The DLR Project Next Generation Train (NGT)

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UIC Energy Efficiency Workshop

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Next Generation Train (NGT) – Project Overview

Main Results

- Increasing the certified speed to 400 km/h
- 50% less energy consumption
  (compared to ICE 3 at 300km/h)
- Car body with 30% less weight
  (compared to TGV Duplex)
- Increase of comfort
    - 30% more passengers
    - 25% reduction of vibrations
- Improvement of wear behavior and life cycle costs

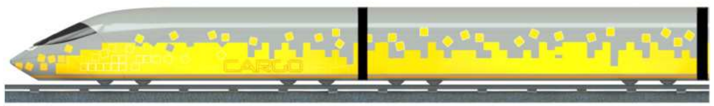
NGT HST

→ ultra-high-speed train, traction power 16 MW, operational speed 400 km/h

NGT LINK

→ feeder train set, traction power 2.5 MW, operational speed 230 km/h

NGT CARGO



→ ultra-high-speed freight train set (e.g. for parcel services)

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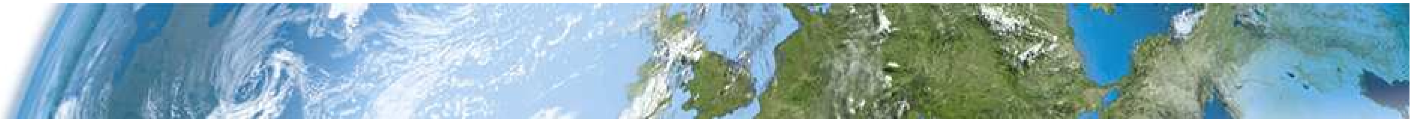
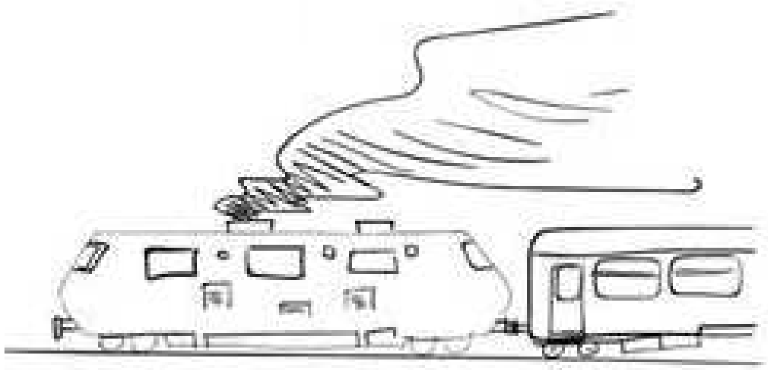


Motivation

EU28: Line electrification and CO_2-emissions from railways

- 46% of railway lines were non electrified in 2012 [1]
- Service on these lines typically provided by diesel traction with significant CO_2-, NOx and PM emissions
- Example SBB in 2015 [2] [3]:
  - Line electrification > 95%
  - Diesel energy consumption < 4%
  - 31% of total CO_2-emissions

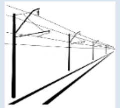
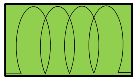
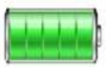


- Internal CO_2 - reduction target of UIC (baseline 1990) [4]:
  - by 2030: **-50%**
  - by 2050: **-75%**

[1] International Union of Railways - UIC, "Rail Transport and Environment, Facts & Figures", 2015
[2] http://www.sbb.ch/sbb-konzern/ueber-die-sbb/zahlen-und-fakten/umwelt/energieverbrauch.html
[3] http://www.sbb.ch/sbb-konzern/ueber-die-sbb/zahlen-und-fakten/umwelt/co2-emissionen.html
[4] International Union of Railways - UIC, "Railway Handbook 2015", 2015

Motivation

What could be the future solution for non-electrified lines?

	Possible Solution	Advantage	Disadvantage
	Full electrification	No local emissions	High investment cost, low utilisation
	Inductive energy transfer system (IETS)	Partial electrification, no local emissions, grid connection with lower power	Modification of some track segments
	Alternative fuels (Biofuels, Natural Gas, …)	Reduction of emissions, adaption of well-known technology	Adaption of existing trains, fuel stations, local emissions, costs
	Pure battery multiple unit	No local emissions, regeneration	Operation range, packaging, costs
	Fuel cell hybrid propulsion	No local emissions, regeneration, range	Fuel stations

➔ No simple solution, novel concepts required

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Approach for future propulsion system

Conceptual requirements

- Propulsion system with emission-free train operation on non-electrified lines
- Boost energy efficiency by recuperation of brake energy
- One concept with different configurations to provide modularity, scalability and flexibility in different scenarios
- Smooth transition from current non-electrified lines to future system

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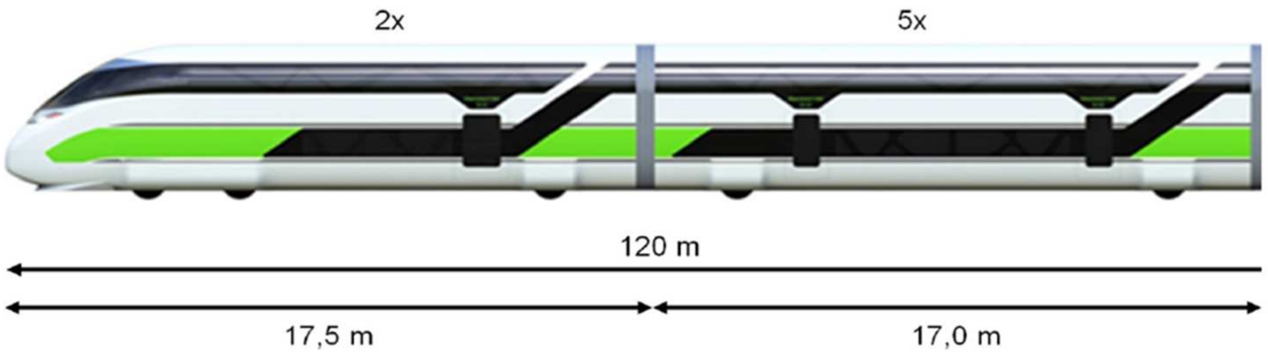
- Combination of on-board energy storage and flexible energy source

Use case NGT LINK

- Innovative train concept with all-wheel drive
- Double-decker regional and intercity train
- Serves as basis for requirements and packaging concept

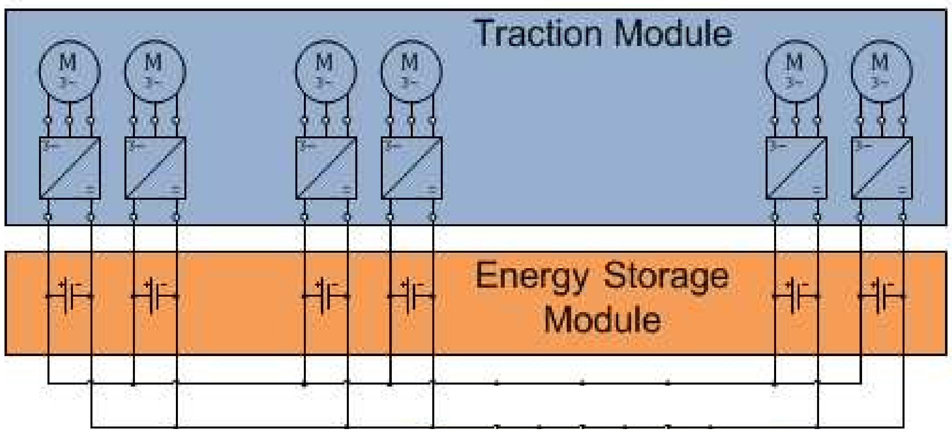


Relevant specifications

Maximum tractive power at wheel	2500 kW
Starting tractive force at wheel	412 kN
Design mass (fully loaded)	272 t
Number of wheelsets and traction drives	32

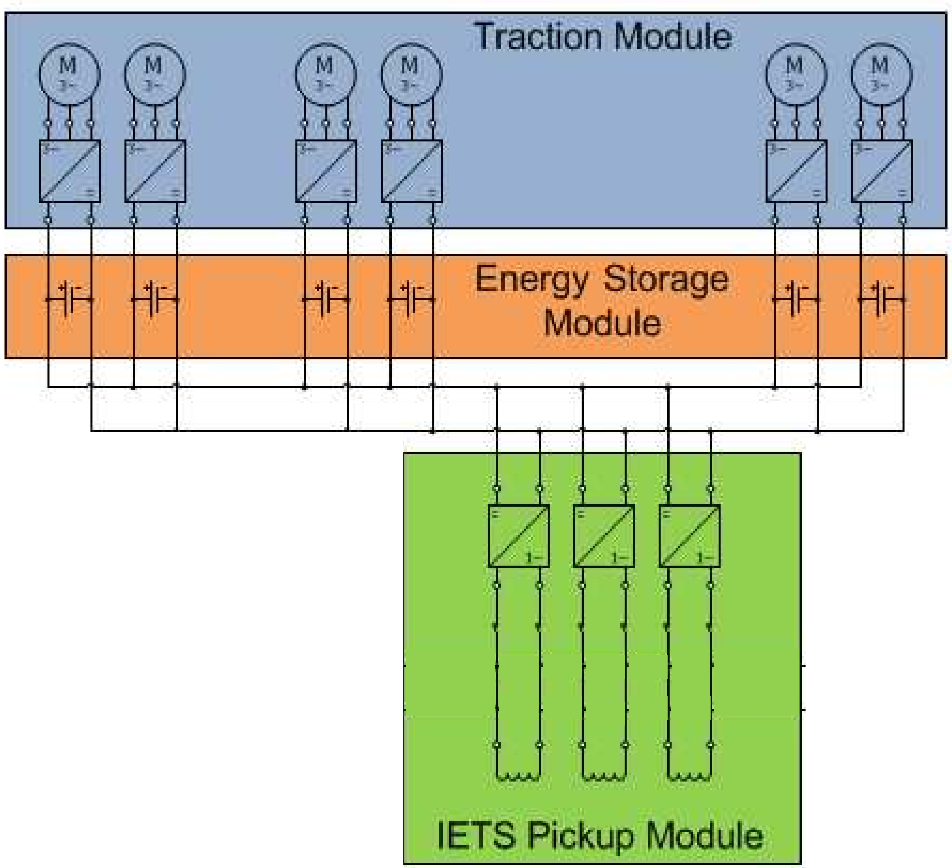
Propulsion concept – main current circuit

Modular approach – base module



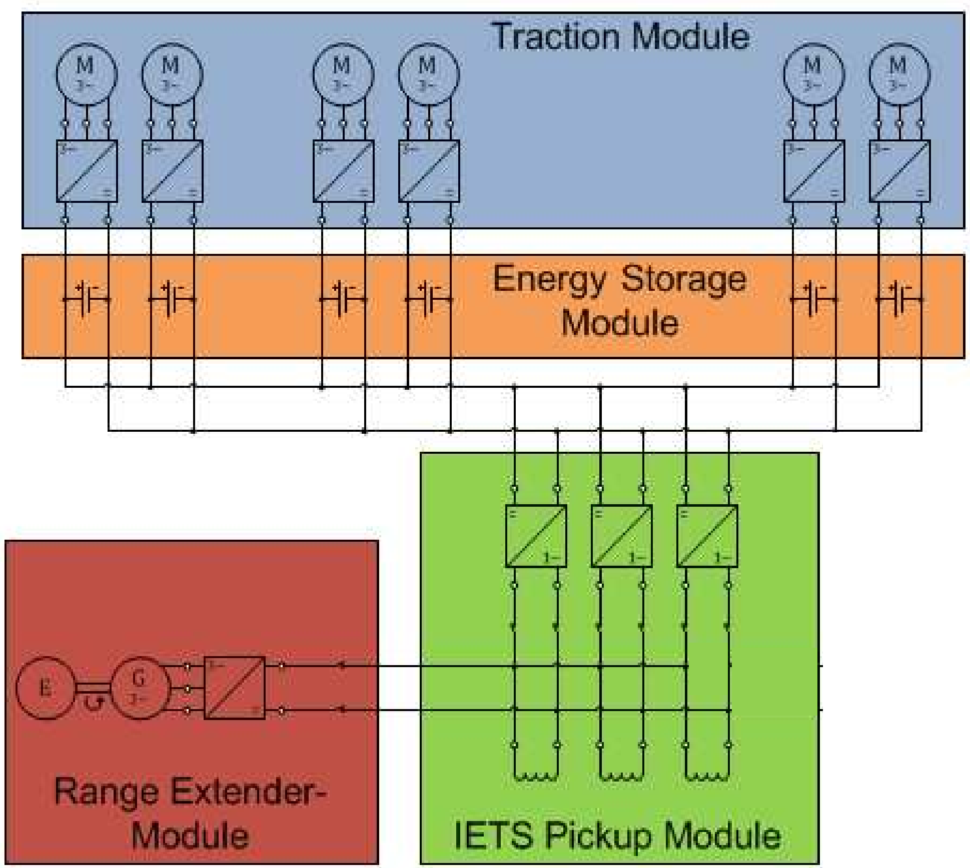
Propulsion concept – main current circuit

Modular approach – base module with IETS



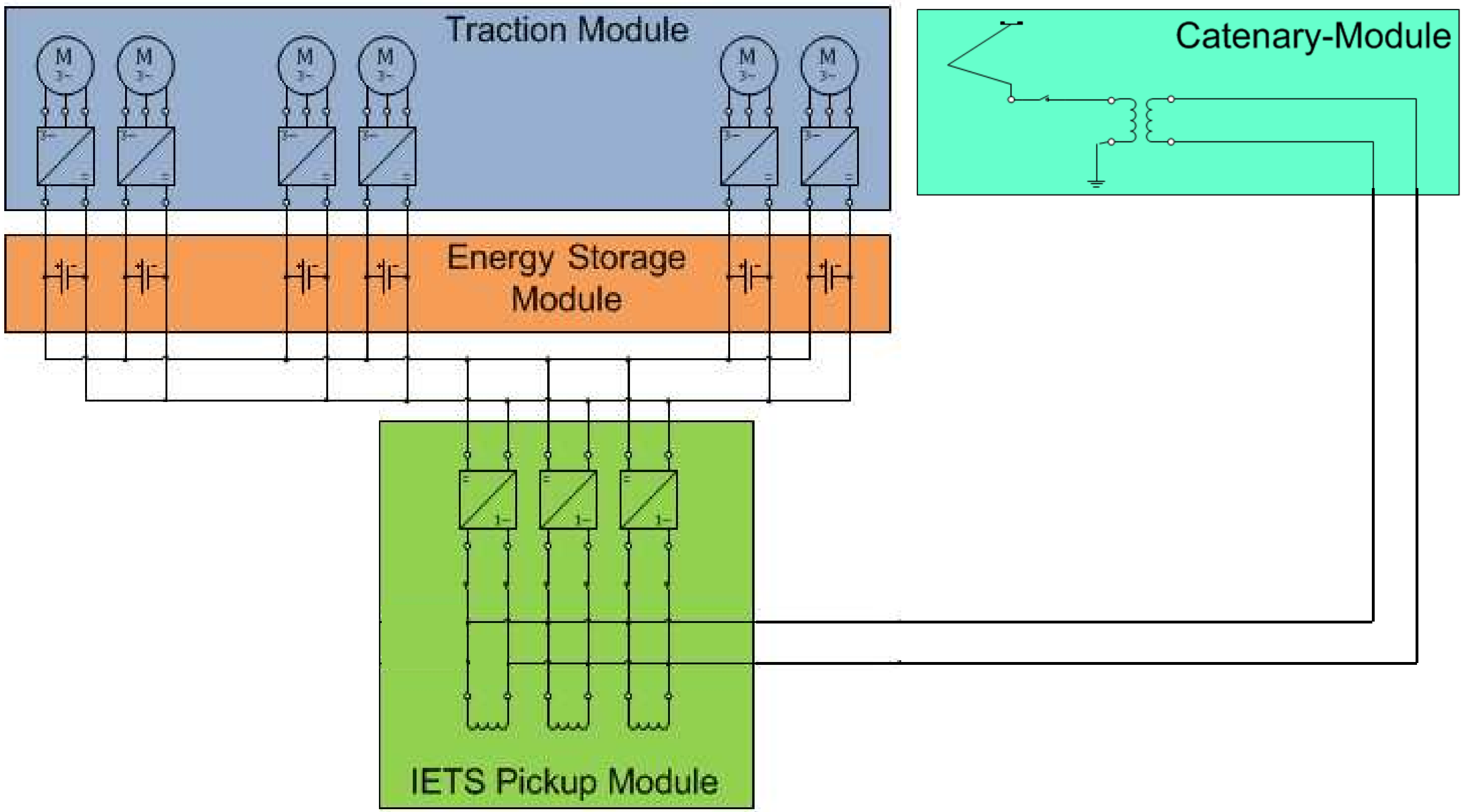
Propulsion concept – main current circuit

Modular approach – base module with hybrid / range extender

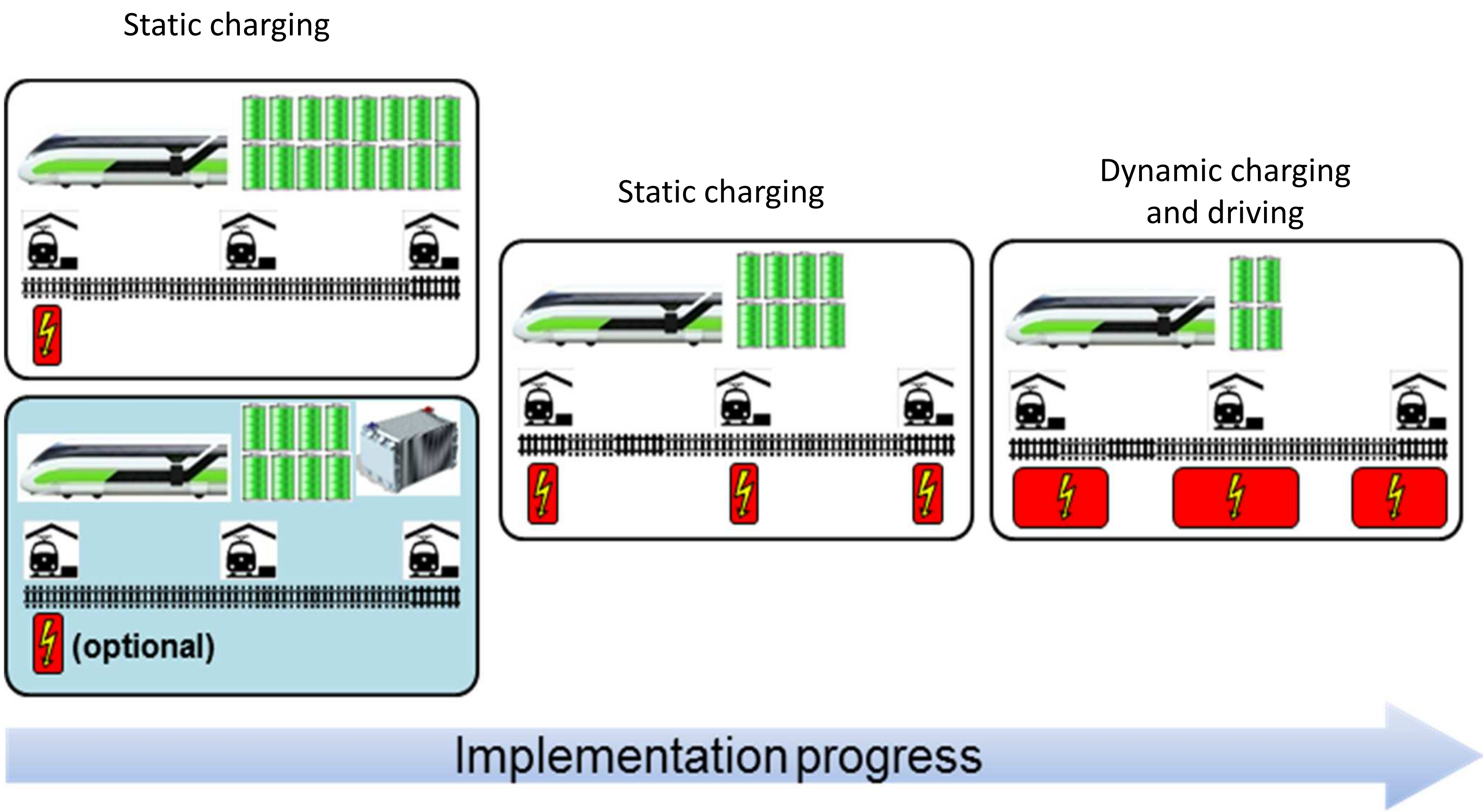


Propulsion concept – main current circuit

Modular approach – base module with catenary module



Implementation strategy



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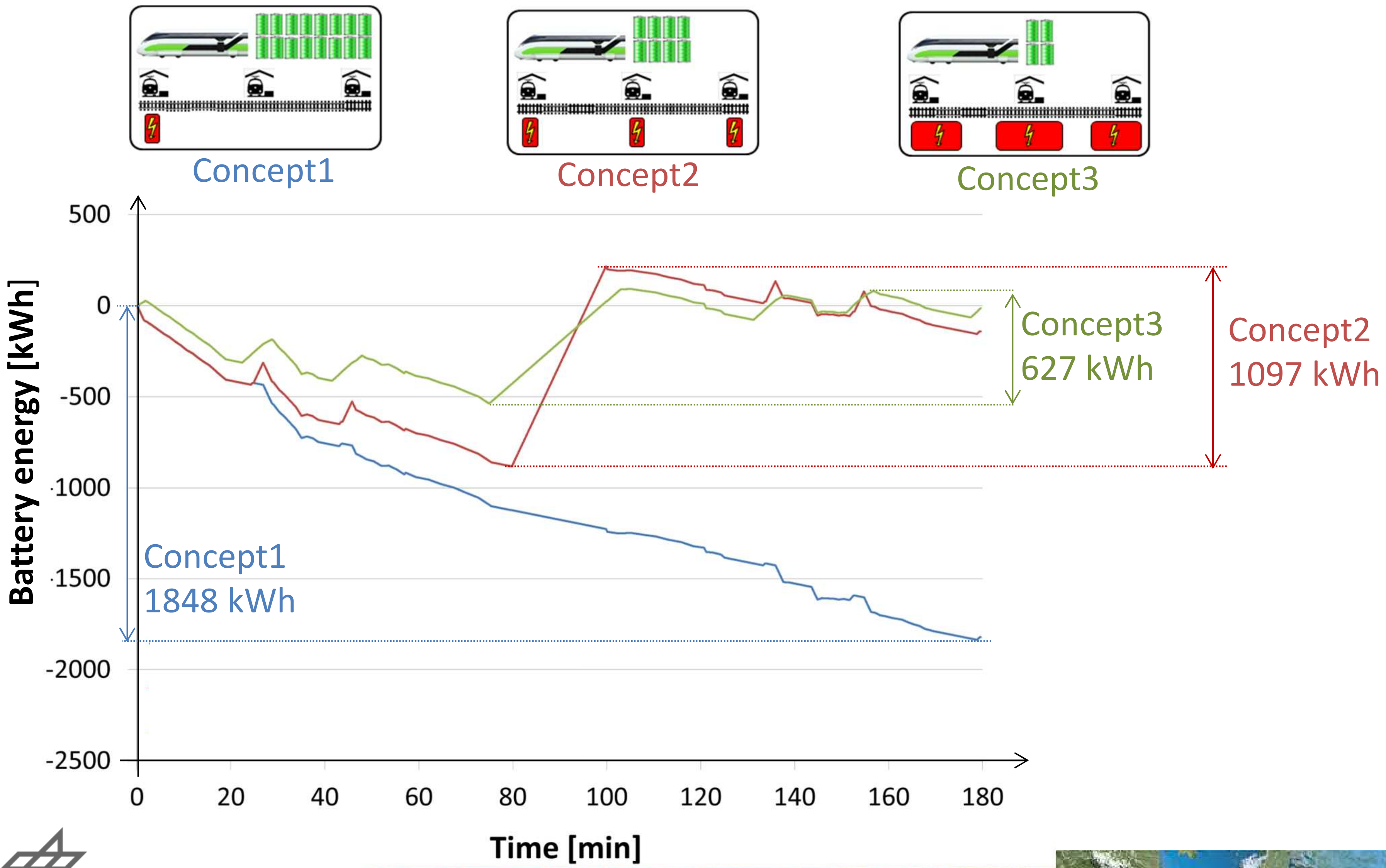
Use case NGT LINK: Battery energy trend



Conclusion

- The modular DLR propulsion concept aims at UIC goal for 2050 (-75% CO_2-emission)
- Hybrid traction concept is most flexible in terms of energy carrier, but high effort on board
- Battery propulsion with charging at terminal station (concept 1):
  - not viable for NGT LINK due to mass and volume restrictions
  - useful for tracks with short non-electrified sections
- Battery propulsion with static charging (concept 2): viable for NGT LINK, balanced effort between infrastructure and on board
- Dynamic charging (concept 3) reduces battery capacity and power, feasible for lines with high throughput

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DLR Projects related to Energy Management (extract)

Project	OLFET	SBB Study	BetHy / iLint	ÖBB-Hybrid	NGT LINK	SSB Study	AeroLiner 3000	C.L.E.A.N Diesel	FINE1
Client	DB		ALSTOM	ÖBB	DLR	SSB		BOMBARDIER the evolution of mobility	Shift2Rail
Energy supply		H_2	H_2						
Energy converter									
Energy storage									
Power transmission									
Energy management									
Thermal management									

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Thank you for your attention. Questions?

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Backup

External Energy Supply

Comparison of options for partial electrification

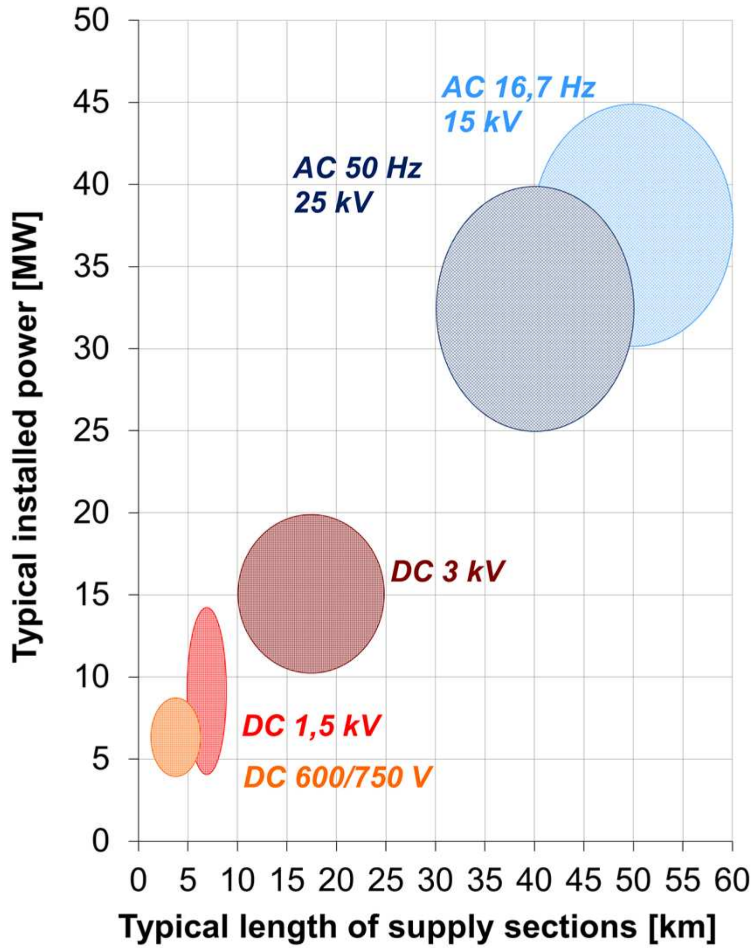
AC-systems:

- Long distances, high power
- High investment cost
- Typically fed by high voltage grid (110 kV)
- Max. power during standstill: 1200 kW [1]

DC-systems:

- Shorter distances, lower power
- Fed by medium voltage grid (10-30 kV)
- Max. power during standstill: 600 kW [1]

➔ **Pantograph limits fast charging – other options?**



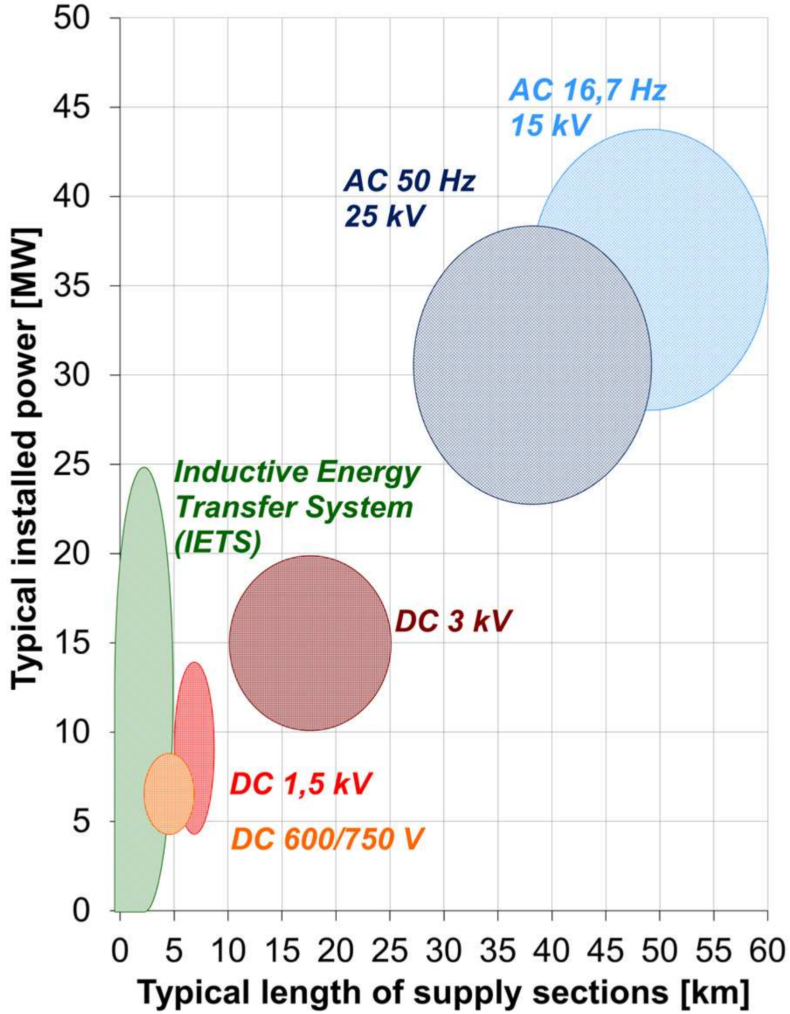
[1] DIN EN 50367 – Railway Applications – Current collection systems

External Energy Supply: Inductive Energy Transfer System

IETS satisfies conceptual requirements

Inductive energy transfer system (IETS):

- Flexible in power dimensioning
- Scalable length of electrified track
- Static and dynamic power transmission possible
- Fed by medium voltage grid (10-30 kV)



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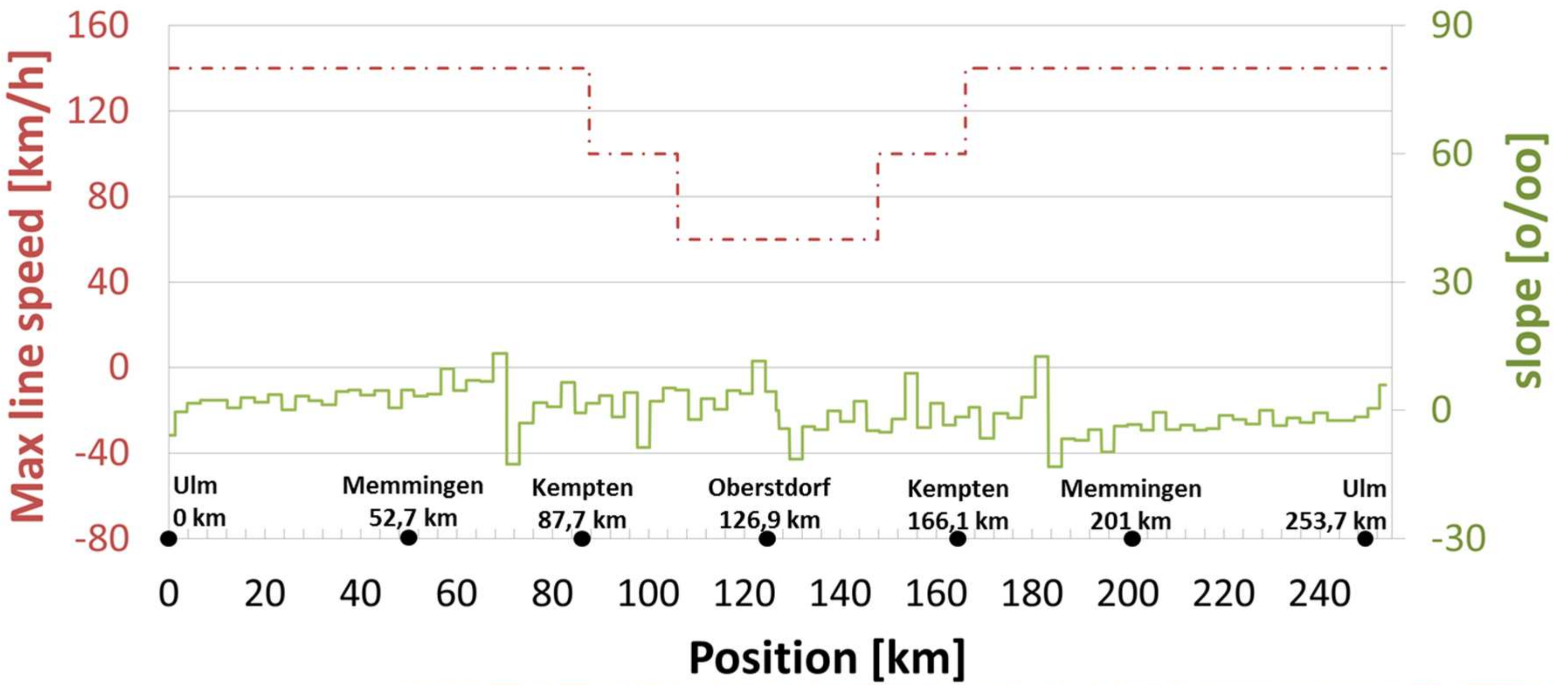
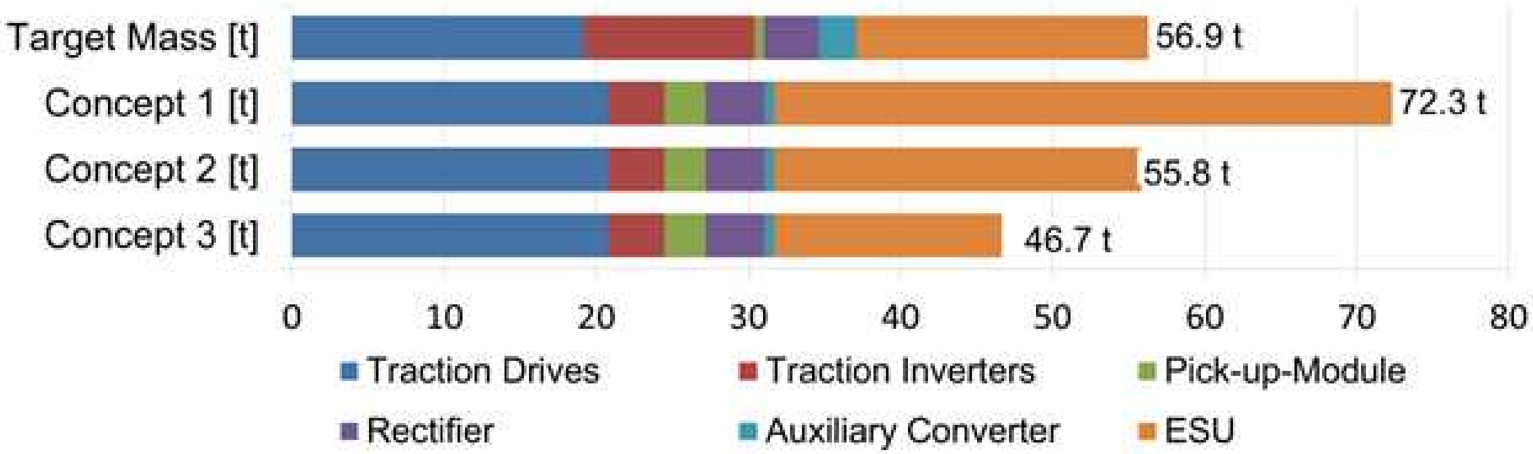
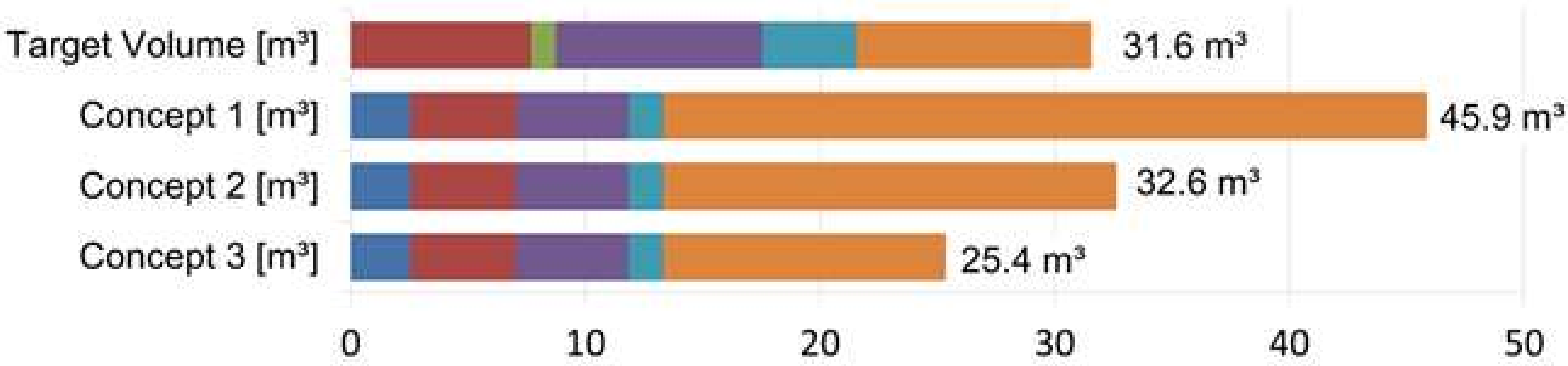
Use case NGT LINK: Reference scenario

- Round-trip on non electrified line Ulm - Oberstdorf (Germany)
- Intermediate stations Memmingen and Kempten
- Overall distance of roundtrip 254 km
- Stoppage time at turning station Oberstdorf: 20 minutes
- Aux power at intermediate circuit: 303 kW continuous (worst case)



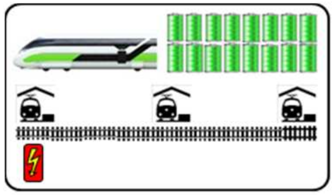
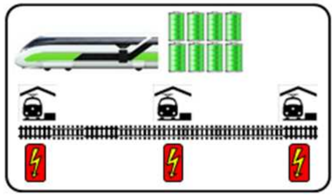
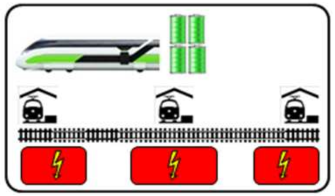
Propulsion concept dimensioning





- Concept 1 not viable due to mass and volume restrictions
- Other concepts are in accordance with the conceptual design

Use case NGT LINK: Battery characteristics

		 Concept1	 Concept2	 Concept3
Used battery capacity	kWh	1848	1097	627
DoD assumption	%	60	60	60
Installed battery capacity	kWh	3080	1828	1045
Discharge power	kW	3290	3290	1882
Charge power	kW	1797*	3290	1350
C-rate discharge	1/h	1.1	1.8	1.8
C-rate charge	1/h	0.6*	1.8	1.3

* No external charging during roundtrip, C-rate calculated from recuperation power