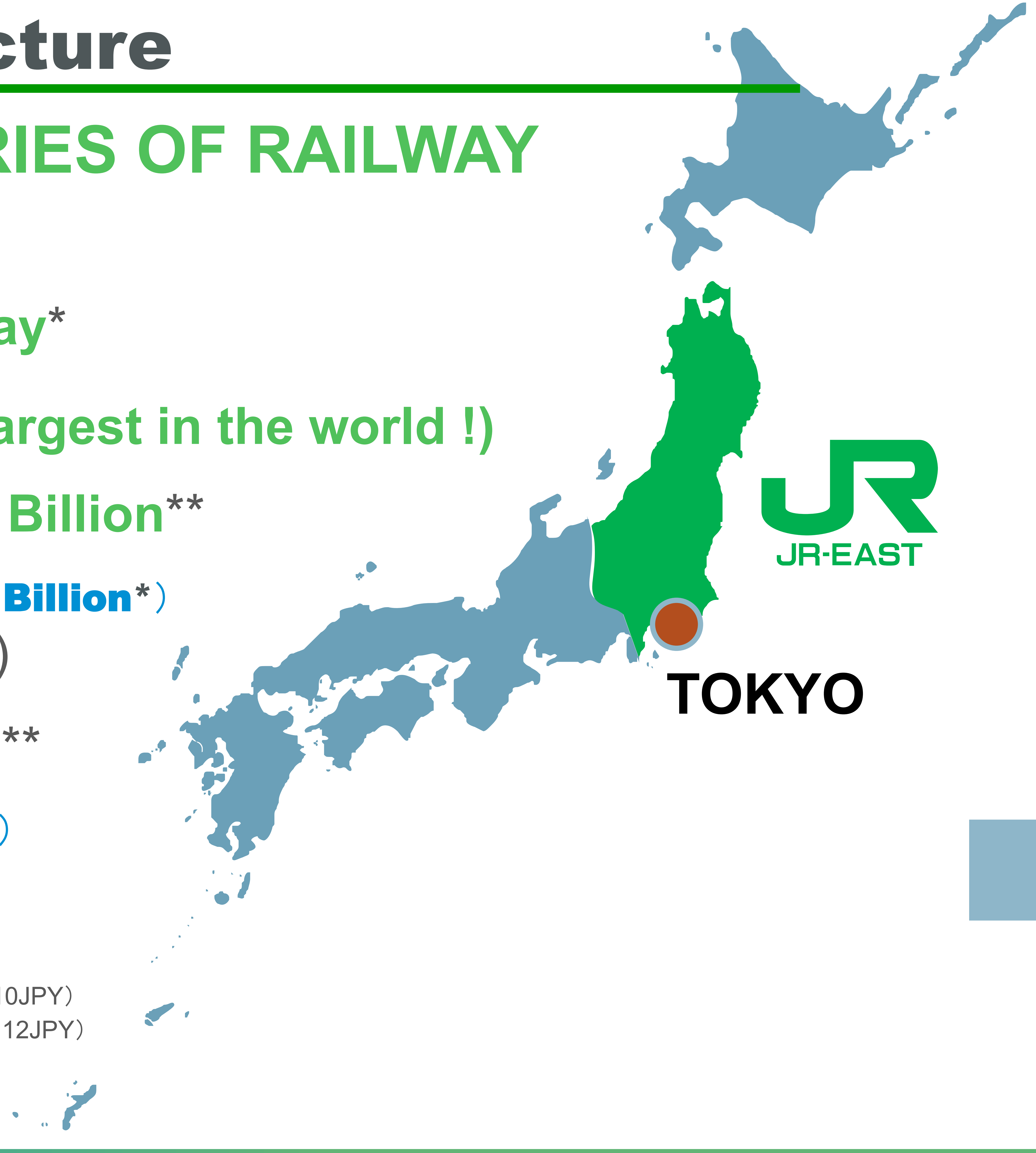
Net Annual Income: **△$ 5.2 Billion****

（ **$ 1.8 Billion*** ）

No. of Employees: **51,560***

*Numbers are as of FY ended March 31, 2020（Calculated by 1$ = 110JPY）

**Numbers are as of FY ended March 31, 2021（Calculated by 1$ = 112JPY）

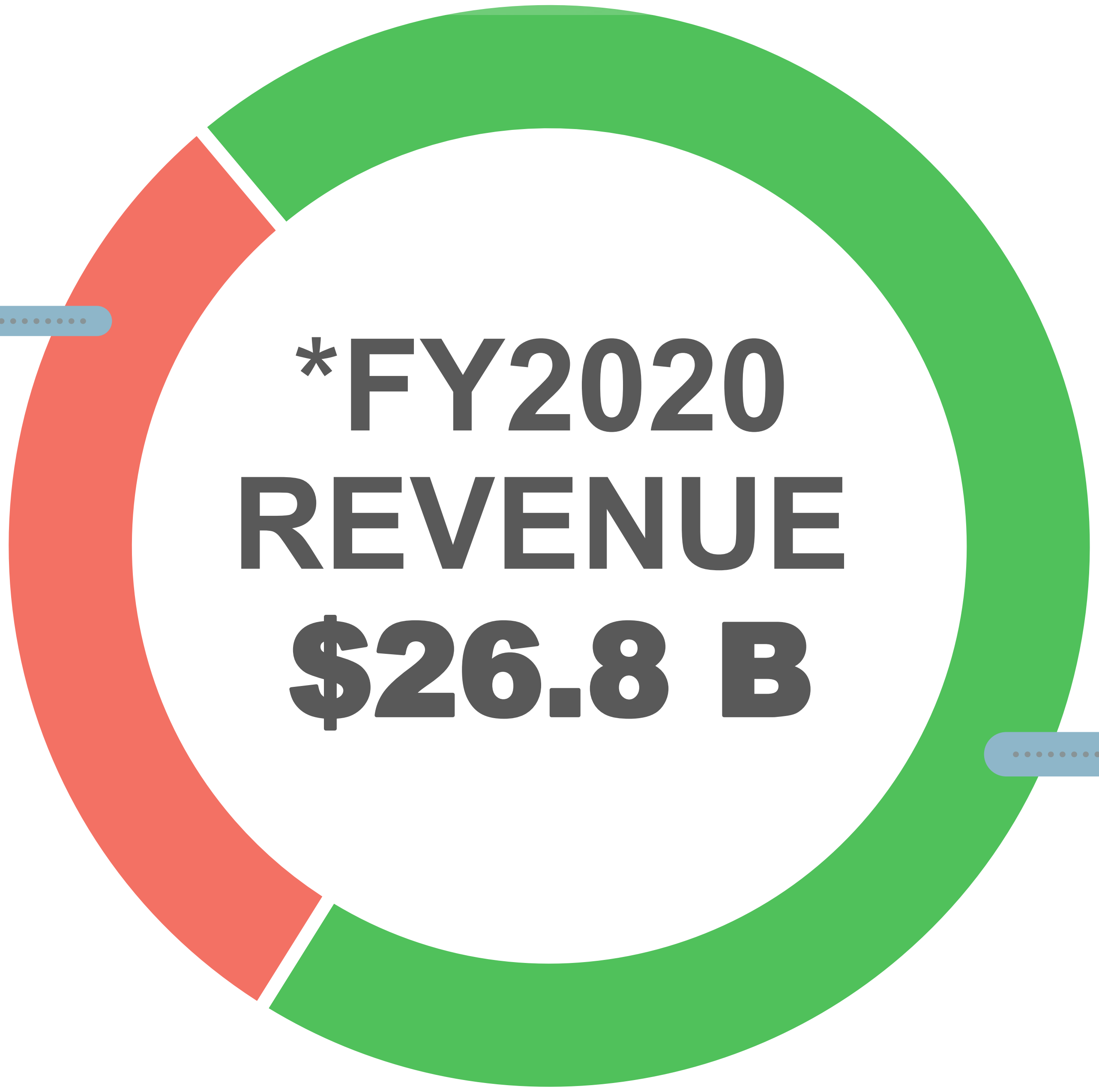



JR-EAST

# Feature 3 - Business Structure

We own and operate a **non-transport business** utilizing assets from **railway operations.**


**32%**
LIFESTYLE BUSINESS




**68%**
RAIL OPERATIONS

**65%** Tokyo Metropolitan Area Network

**32%** High-speed

**3%** Other rail network

Revenue from Rail Operations
**$ 18 Billion**

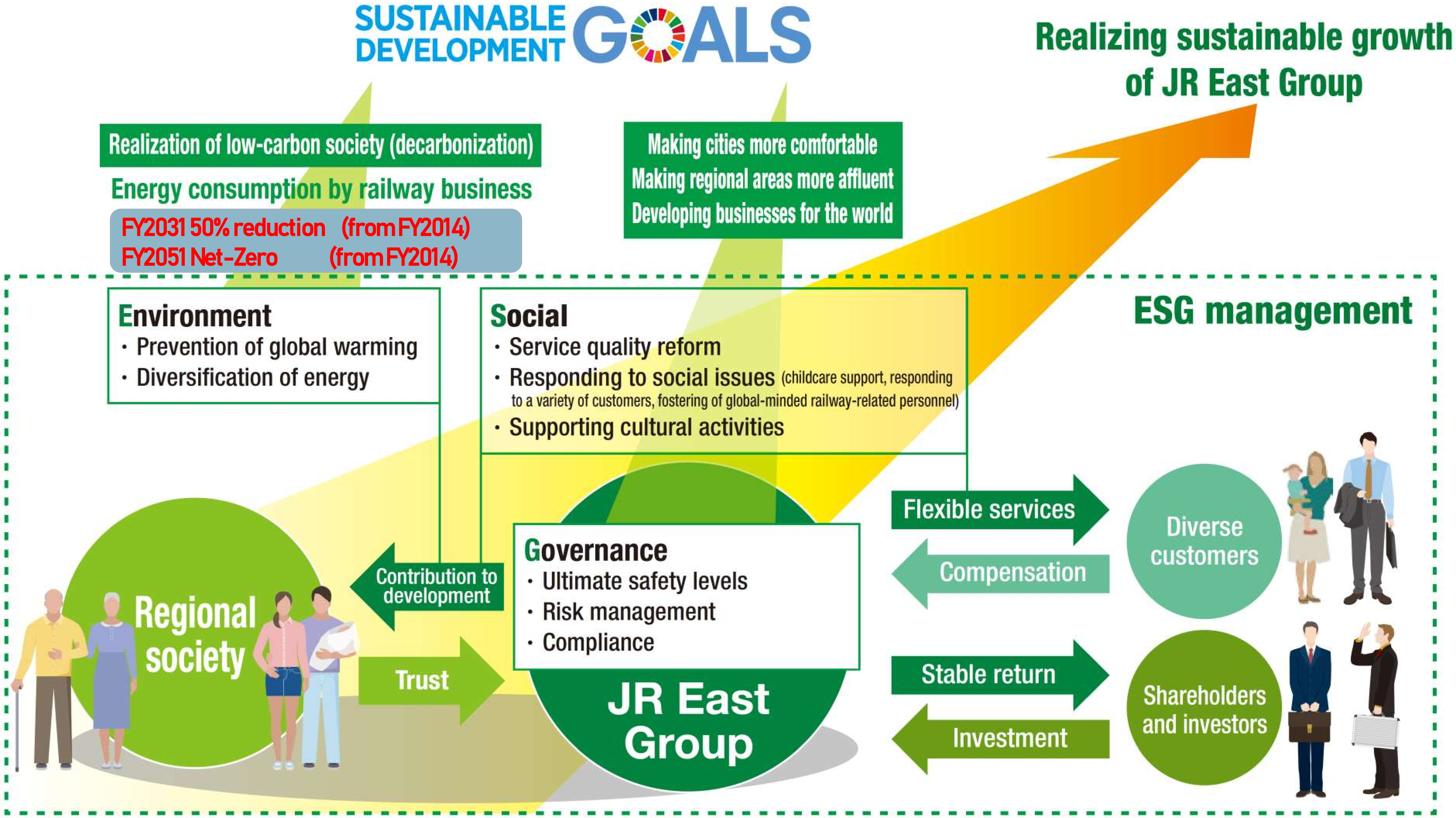
*Numbers are as of FY ended March 31, 2020
Calculated by 1$ = 110JPY

# Agenda

## 1 Summary of JR East – 3 Features

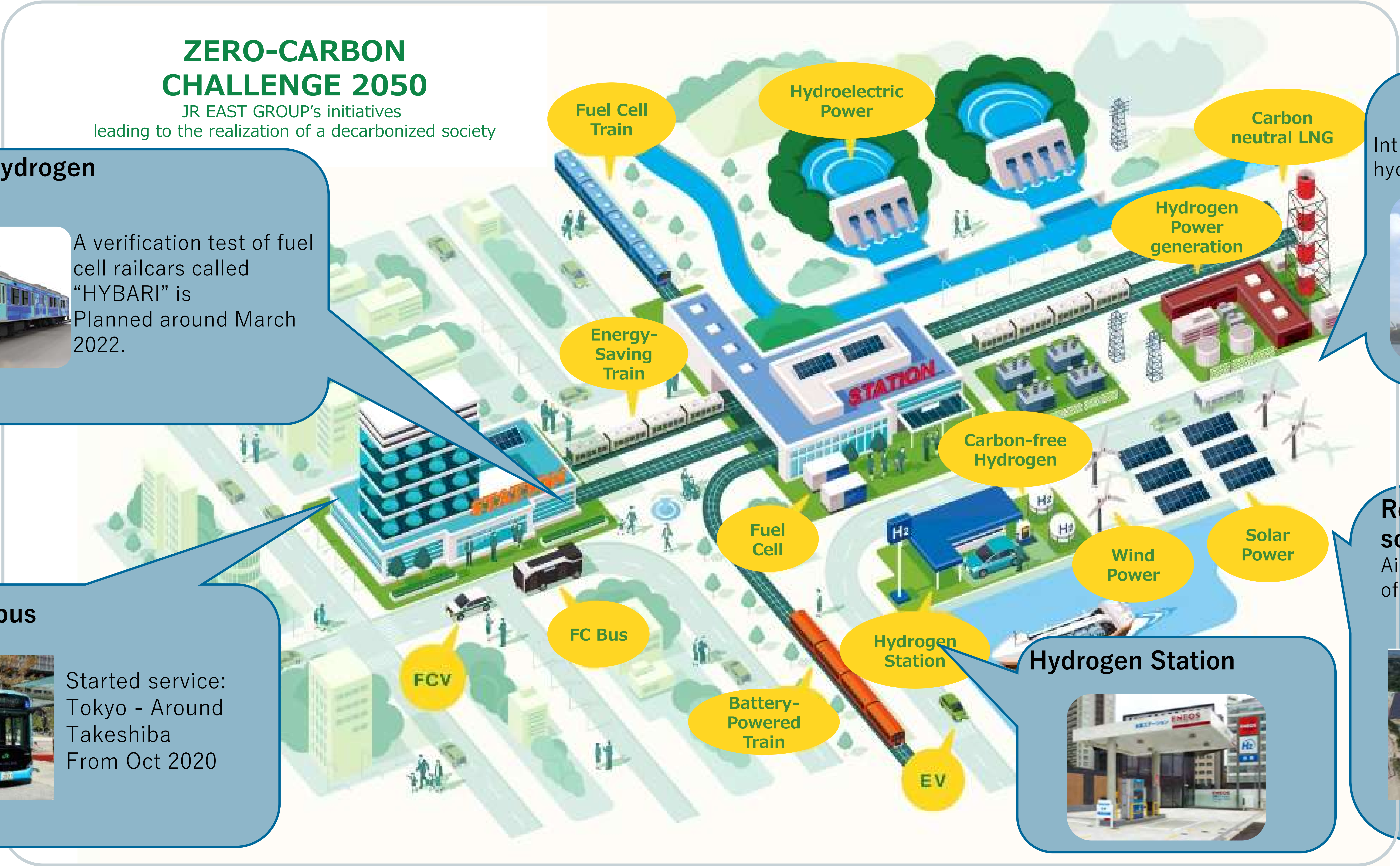
## 2 Our Energy and Environment Strategies and Initiatives

# Practicing ESG Management for Carbon-free Society




SUSTAINABLE DEVELOPMENT GOALS: 17 Sustainable Development Goals the world agreed upon for 2030

# Overview of Zero-Carbon Challenge 2050




## Utilization of hydrogen

A verification test of fuel cell railcars called "HYBARI" is Planned around March 2022.

## Fuel battery bus

Started service:
Tokyo - Around Takeshiba
From Oct 2020

## Kawasaki Thermal Power Station

Introduce CO2-free hydrogen power generation

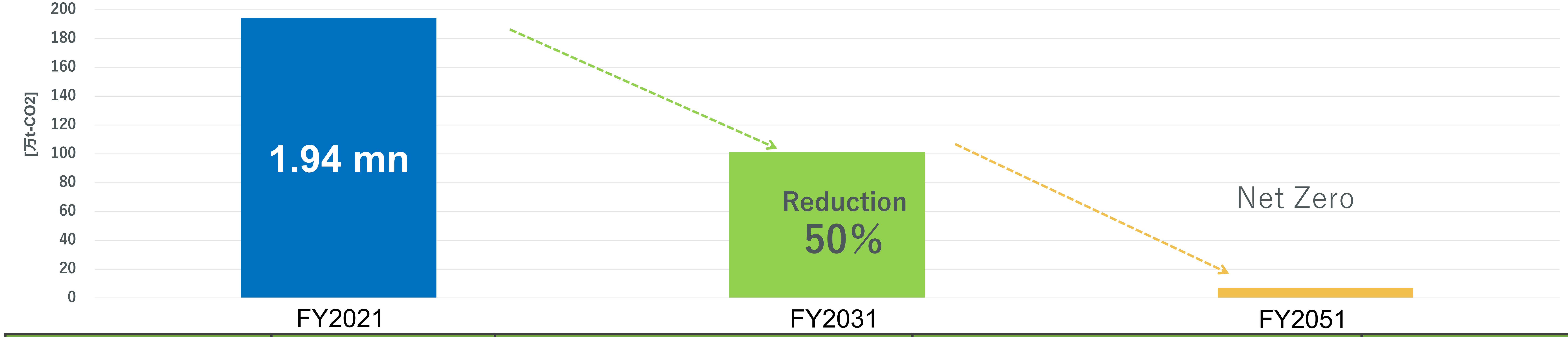
## Hydrogen Station

## Renewable energy power sources

Aim to achieve total power output of at least 1 million kW

# Zero-Carbon Challenge 2050 – JR EAST

## Net Zero CO2 Emissions by FY2051.3




| Energy type (Breakdown of CO2 emissions) | ~FY2031.3 | ~FY2041.3 | ~FY2051.3 |
| --- | --- | --- | --- |
| Purchased Electricity (52%) | Advance the introduction of energy-saving facilities | | |
| | Tohoku area $CO_2$ free by FY2031.3 | Purchase area $CO_2$ free by FY2051.3 | |
| Self-generated electricity (40%) | Reduce carbon in step with renewal of power plants and other facilities | | Our power plants CO2 free |
| Fuel (8%) | Introduction of energy-saving facilities<br>Deploy catenary and battery-powered hybrid railcars | | |
| | Develop fuel cell railcars, conduct verification tests, etc. | | |

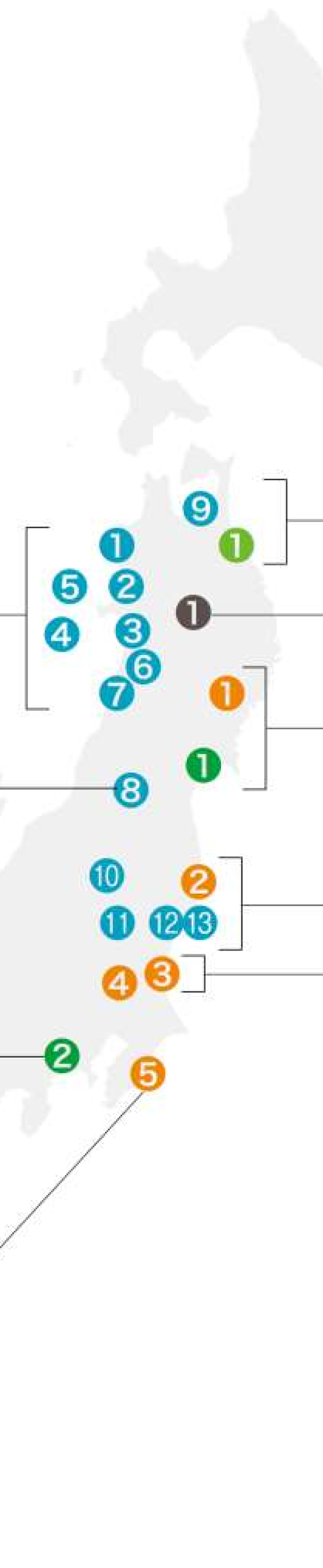
# Energy Creation – Introducing Renewable Energy

## Targets

0.7 GW in FY2031

1 GW in FY2051.

The JR East Group's current renewable energy development plan



**Akita Prefecture**

In operation

1. Minehama Wind Farm★ 5MW
2. Mitane Wind Farm★ 7.5MW
3. JR Akita Shimohama Wind Power 2MW

Development feasibility study underway
(Conducting survey as part of a multi-company organization)

4. Yuri Honjo Offshore Wind Power Project★ Approx. 700MW
5. Noshiro, Mitane and Oga in Akita Prefecture Offshore Wind Power Project★ Development feasibility study underway

Undergoing assessment or development

6. Nishime-Nishinosawa Wind Power Project★ Approx. 7.5MW
7. Yuri-Ouchi Wind Power Project★ Approx. 42MW

**Yamagata Prefecture**

Undergoing assessment or development

8. Kuriko-Yama Wind Power Project★ Approx. 34MW

**Kanagawa Prefecture**

In operation

2. J Bio Food Recycle's Yokohama plant

**Chiba Prefecture**

In operation

5. Otaki Solar Power Plant★ Approx. 15MW

**Aomori Prefecture**

In operation

1. Hachinohe biomass power plant Approx. 12MW

Undergoing assessment or development

9. Noheji-Shibasaki Wind Power Project★ Approx. 7.5MW

**Iwate Prefecture**

Development feasibility study underway

1. Omatsukurayama southern Geothermal Assessment

**Miyagi Prefecture**

In operation

1. Osaki Sanbongi Solar Power Plant★ Approx. 6MW

Scheduled to start operations in FY2023

1. Tohoku Bio Food Recycle Sendai Plant Approx. 0.8MW

**Fukushima Prefecture**

In operation

2. Tomioka Revitalization Mega Solar Power Plant SAKURA★ Approx. 30MW

Undergoing assessment or development

10. Otaki-Yama Wind Power Project★ Approx. 150MW
11. Kawauchi Onitaro-Yama Wind Power Project★ Approx. 40MW
12. Umaage-Yama Wind Power Project★ Approx. 36MW
13. Kagura-San Wind Power Project★ Approx. 68MW

**Ibaraki Prefecture**

In operation

3. Isohara Solar Power Plant★ Approx. 17MW

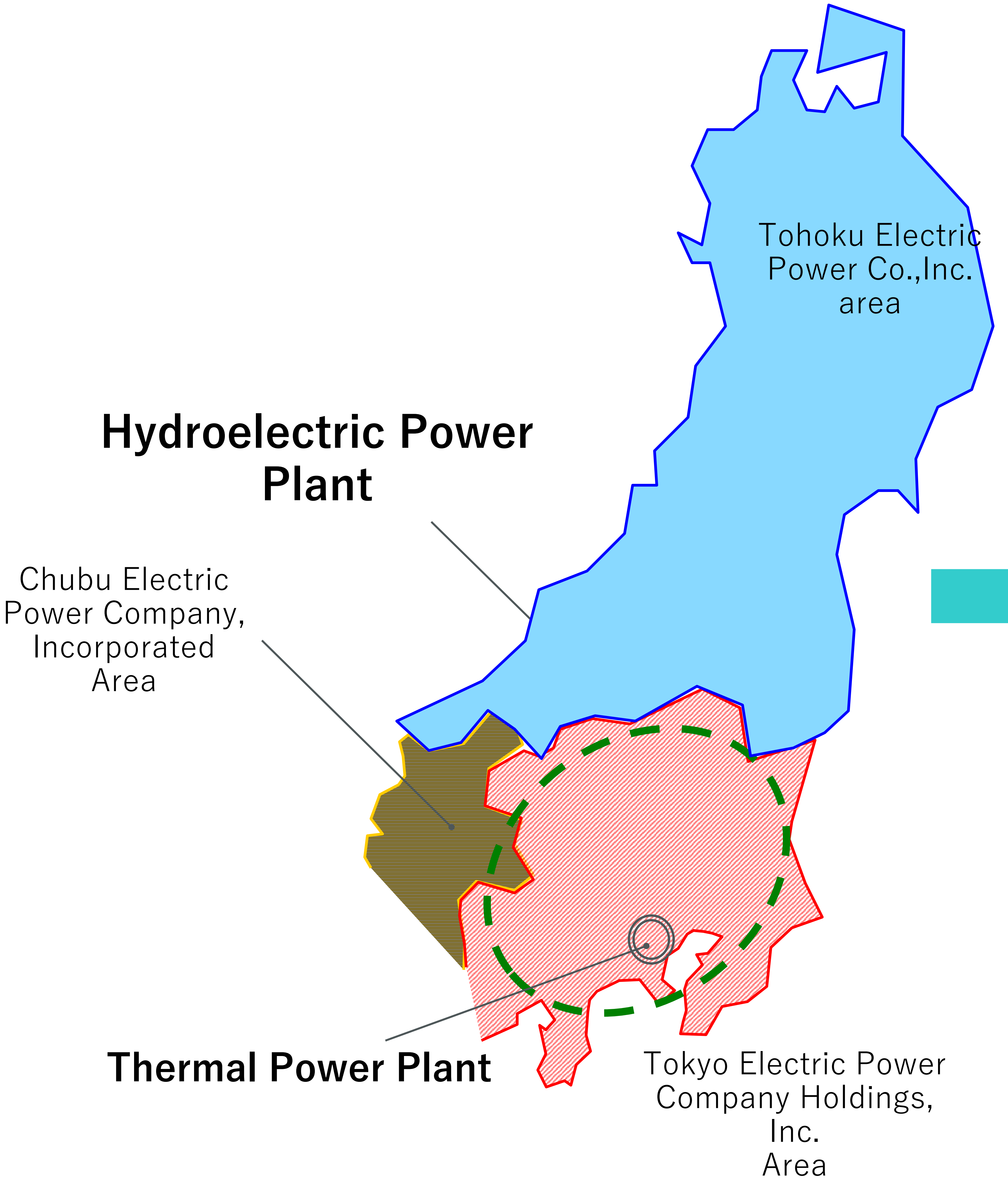
Undergoing assessment or development

4. Daigo Solar Power Plant★ Approx. 46MW

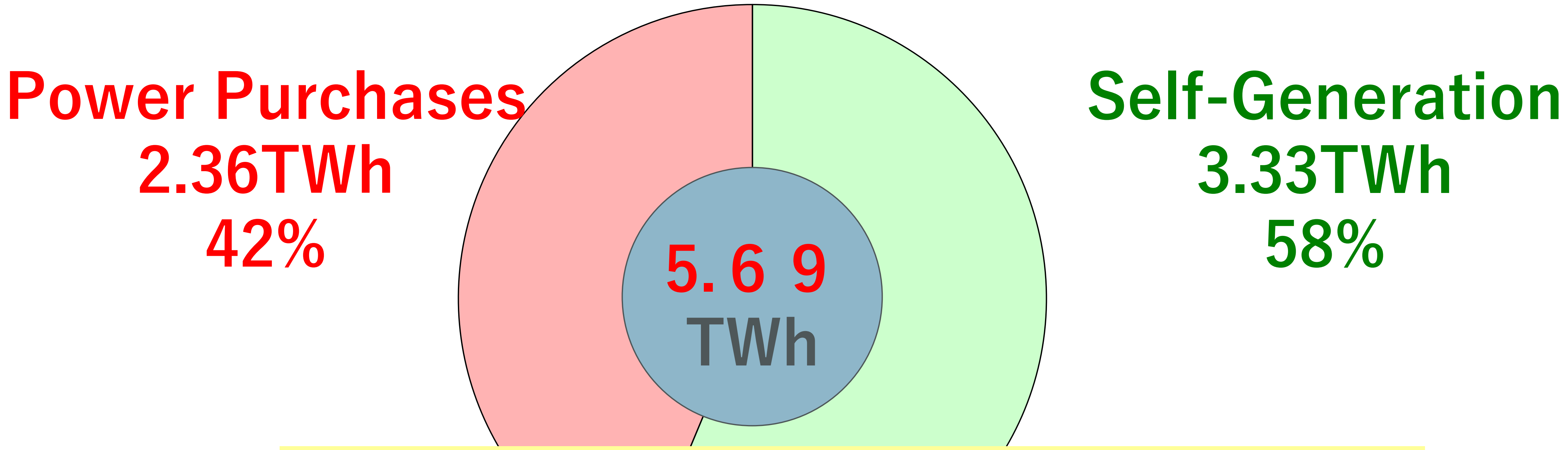
The star (★) indicates JR East Energy Development Co., Ltd. development and investment projects.

● Wind power generation ● Solar power generation ● Geothermal power generation
● Wood biomass power generation ● Biogas power generation

# Energy Creation – Operating our Plants

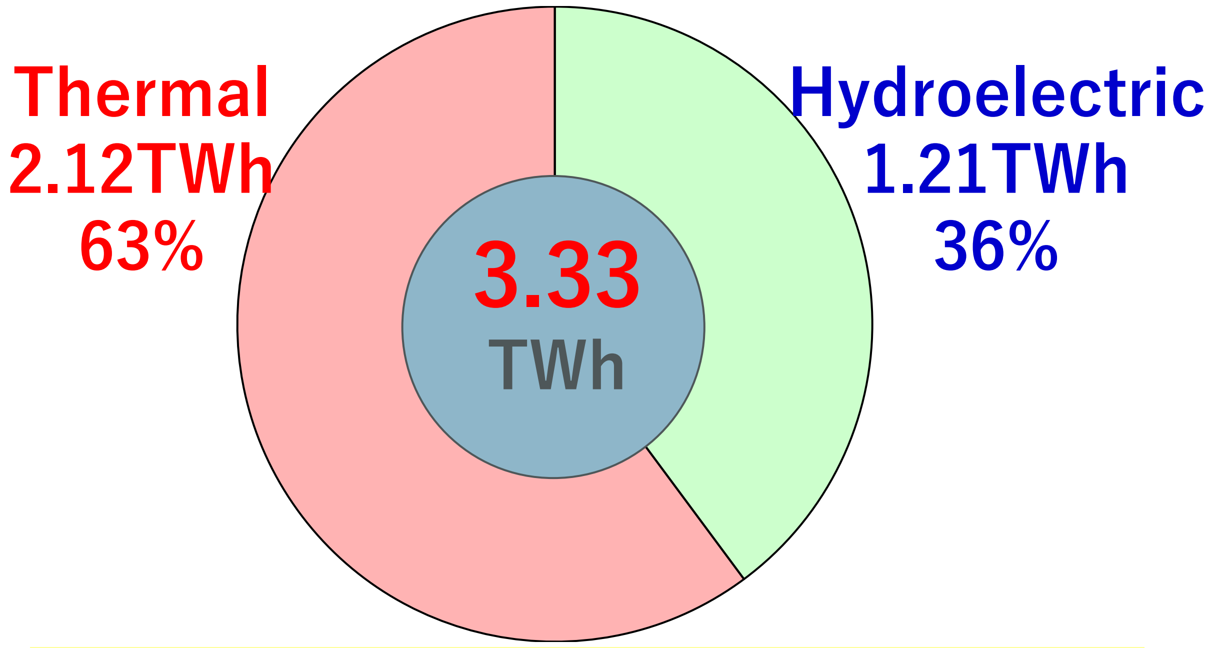



## JR East breakdown of electricity consumption FY2021.3



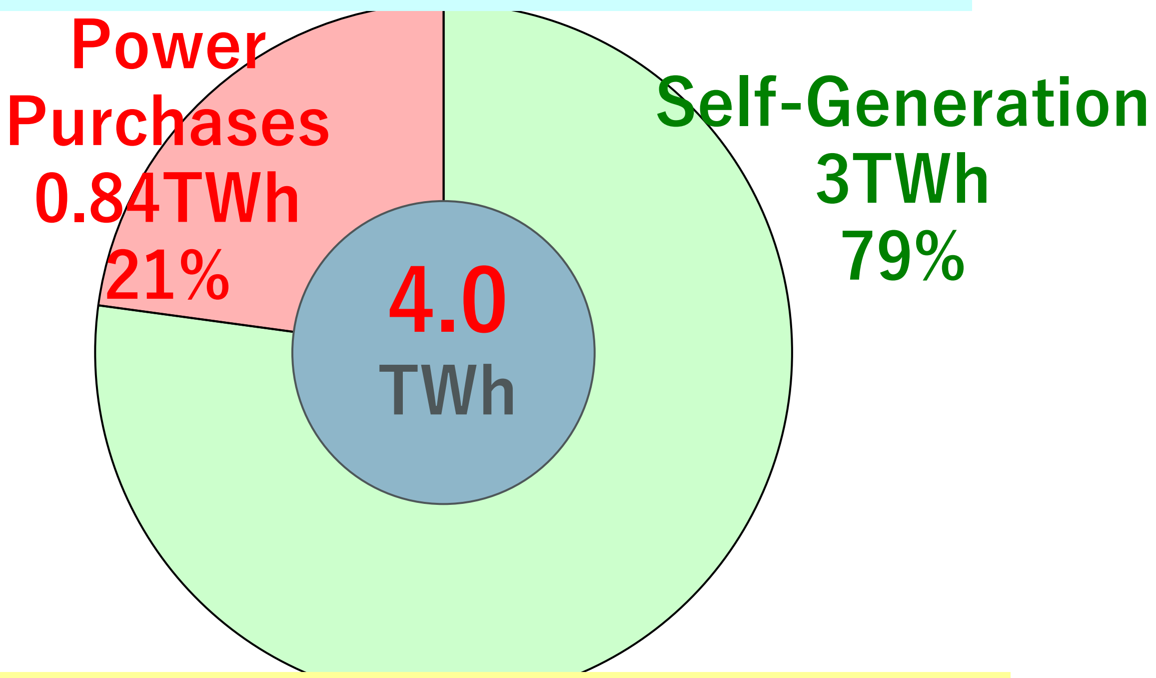

**60%:Self-generation electricity**
**40%:Purchase electricity**

### Self-generation




**60%:Hydroelectric**
**40%:Thermal**

### Tokyo Area（FY2020）




**Approx. 80% Self-generation**

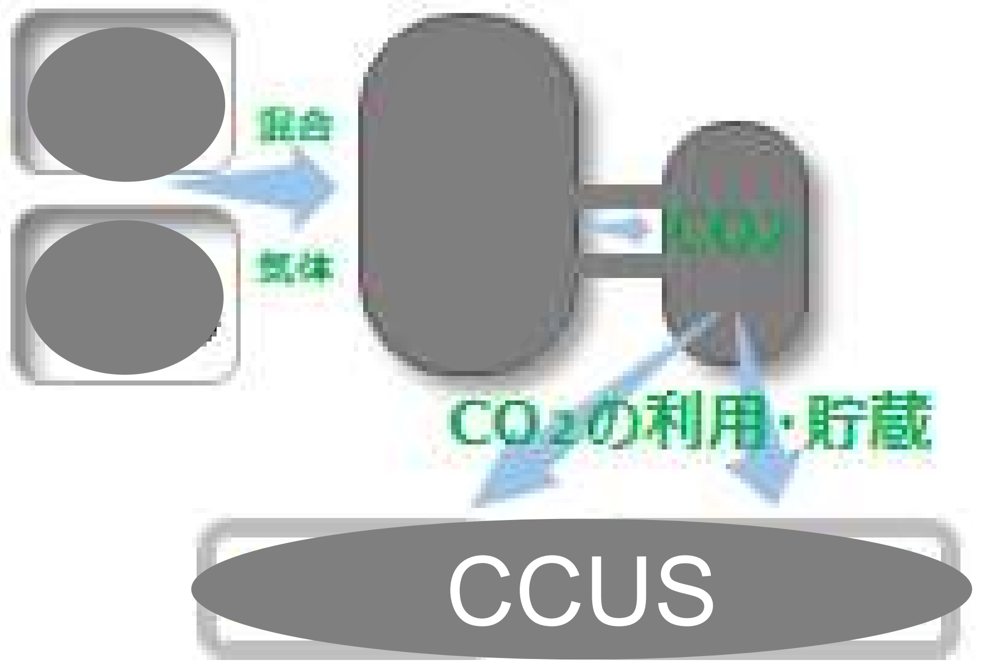
# Energy Creation – Hydro Power Station

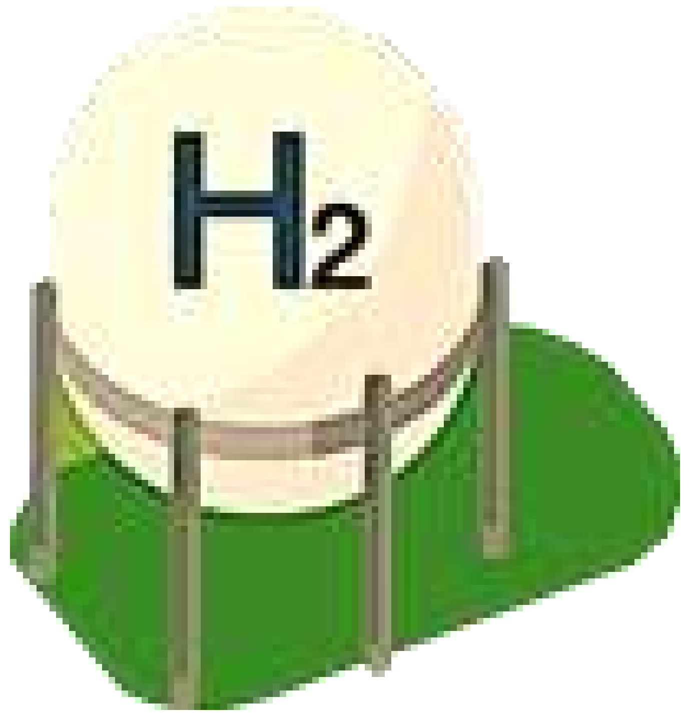
- Location : Shinano-gawa River Water System (Niigata Pref.)
- Total Output : 449,000kW
- Power Generation : 1.23 bil kWh anually

# Energy Creation – Thermal Power Station

We renewed with combined cycle power generation, and switched LNG from kerosene, which reduced $CO_2$ emissions.
We achieved higher efficiency of the power generation facilities, and we will consider the use of hydrogen as fuel and CCUS* technology in the renewal.

*Carbon Capture Utilization and Storage.



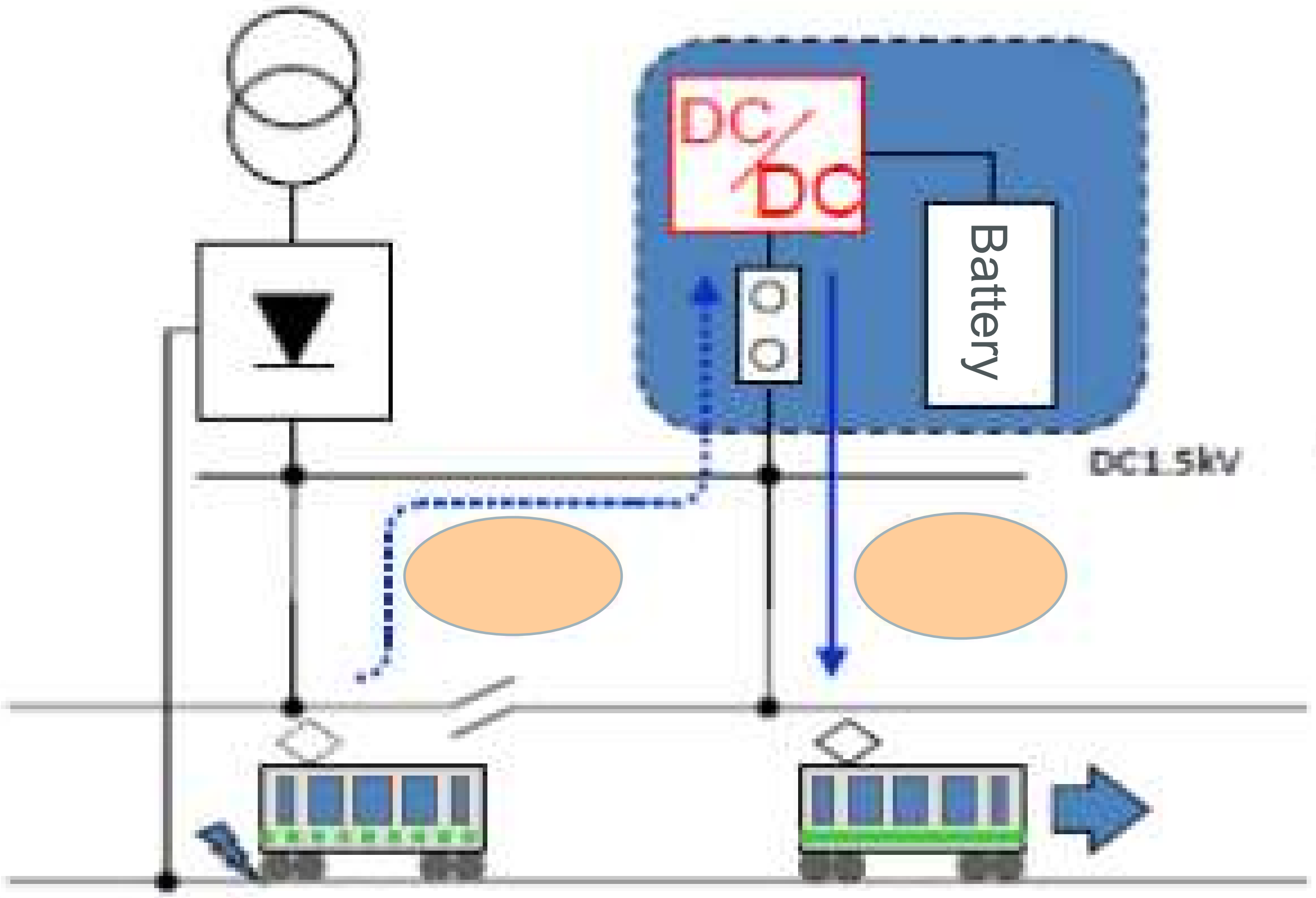




- ◆ Location : Kanagawa Pref.
- ◆ Total Output : 809,000kW
- ◆ Power Generation : 2.07bil kWh/y

# Energy Storage –Regenerative Energy Storage System

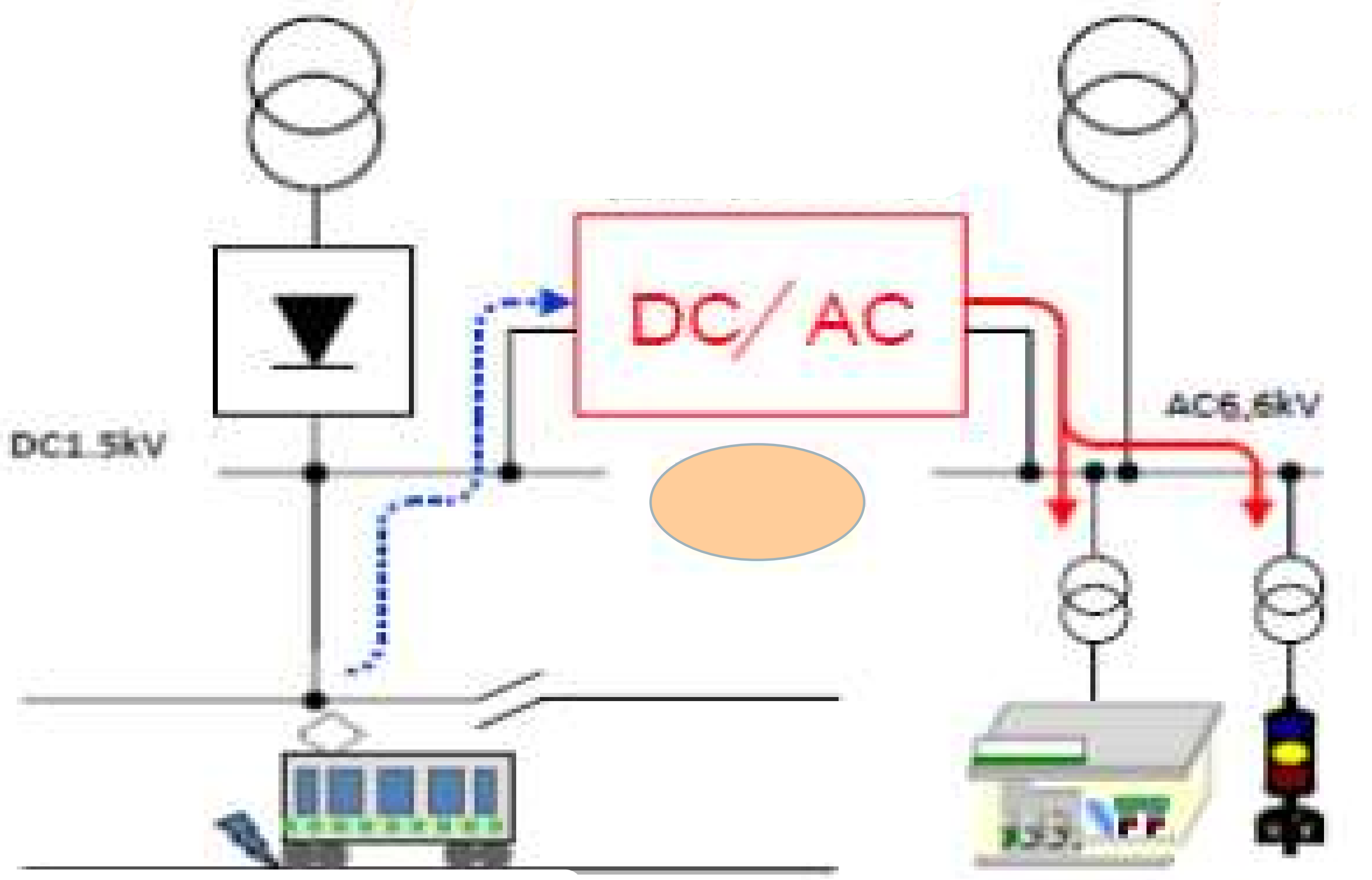
We are promoting the installing energy storage facilities for utilizing regenerative energy.

### Regenerative Energy Storage(Battery Post)



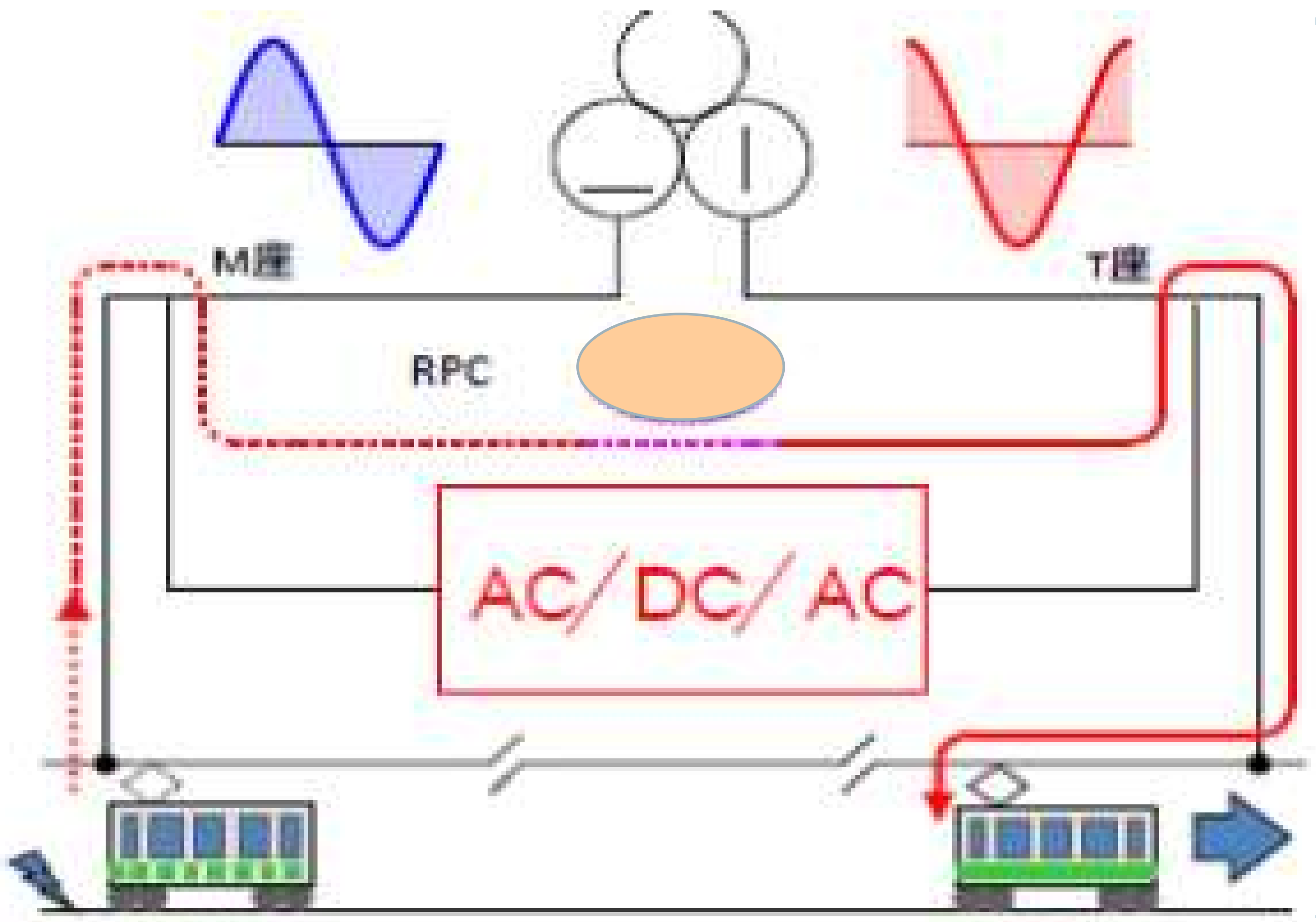

Storing regenerative energy generated when trains brake in an energy storage device

### Regenerative Inverter




Stored regenerative energy is converted from DC to AC, and used for train operation

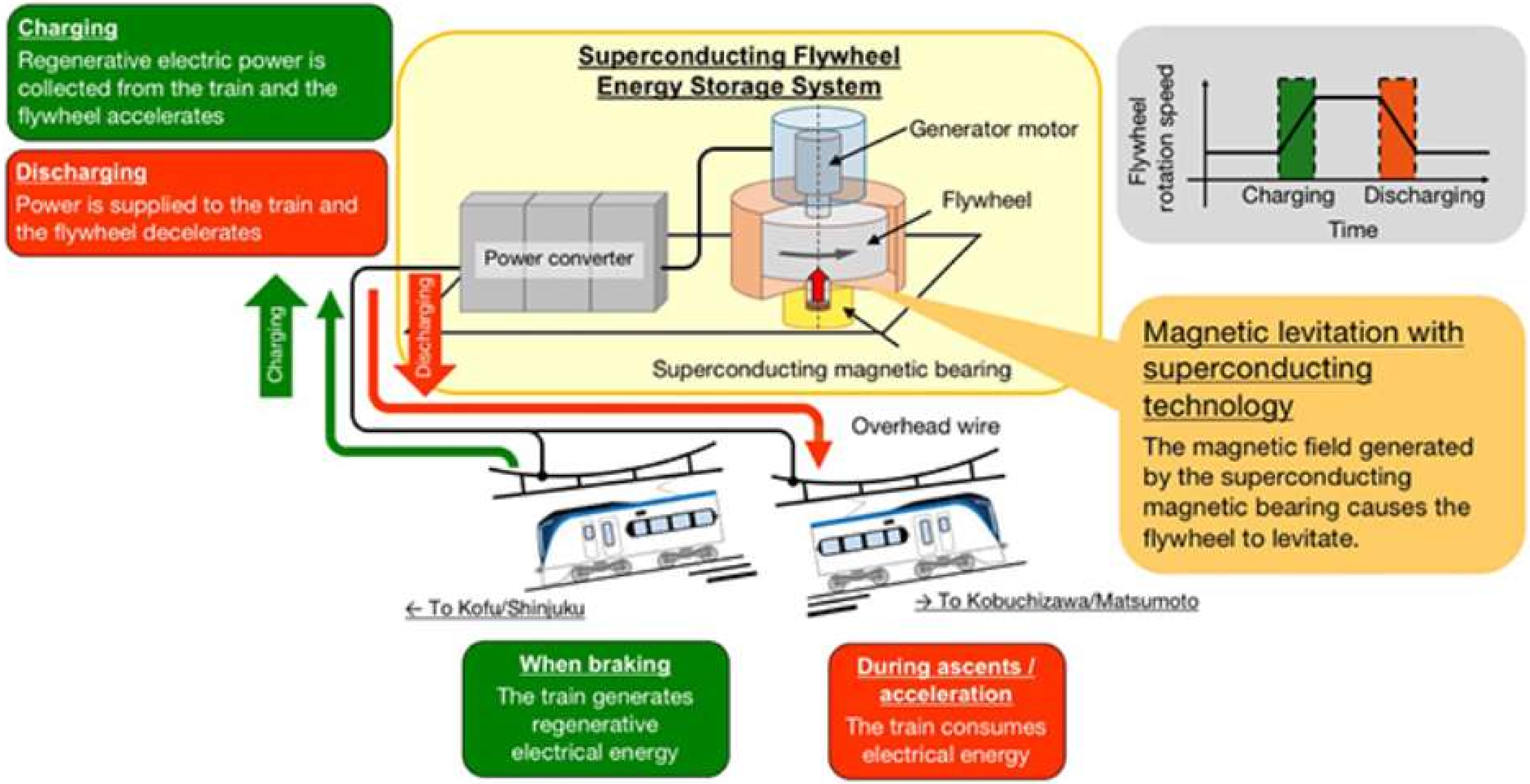
### RPC
(Railway Static Power Conditioner)




Also, stored regenerative energy is used for other sections

# Energy Storage

We are developing a Superconducting Flywheel, which can minimize energy decrease due to friction loss as well as eliminating the need for periodic large-scale maintenance.



# Energy Saving – Rolling Stocks

Introduction of energy-saving vehicles which possess ;

- Regenerative Brake
- VVVF Invertor; Variable Voltage, Variable Frequency


E235 Series Commuting train

E7 Series Shinkansen

# Energy Saving – Rolling Stocks

We have reduced energy consumption for train operations.


200 Series(1982)

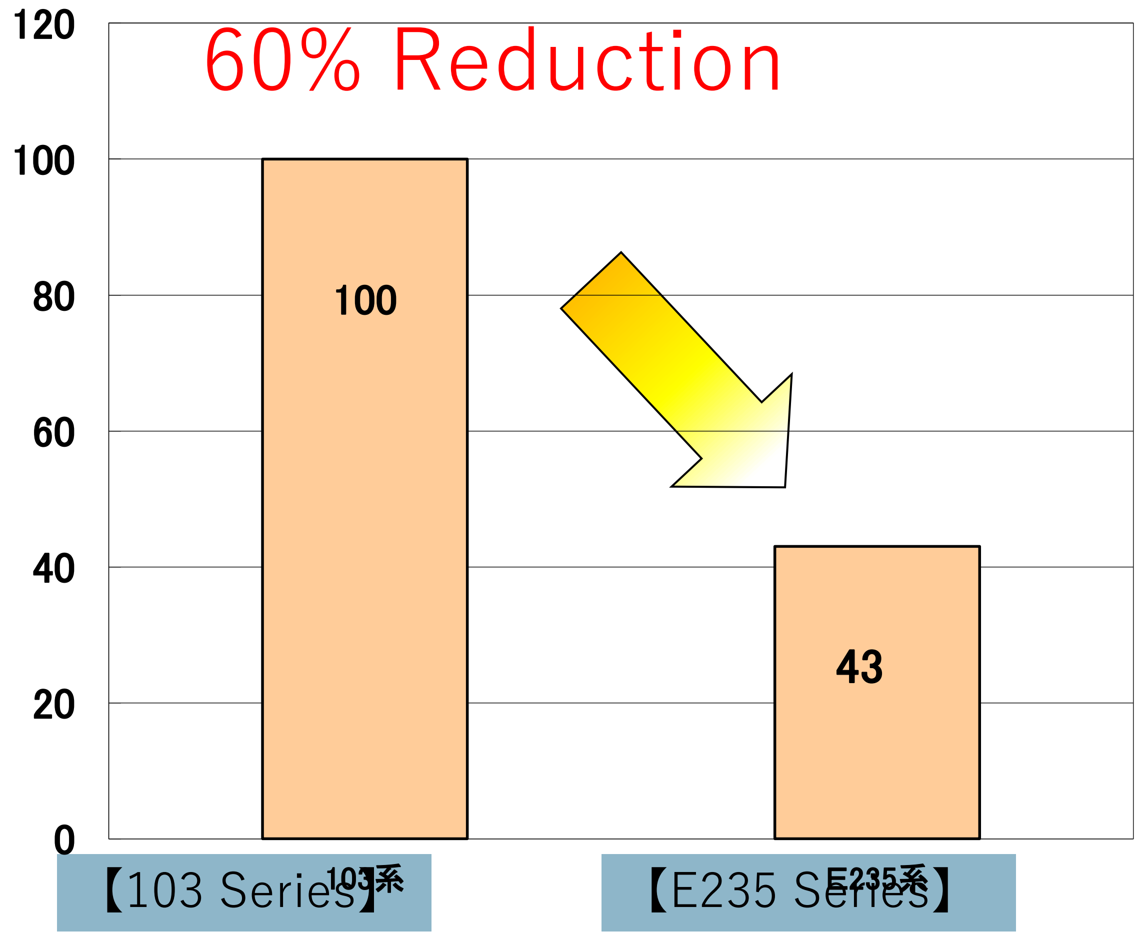

E7 Series(2015)

Energy Consumption



103 Series(1963)


E235 Series(2015)



# Energy Saving – Rolling Stocks(non-electrified section)

We have proactively introduced **Hybrid Railcar** (Diesel-Powered,  Electric-Motor-Driven), and **ACCUM**, an electrically driven railcar whose energy is derived from rechargeable batteries.

**Oga Line**

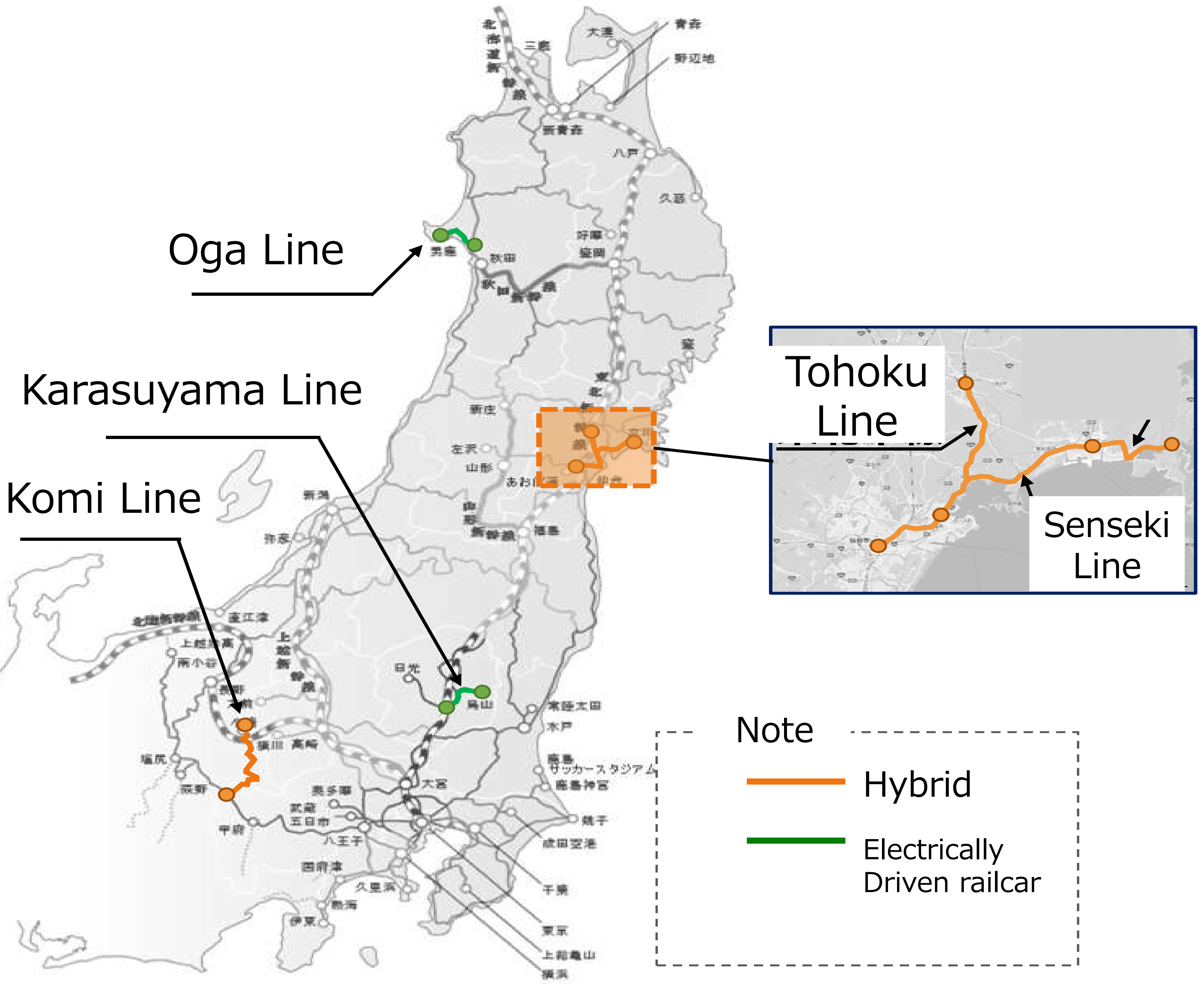
**ACCUM**

**Karasuyama Line**

**ACCUM**

**Komi Line**

**Hybrid**




**Gono Line etc.**

**Hybrid**

**Senseki-Tohoku Line**

**Hybrid**

# Energy Saving – *ecoste*

***ecoste*** Environment Earth Conscious Station of East Japan Railway Company
We are introducing a variety of elements at stations under the 4 headings.

■**Energy Conservation**

Promoting more advanced energy conservation

■**Energy Creation**

Actively implementing renewable energy

■**Eco-Awareness**

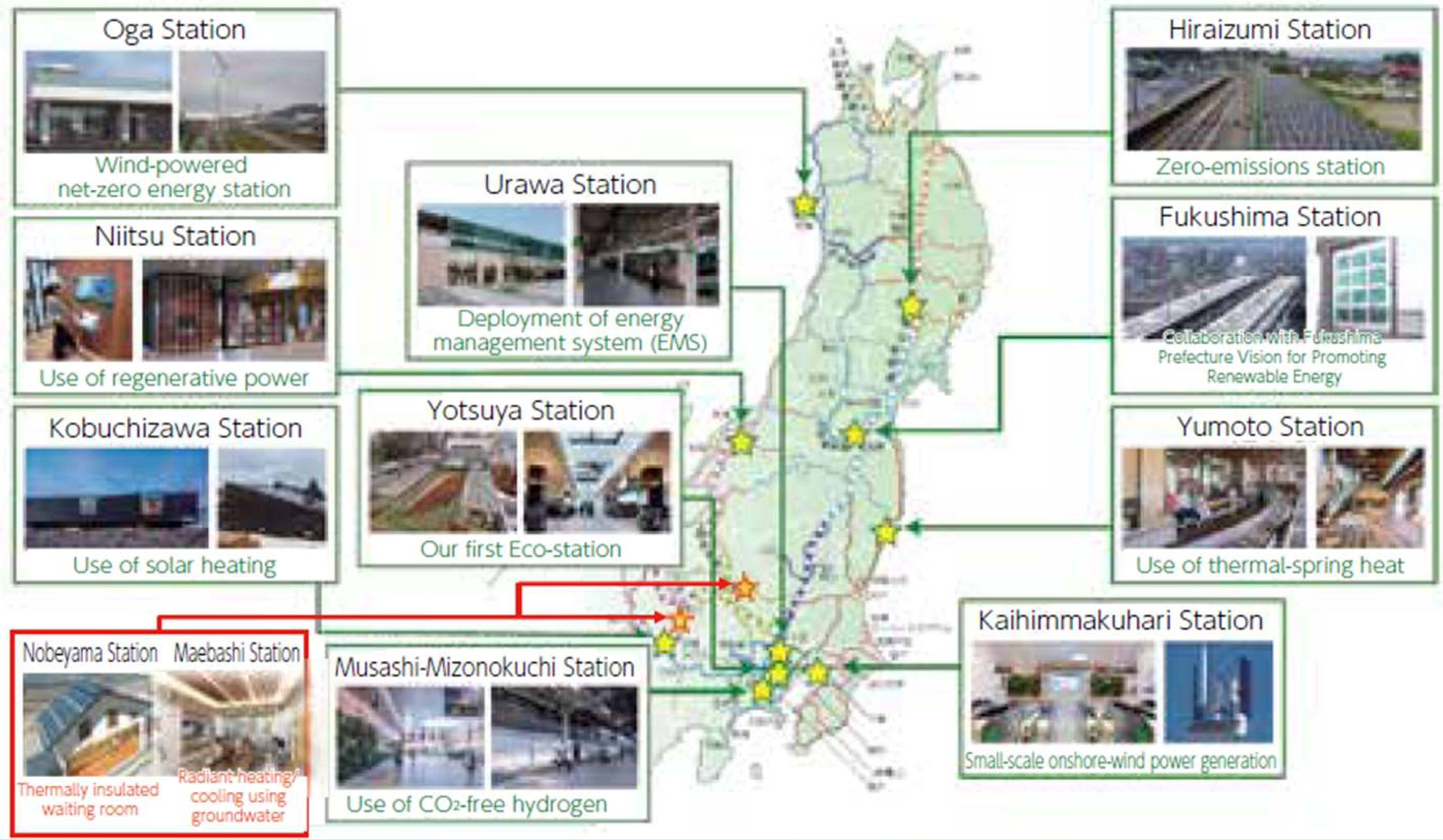
Preparing facilities evoking users' eco-awareness

■**Environmental Harmonization**

Creating vitality by harmonizing people
with their environment

# Energy Saving – *ecoste*

We have introduced 12 *ecoste* stations and will continue to develop.



# Energy Saving – *Oga station*

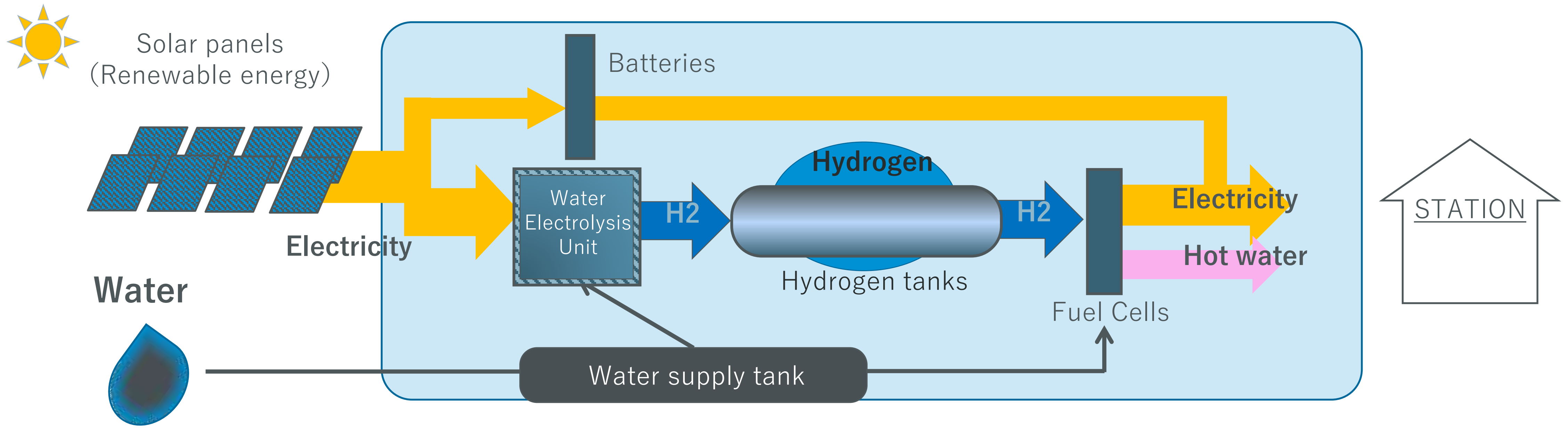
We introduced 9 small wind turbines and batteries, supplying the electricity to facilities at the station. Excess power is used for ACCUM, battery driven train.

Oga Station is a CO2-free station operated with electricity from JR Akita Shimohama Wind Power Station.

# Energy Saving – *Musashi-Mizonokuchi Station*

The hydrogen-based autonomous energy supply system (H2One) is in operation to use hydrogen from renewable as a model station.
Electricity is used for LED lighting on the platforms. Under emergency, it is used for lightings outside of the station and restrooms.





# Diversification of Energy - Hydrogen Energy

We will continue to work to diversify our energy sources, and we will accelerate efforts to realize a hydrogen society based on our station and railway line resources.

〇Hydrogen Station Opening

〇Adapting Fuel Cell Buses and replacing business-use automobiles


〇Hybrid railcar(fuel cell) test trains(HYBARI)

# Diversification of Energy – Hybrid/Fuel Cell Test Trains

We will commence trial runs of hydrogen-powered fuel cell test trains on the Tsurumi Line and other lines stating in FY2021.

Roadmap for achieving hybrid/Fuel Cell Trains

| ~FY2031.3 | ~FY2041.3 |
|---|---|
| Develop fuel cell railcars<br>Conduct verification tests | Consider line segments for deployment<br>Implement for passengers |

# TCFD Recommendation-Related Initiatives

In January 2020, JR East announced its support for the Task Force on Climate-related Financial Information (TCFD) recommendations.

We analyzed the financial impact until 2050 based on the flooding scenario, and the estimated financial impact as follows;

| Presence or absence of inundation measures | Scenario | Increase in financial impact (Billion of yen) (decrease in fares and increase in disaster recovery expenses |
|---|---|---|
| | | Estimate period, total |
| **No** inundation measures (hardware / software) | RCP2.6(2℃) | +51.4 |
| | RCP8.6(4℃) | +60.0 |
| Inundation measures in place (hardware / software) | RCP2.6(2℃) | +19.8 |
| | RCP8.6(4℃) | +24.2 |

In order to alleviate the risks and financial impact, JR East has developed countermeasures for natural disasters according to the importance of facilities from both perspectives of hardware (facilities) and software (human responses).
For example, decision support system for vehicle evacuations.

For details can be found on our website JR-EAST:Integrated Report.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**Thank you for your attention.**

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# Questions
# Discussion

Koji KASAI
Deputy General Manager,
Corporate Management Planning
Department,
East Japan Railway/JR East

**Thank you for your attention.**

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# Questions
# Discussion

General

**Thank you for your attention.**


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*Medias to be made available on the event page*
*https://uic.org/events/trackside-energy-storage*

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