Future Traction Systems - from Vision to Reality

Creating Sustainable Value at Sustainable Cost

KTH Railway Group Seminar
Ganesh Chandramouli
Product Manager, Coordinator External R&D collaboration
Rolling Stock Equipment Division, Energy and Motion
Bombardier Transportation Sweden
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"Of how the future will unfold, the past floats in blissful ignorance”
- Christina, Queen of Sweden (1632 – 1654), written ca 1682

“Rail travel at high speed is not possible, because passengers, unable to breathe, would die of asphyxia.”
- Dr. Dionysius Lardner, professor of Natural Philosophy and Astronomy, 1823

Post card image depicting the world in 2000 created by J Villemard for the 1900 Paris World Exhibition
- Source Wikimedia Commons
Recent Railway Propulsion breakthroughs at BOMBARDIER

MITRAC 3 LAUNCHED – Propulsion solutions for the next decade

Future Performance Captured
- Energy efficiency
- Reduced cooling
- Increased power density

MITRAC 3 TC 1500

Modular Flexibility
- Car
- Bogie
- Single Axle
- ASM / PMSM

Customer Value Achieved

R&D – in partnership
SiC Converter in Stockholm MOVIA Metro 2018
- 34% propulsion losses
- 22% size
- 51% weight
- 19 dB noise

GreenSiCtrac Demo

Battery power in TALENT EMU 2018
100 km range, 7-8 min recharge

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Is there a need for new Propulsion Technologies?
MEGATREND perspectives

Extrapolated Mega Trends
- Population Growth
- Urbanization
- Digitization & Connectivity
- Climate Change

Railway Impact
- Higher Capacity
- Higher Availability
- Improved Intermodality

Propulsion Design Parameters
- Performance
- Integration
- Availability
- Infrastructure
- Maintenance
# Propulsion Technology Evolution

## Possibilities and Impact

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**Railway Impact**

- Higher Capacity
- Higher Availability
- Improved Intermodality
Trade-offs in Powertrain Innovation

**BOTTLENECKS**

- Raw material cost (Battery, PM)
- Processing cost (SiC)
- Safety and Security
- Reliability
- Market Acceptance

**INVENTION**

- Digitization
- Package
- SiC
- PM
- Battery

**TECHNOLOGY**

- Multilevel MF
- Performance
- Efficiency
- Size/Weight
- Reliability
- Cost

**ECONOMY**

- Benefit

**INNOVATION**

- Commercial maturity
- Technical maturity

**ENABLERS**

- Energy Cost increase
- Combined technologies
- Business Model Innovation
- Standards Innovation
- Inter-Industrial Collaboration
What would drive the choice of Technologies?
Dealing with Uncertainty – Evaluating Outcomes?

Extrapolated Mega Trends

Population Growth
Urbanization
Digitization & Connectivity
Climate Change

Uncertain Trend Scenarios

Scenario I
- Low First Cost
- Medium TCO
- Standardized Products
- Global Manufacturing
- Global Standard Service

Scenario II
- Medium First Cost
- Low TCO
- Modular Products
- Global Manufacturing
- Mobility as a Service

Scenario III
- High First Cost
- Medium TCO
- Customized Products
- Multi-Local Manufacture
- Cross-Border Service

Scenario IV
- Low First Cost
- High TCO
- Modular Products
- Multi-Local Manufacture
- Local Service

Evaluation – Axis of Sustainability
(reduced environmental footprint)

Globalization
Servitization
Commoditization
Protectionism

Value
Cost

• Higher Capacity
• Higher Availability
• Improved Intermodality
Technology Applications?
Scenario examples – choices still abound

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Evaluation – Axis of Sustainability
(reduced environmental footprint)

- Value
- Cost

Scenarios
- Globalization
- Commoditization
- Servitization
- Protectionism

Device
- SiC IGBT

SiC MOSFET

Package

Motor

Battery

Topology
- Multilevel MF
- AC

Digitization
- Assisted Reluctance
- PM energy efficient
- PM few driven axles
- Digitized Manufacture
- Digitized Service and Manufacture
- Virtual Homologation
- Virtual Arrangement

Battery
- SiC MOSFET

Motor
- Assisted Reluctance

Topology
- Multilevel MF

Digitization
- Virtual Homologation

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Choosing Sustainable Value at Sustainable Cost

What do we want to achieve together and how soon?

If our end goal is sustainability at an attractive cost we can influence this outcome in most scenarios by innovative Business Models, Standards and Collaboration. Technology innovation will follow.

**Areas of Influence**

**Business Models**
- Buying models considering Energy Cost and Emissions?
- Data sharing, ownership and security models?

**Standards**
- Service Life << 30 years?
- Noise emission levels?
- Virtual Homologation?

**Combined Technologies**
- SiC + Digitized optimization ➔ Less PM /Battery Cost ➔ High SiC volumes ➔ Less SiC Cost

**Inter-Industrial Collaboration**
- Road e-mobility + Rail + Telecom
- Intermodality & Railway supersystem
- Rolling Stock Owner + Operator + OEM + Infrastructure Owner

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**Influence Outcomes – Axis of Sustainability**
(reduced environmental footprint)

**Value**

**Cost**
"The future's not set. There's no fate but what we make for ourselves."

Questions & answers
Thank you very much!

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