



Through the looking glass and crystal boule

- power electronic collaboration for electrified mobility

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Power Electronics Day, Stockholm
May 16, 2024

A Swedish dream?

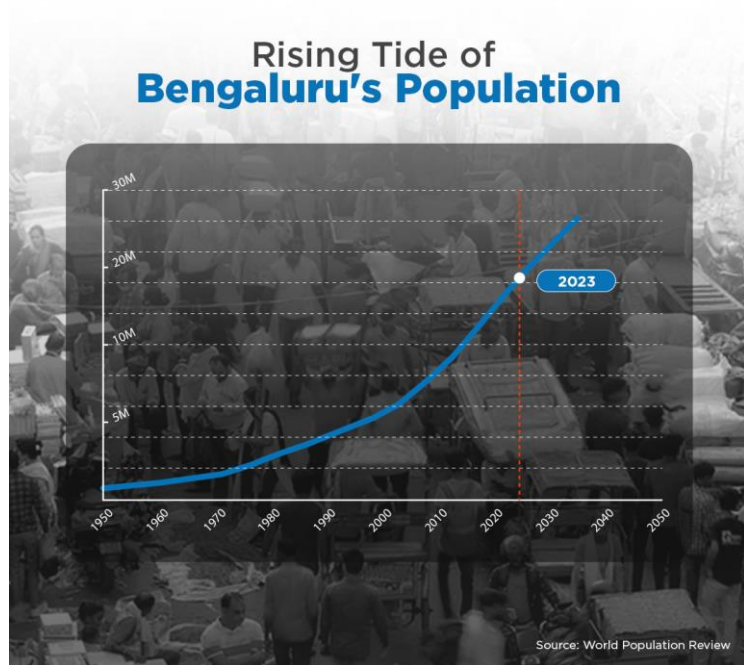


Source: Sweco, 15 minute city

and a very global reality



A reasonable prediction for transport



+ 28 %¹

2040



+ 300 %²



+ 43 %¹

+ 300 %²



+ 1,7 % / year²

Today transportation represents 25%⁴ of global greenhouse gas emissions

1) <http://trafikverket.diva-portal.org/smash/get/diva2:1615338/FULLTEXT01.pdf>

2) <https://doi.org/10.1016/j.trip.2024.101016>

3) <https://ec.europa.eu/assets/epsc/pages/espas/chapter1.html>

4) https://www.un.org/sites/un2.un.org/files/media_gstc/FACT_SHE_ET_Climate_Change.pdf

Are we picking the right mode of transport?

+ 18 %

50 000 people / h

4 M tCO₂e* / year

2 100 – 9 000 people / h

850 M tCO₂e* / year

+ 1 % point

Passenger km

Modal share

EU27 passenger rail transport evolution 2007 - 2018



Why not choose rail?



49%



33%



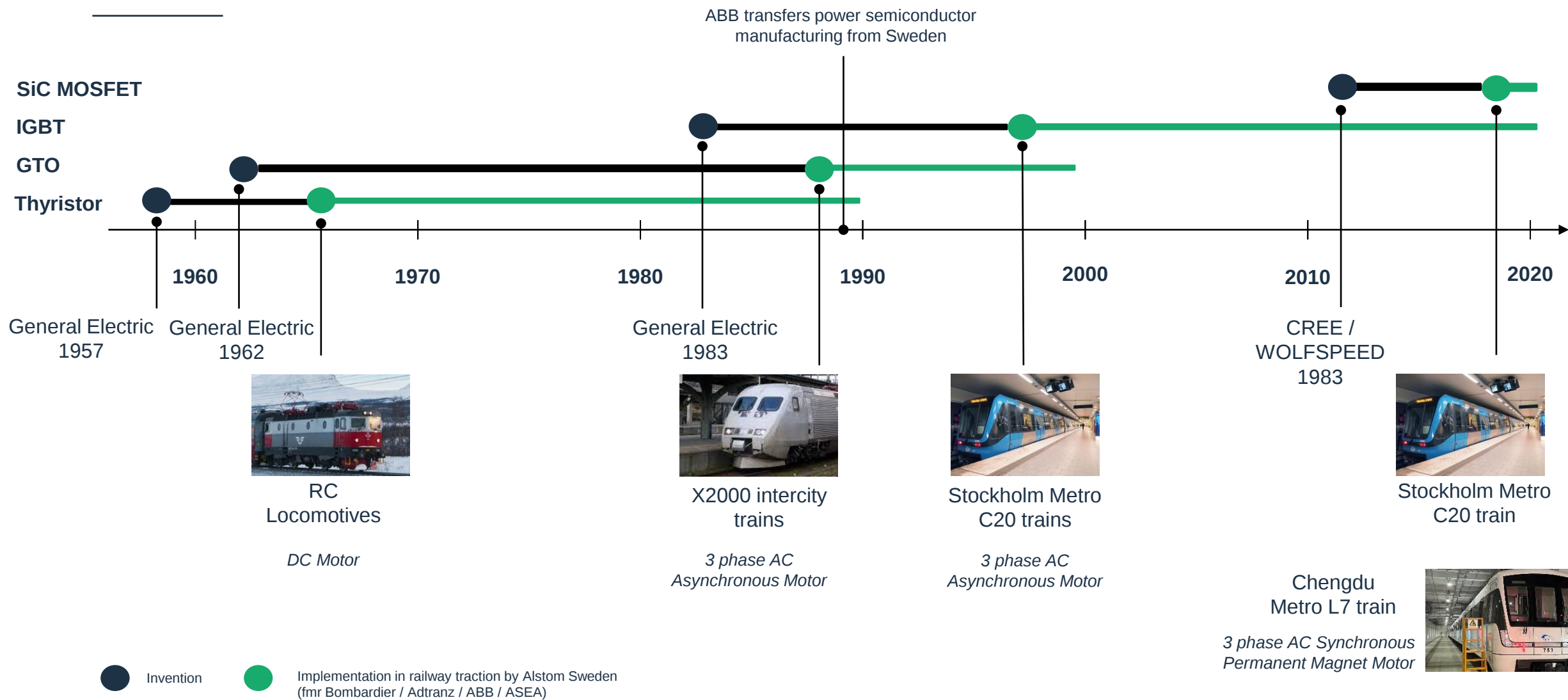
32%



Through the looking glass

Power electronics and rail mobility

Power semiconductors and railway traction systems at Alstom Sweden



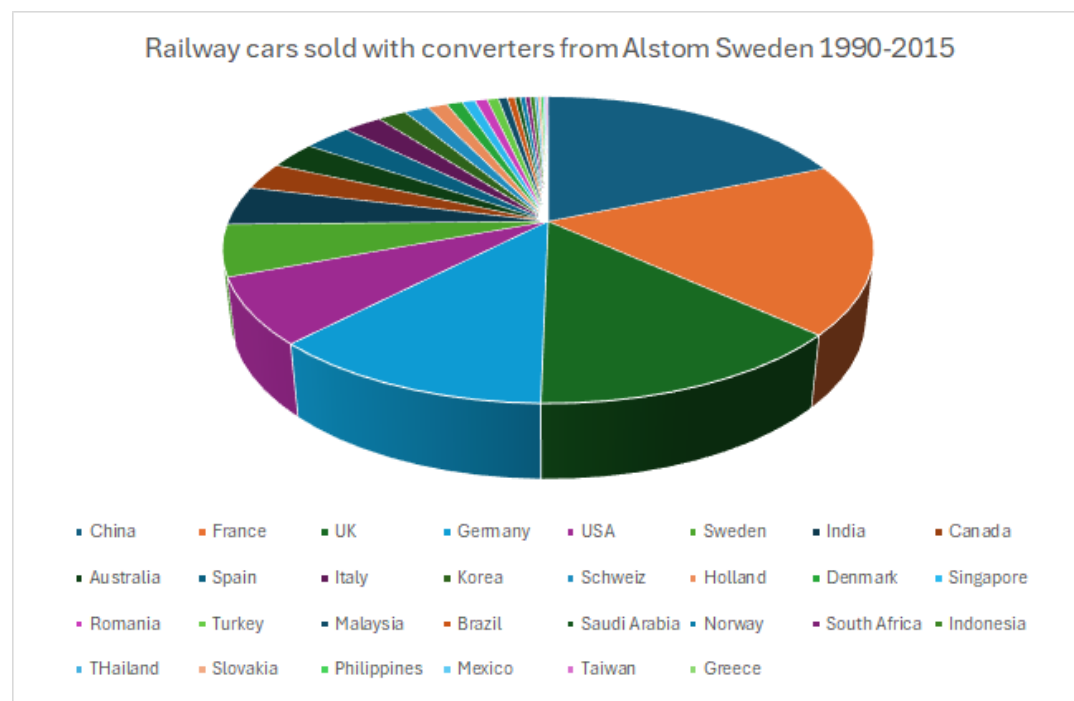
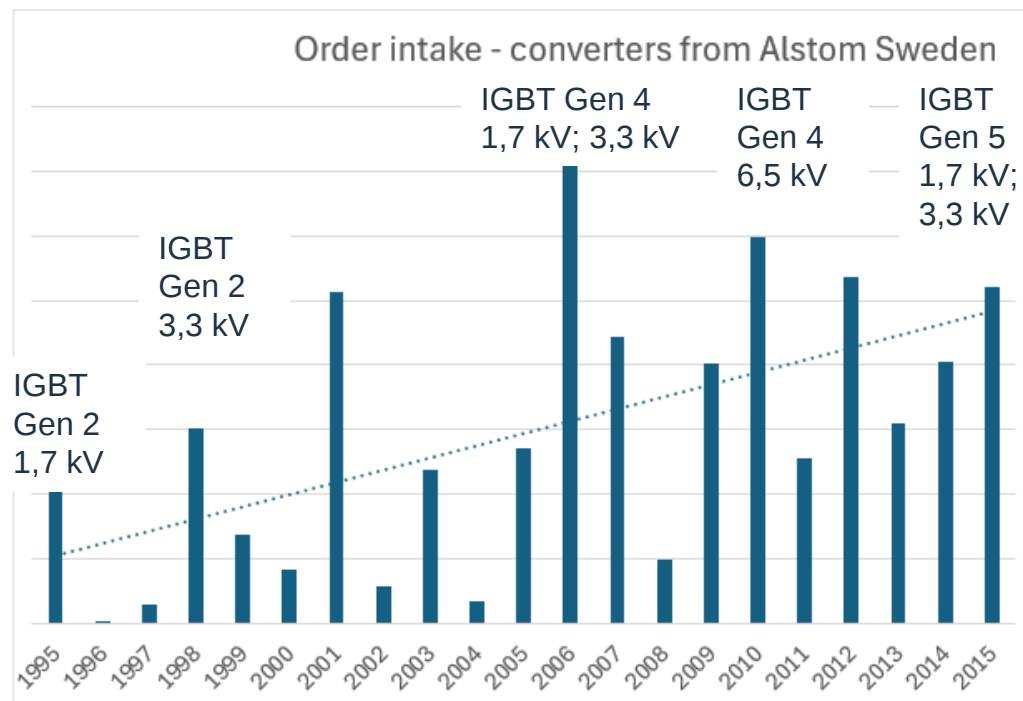
Alstom Sweden Product Range 2012



	LRV	Metro	Regional / Commuter	Intercity HS, VHS	Loco
References (selection)	Stockholm A32 Pittsburgh	Shanghai L1,7,9,12; Beijing L4,12,14,16; Shenzen; Madrid S3000,8000; Delhi RS2; Bangkok; New York, R179; Mexico City; Sao Paolo; Toronto; Adelaide; Singapore DTL,R151; Mekkah; London SSL, VLU; Stockholm C20, C30; Agra-Kanpur	SNCF AGC, AGC BEMU, Ile de Franc, Regio 2N; Talent II (DB and private); DB BR422,423,430,490; Do2010; Gauteng; Queensland; Mumbai MRVC II; Crossrail, LoTrain, CL379 BEMU; New Jersey; Delhi-Meerut RRTS	SJ X55; CRH1; CRH380D; Frecciarossa ETR400; ILSA; Västtrafik	Quishuyan
Systems	750VDC Traction, Auxiliary	750VDC, 1500VDC, 25kVAC Traction, Auxiliary	750VDC, 1500VDC, 15kVAC, 25kVAC, Diesel-Electric, Battery Propulsion Traction, Auxiliary	750VDC, 1500VDC, 3000VDC, 15kVAC, 25kVAC Traction, Auxiliary	25kVAC Traction, Auxiliary
Key Technologies	Asynchronous motors, Si IGBT	Asynchronous motors, PM-motors, Si IGBT, SiC MOSFET	Asynchronous motors, PM-motors, Si IGBT, Battery propulsion, 2nd harmonic filterless	Asynchronous motors, Si IGBT	Asynchronous motors, Si IGBT

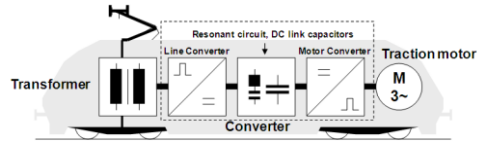
Converter families	TC1400, AU1400 Standalone Underfloor / Roof				
		TC1100 Module Based Underfloor			
			TC1200, Module Based Roof		
			TC1300 Machine Room		TC1300

Developing and delivering IGBT based railway traction from Sweden



Growth without domestic power semiconductor manufacturing

Development of Alstom's latest generation traction platform



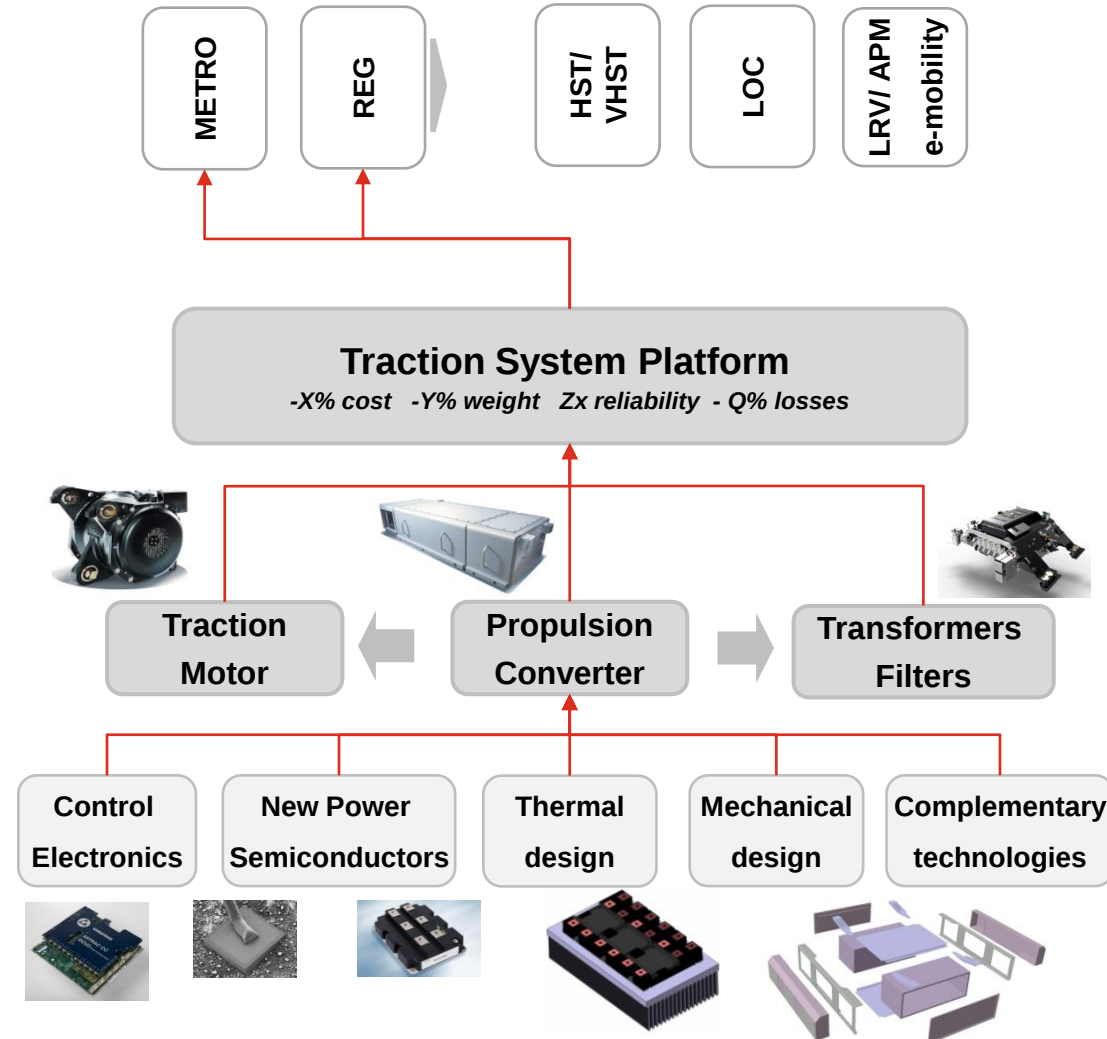
Re-balance

Re-structure

Re-modularize

Re-design

Re-invent



Vehicle

System

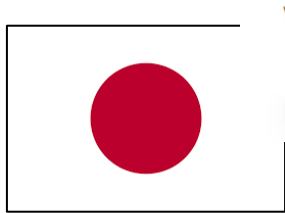
Product

Technology

SiC technology development status in 2012



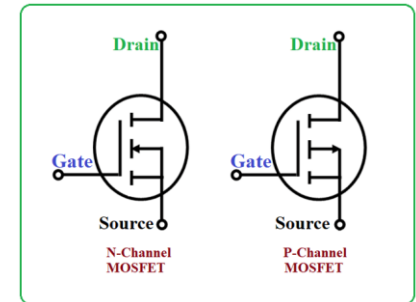
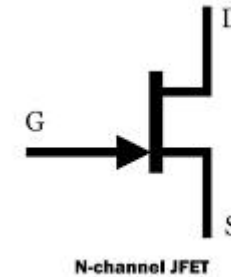
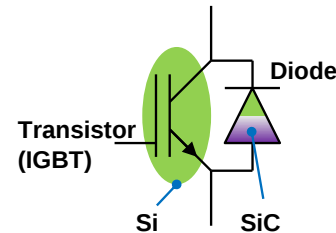
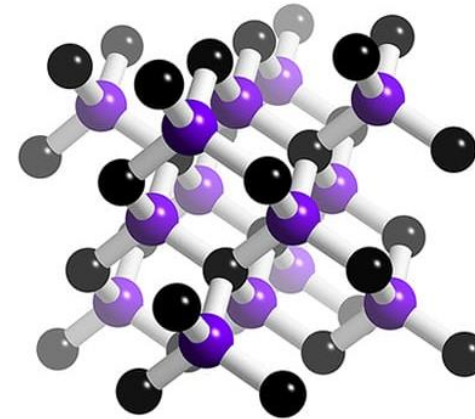
~ 2000



2009 ~ 2015



2012



Europe 2012 - left to our own divisive devices?

Collaboration for electric traction innovation 2010 - 2020

grönatåget



GreenSiCtrac Demo



VINNOVA
Sweden's Innovation Agency



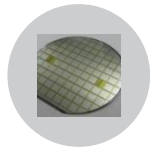
Sector specific collaboration on applied power electronics

MITRAC TC1500 - Harnessing the power of power electronics

A holistic powertrain approach



New semiconductor packaging



New semiconductor devices



New control architecture



System trade-offs



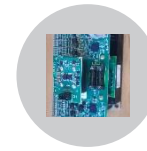
System architectures



Modular mindset



Innovative control functions



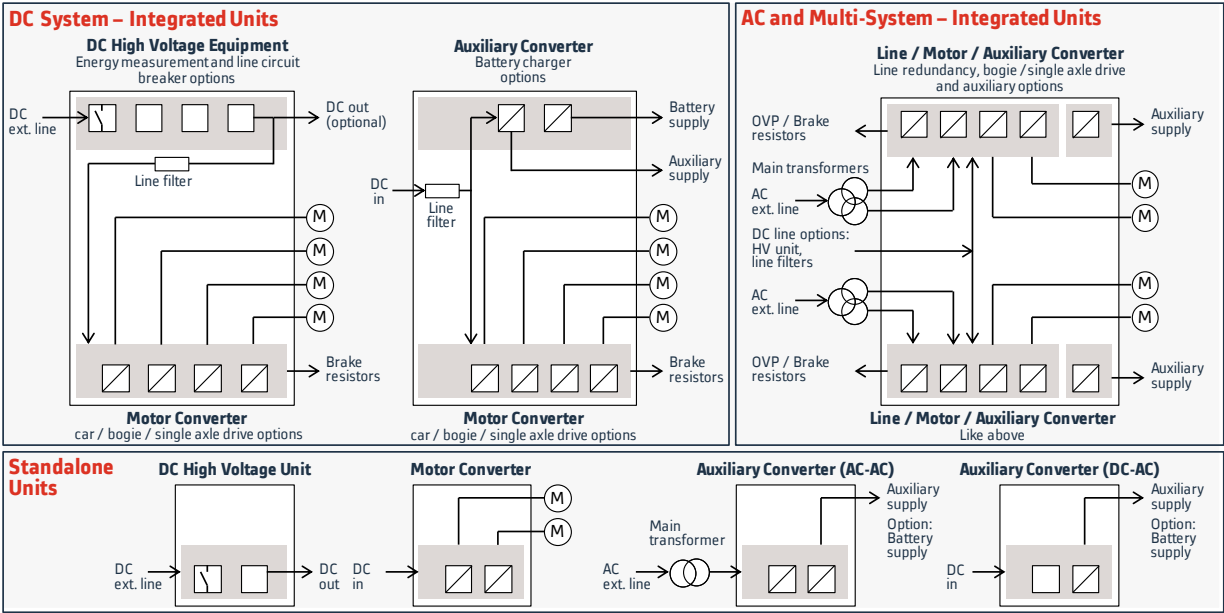
Intelligent gate drive

One common modular platform – full range from Metros – Intercity trains

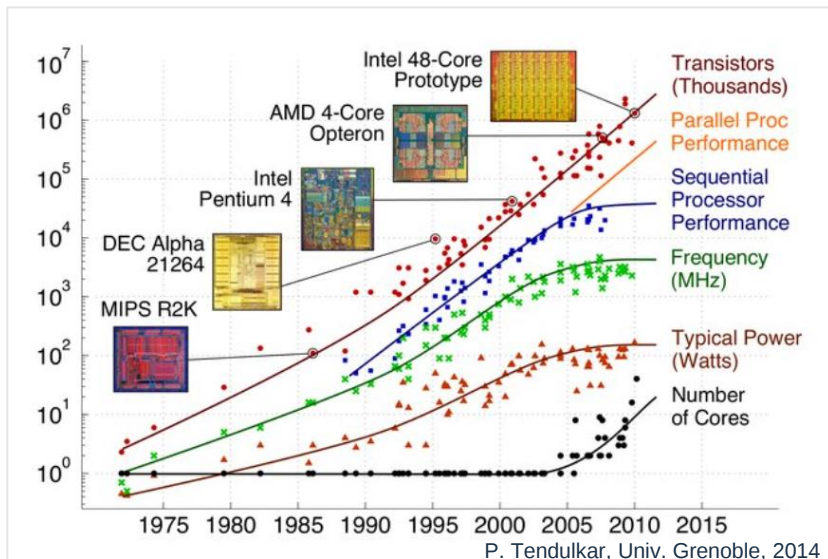
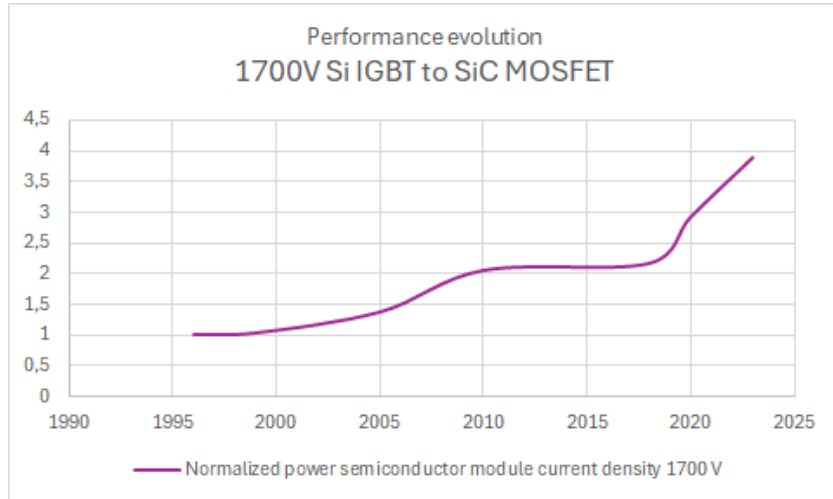
MITRAC TC1500 modular traction platform



	Metro	Mainline - Regional / Commuter / Intercity
Supply Voltages	750VDC, 1500VDC, 25kVAC	750VDC, 1500VDC, 15kVAC, 25kVAC
Functions	Traction, Auxiliary, Single-/Dual-/Multi-system supply	Traction, Auxiliary, Single-/Dual-/Multi-system supply including Battery / Hydrogen traction
Drive configurations	Car Drive, Bogie Drive, Single Axle Drive	
Motor types	Asynchronous, PM Synchronous	
Cooling methods	Forced Air, Car Motion Air	
Power semiconductor types	Si IGBT, SiC MOSFET	
Unique innovations	2nd harmonic filterless, Sensorless	



Through the looking glass



POWER ELECTRONICS



CPUs

"Well, in our country," said Alice, still panting a little, "you'd generally get to somewhere else—if you run very fast for a long time, as we've been doing."

"A slow sort of country!" said the Queen. "Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"



Through the crystal boule

Power electronics and ALL
mobility

E-mobility collaboration

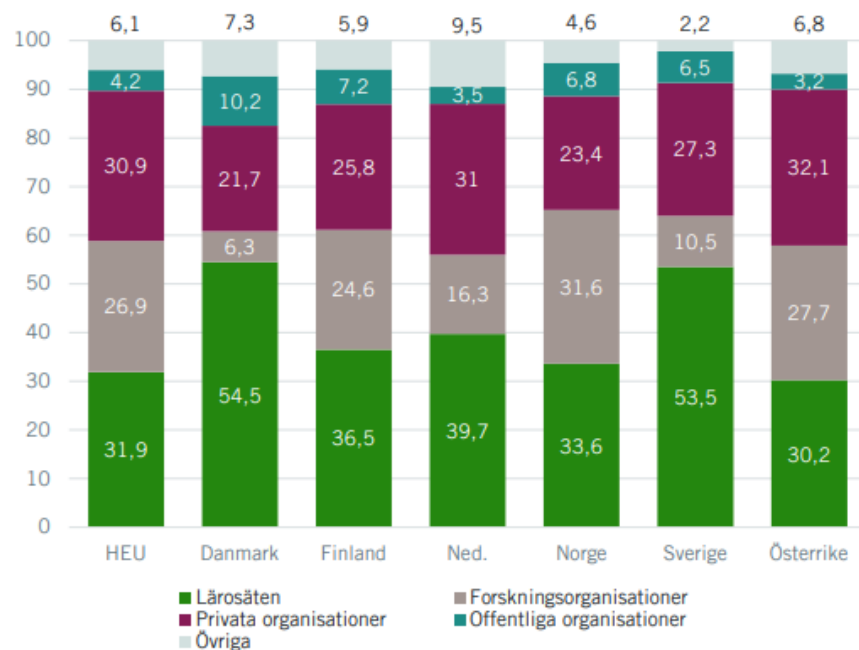


Cross sector collaboration

Is Swedish public funding helping us to get where we need to fast enough?

What OECD recommends Sweden to do

Figur 3: Beviljad EU-nettofinansiering per organisationstyp i procent av varje lands totala finansiering samt för hela ramprogrammet Horisont Europa.



Källa: Europeiska kommissionen, Funding & tender opportunities, Dashboard, 8 februari 2023

- "...seek to establish an overarching national vision and strategy for research and innovation..."
- "...not overly successful in securing EU Framework research funding..."
- "...give further consideration to how their different funding programmes align with each other to address shared priorities..."
- "Unexploited opportunity for the national research funding agencies to play a leadership role at a European level."
- "Opportunities not only to influence the European research agenda but also to use this agenda to help give direction to national research funding..."

Source: PUBLIC RESEARCH FUNDING IN SWEDEN OPTIMISING THE SYSTEM IN RESPONSE TO MULTIPLE DEMANDS, OECD May 2023

Curiouser and curiouser!

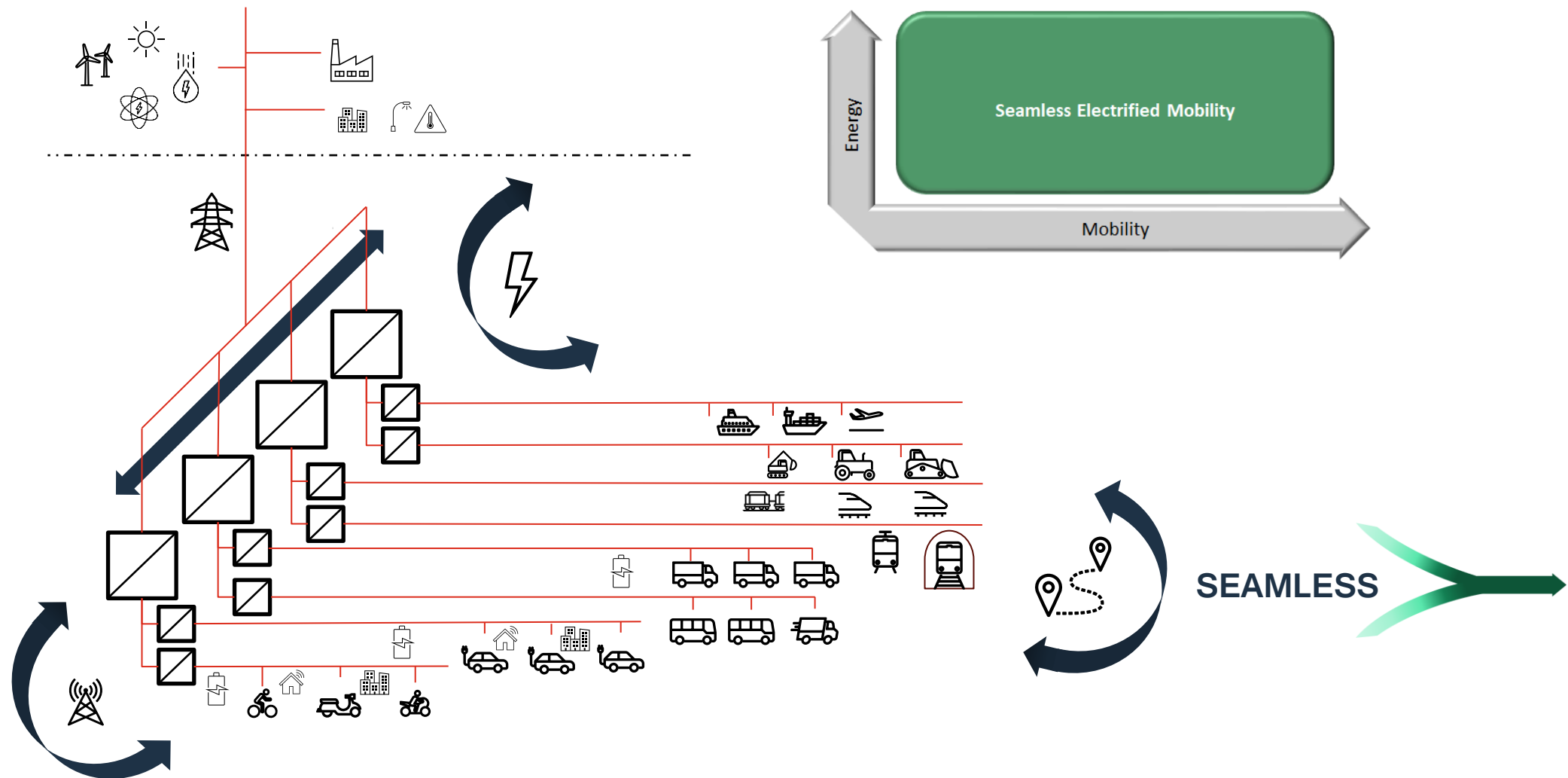


- Would you tell me, please, which way I ought to go from here?
- That depends a good deal on where you want to get to.
- I don't much care where.
- Then it doesn't much matter which way you go.
- ...So long as I get somewhere.
- Oh, you're sure to do that, if only you walk long enough."

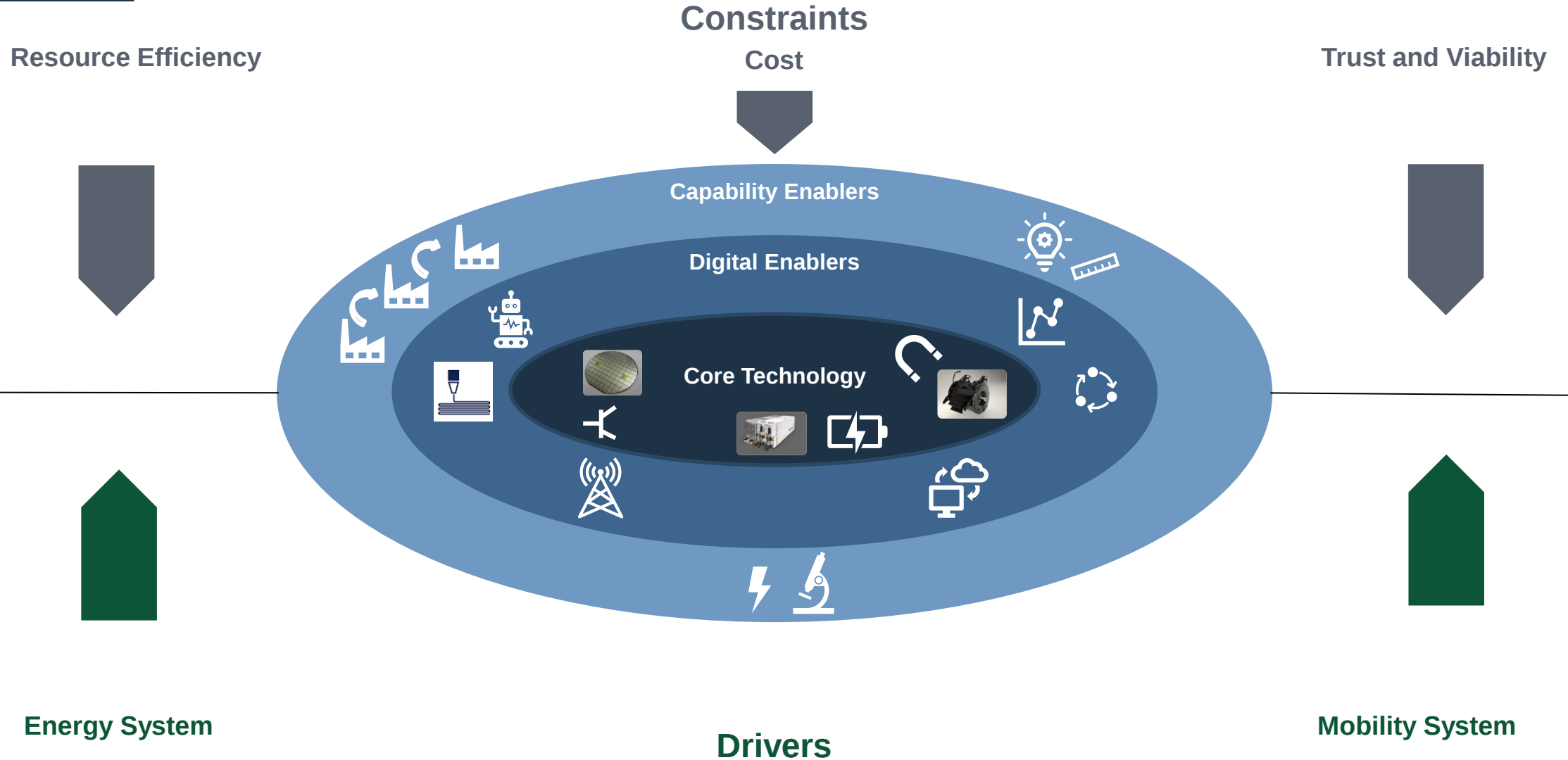
Perhaps we could set a direction?

SEAMLESS Electrified Mobility

Achieving impact

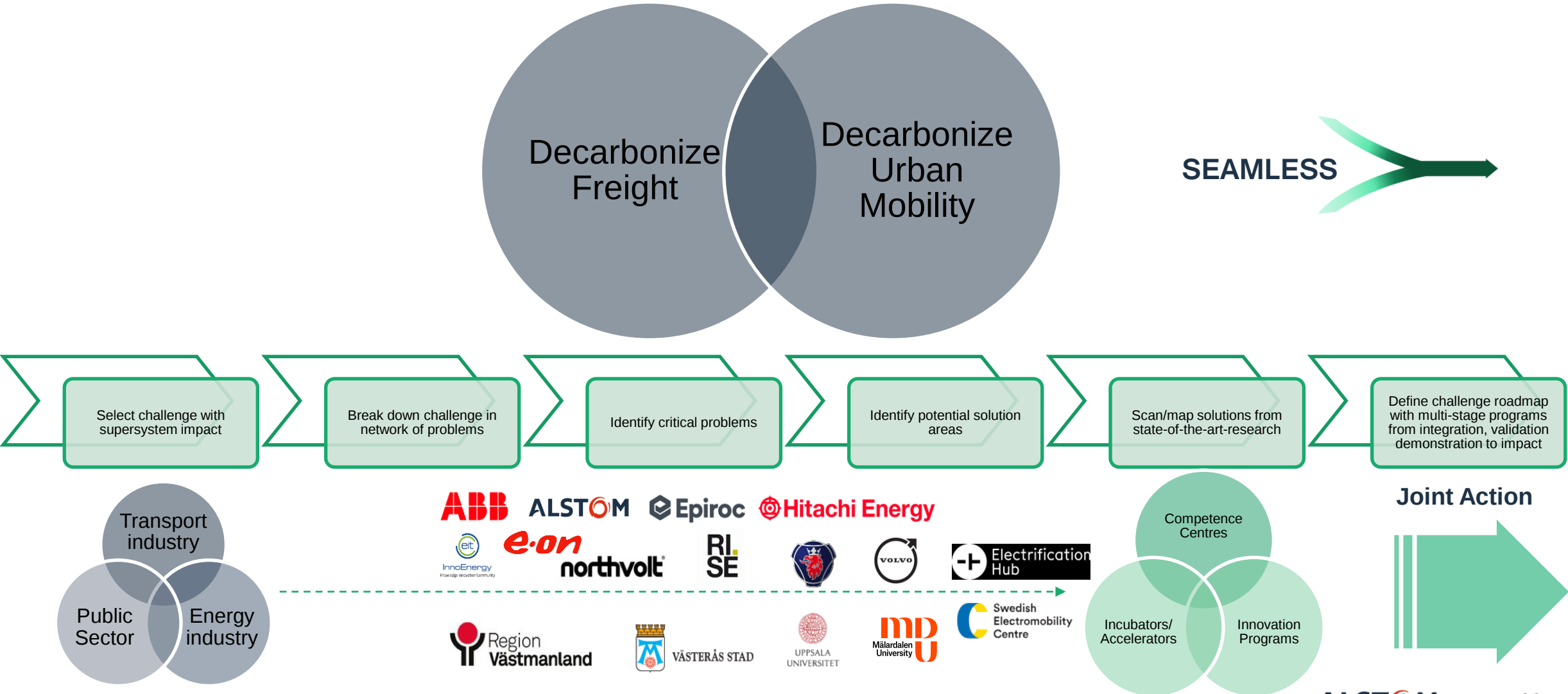


Technologies, drivers and constraints for seamless electrified mobility

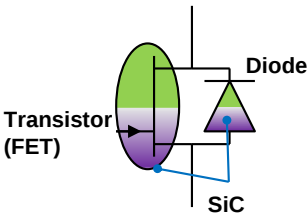
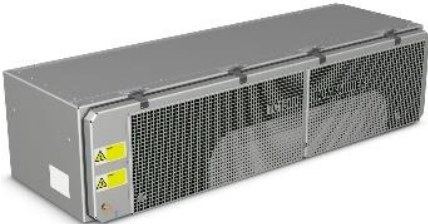
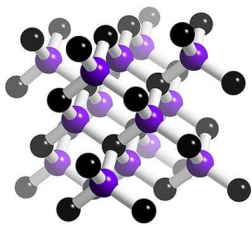
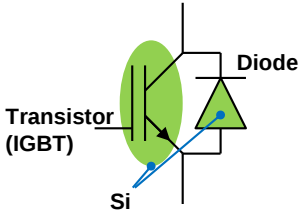


SEAMLESS Electrified Mobility

From challenge to solution space and implementation

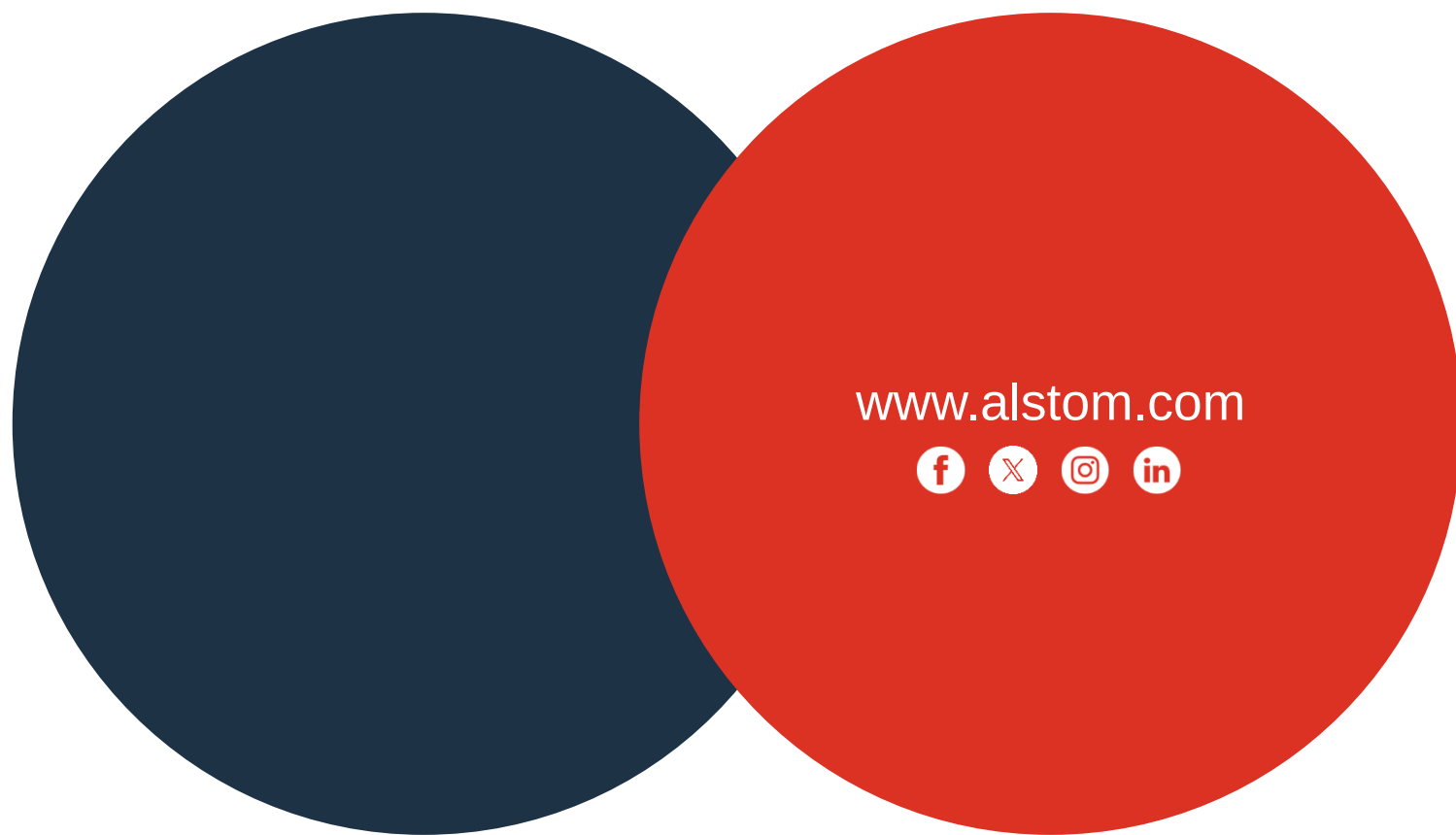


Global inspiration - Swedish innovation - Global impact



Wake up Alice, please wake up!





ALSTOM
• mobility by nature •