Device Performance

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INNOVATIVE TOOLS FOR OFFSHORE WIND AND DC GRIDS

Performance of outdoor insulation under HVDC stress

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The UK Energy Transition

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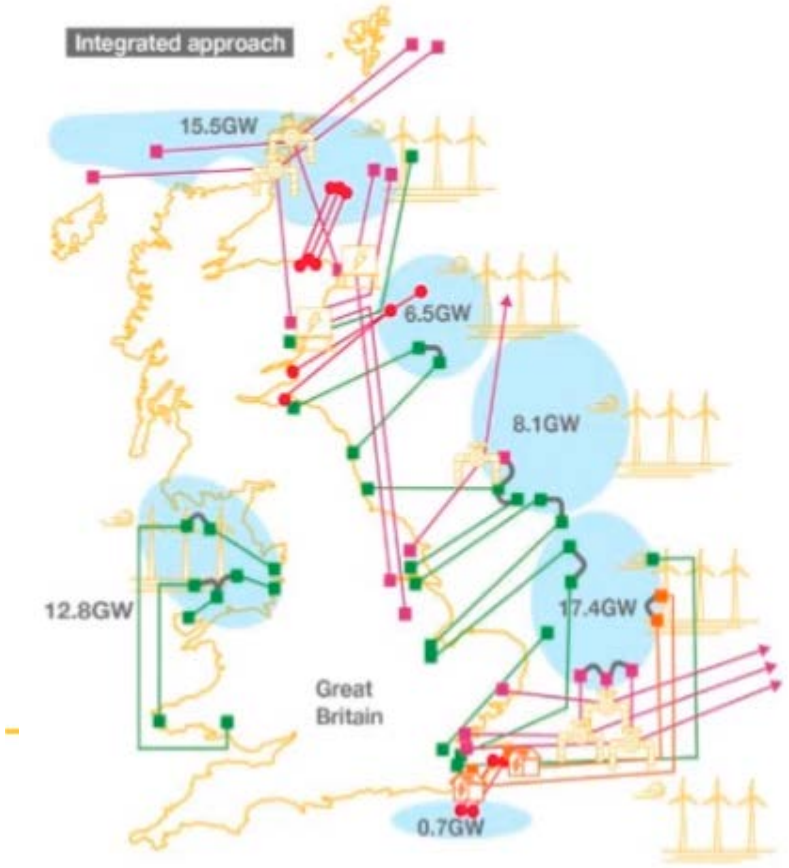
Boris Johnson: Wind farms could power every home by 2030

6 October



Key

- High Voltage Direct Current point-to-point Link
- High Voltage Alternating Current point-to-point Link
- Multiple windfarms
- HVDC multi-terminal
- Meshed HVDC substation
- HVDC island switching station
- HVAC interlink
- HVDC multi-pupose interconnector
- Onshore HVDC switching station
- OWF connection to existing HVDC converter station

Lines demonstrate the number of links, not the number of individual cables. Some of the links shown may be formed by a number of cables.

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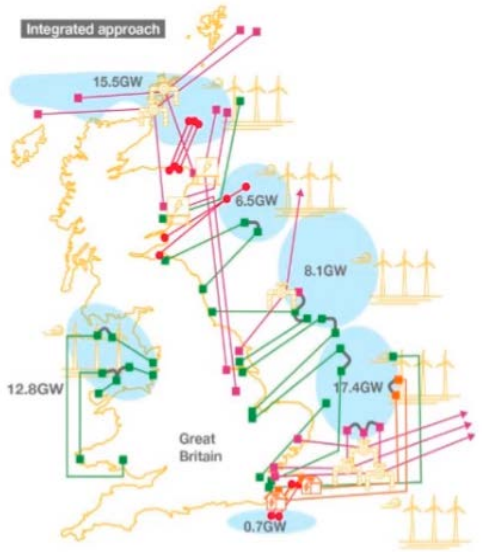
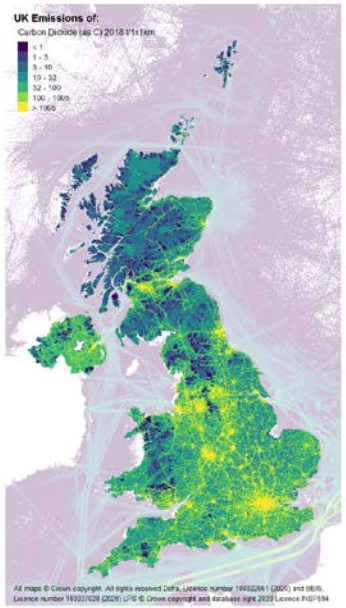
The Onshore Grid

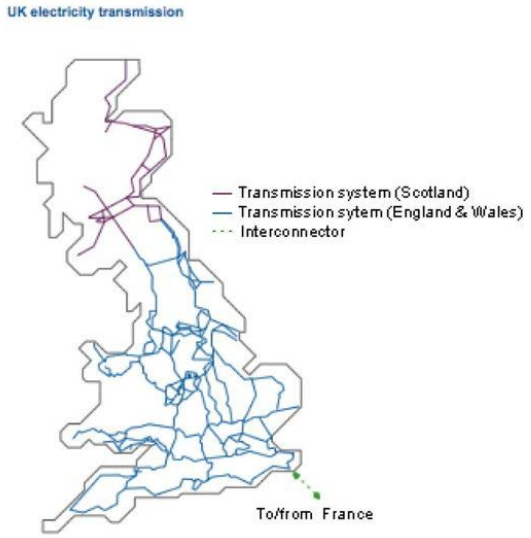
if: ...



2050 offshore wind target
83 GW



(CO2 emissions)
Electricity consumption



Current UK HV Grid

then: ...

?

2050 UK Grid

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Increasing the Grid Transmission Capacity

Increase power transmission

- New lines
- Uprating AC voltage
- HVDC conversion

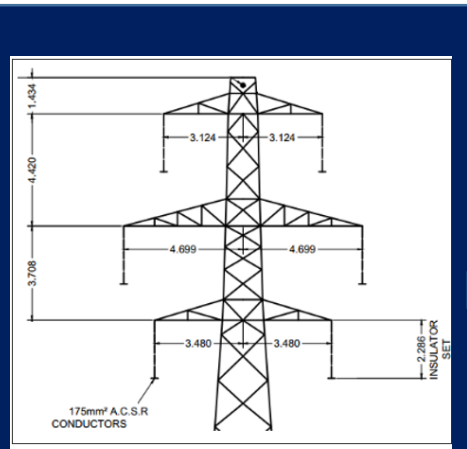

Figure 1. Original HVAC energized Line

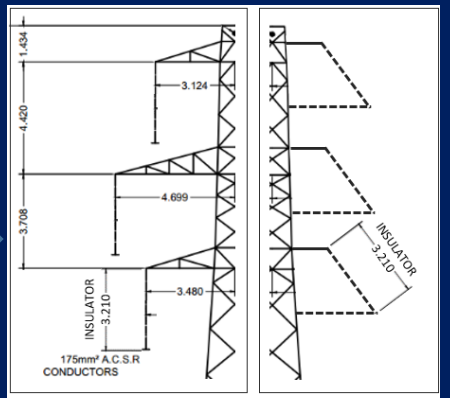

Figure 2. Two HVDC Line options: suspension and Cross Arm insulators.

D. Pinzan, M. E. A. Slama, O. Cwikowski, and M. A. Haddad, “Insulation Solutions for HVAC to HVDC Conversion of a High Voltage Transmission Overhead Line: the L7 Tower Case Study,” Budapest, Hungary, Accessed: Oct. 27, 2019.

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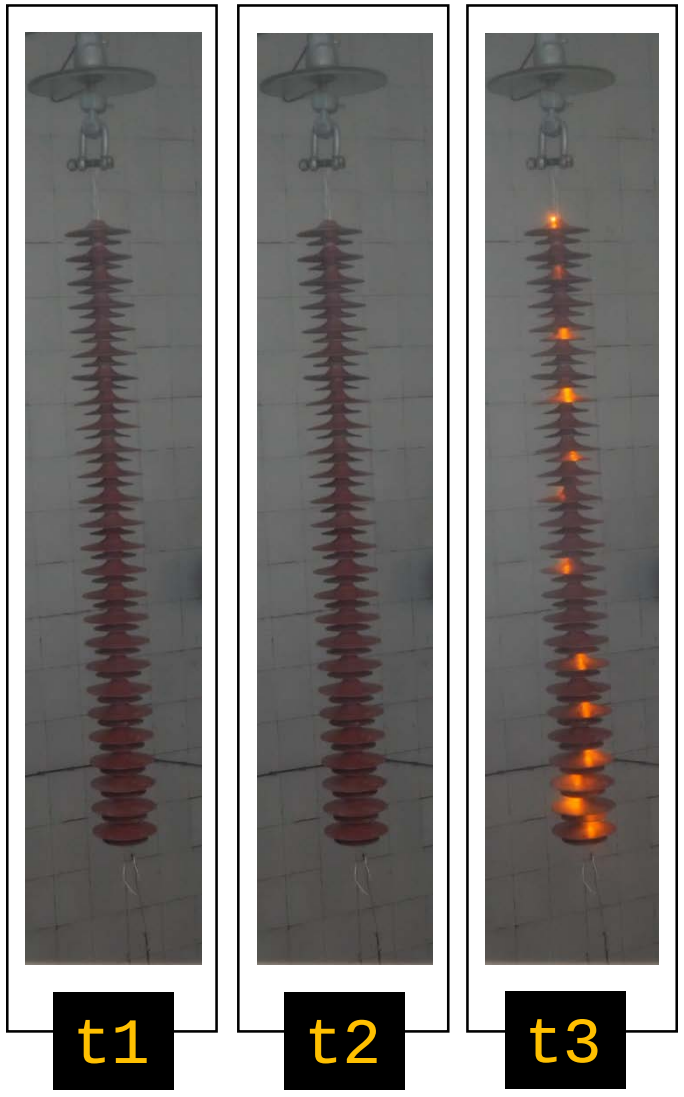
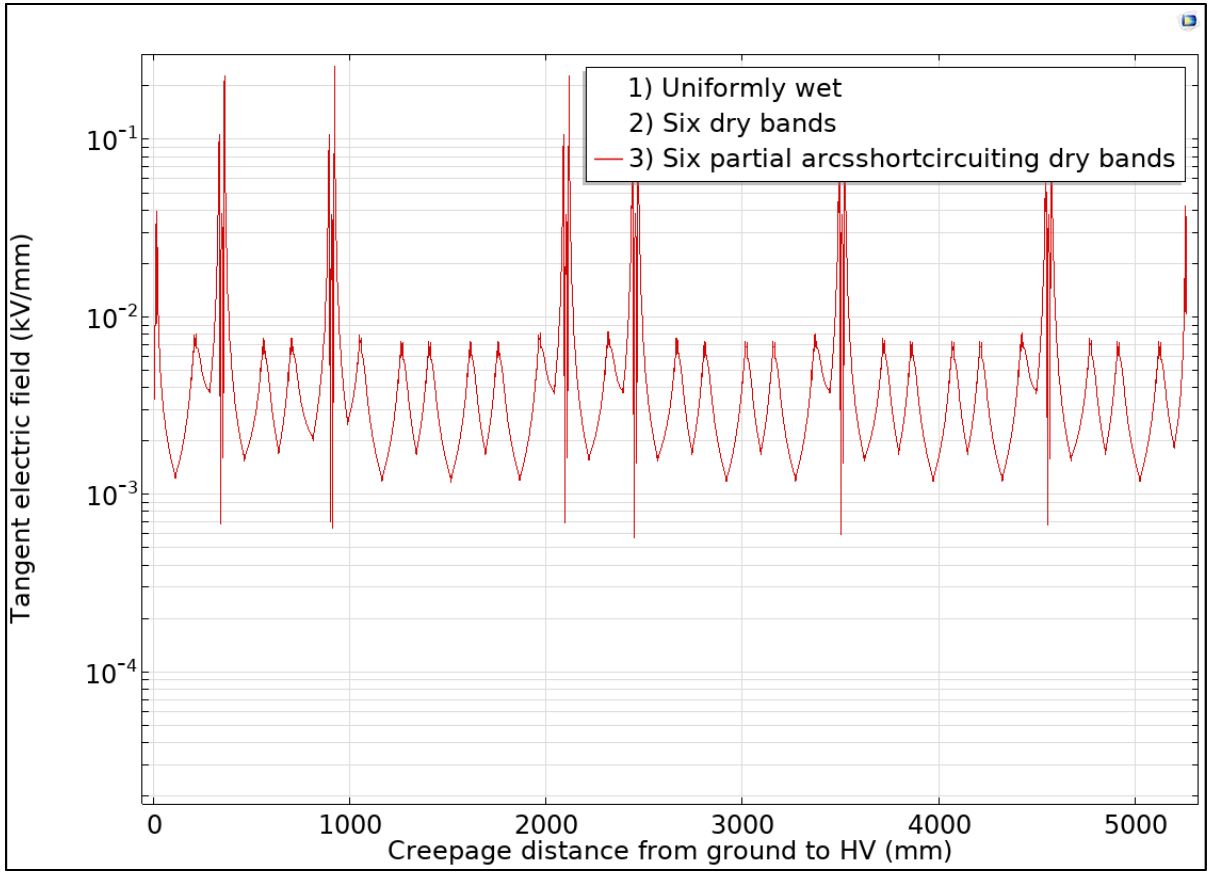
Testing and Modelling HVDC Insulators





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What is it like to become an engineer?

- Short term (9 years now for me!)
- But a long term exciting life…

A **lot** of painful studying

International meetings

Lab testing

Engaging with kids

Visiting testing sites

Group brainstorming

Building relationships

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Characterisation and Modelling of Compound Semiconductors in Power electronics

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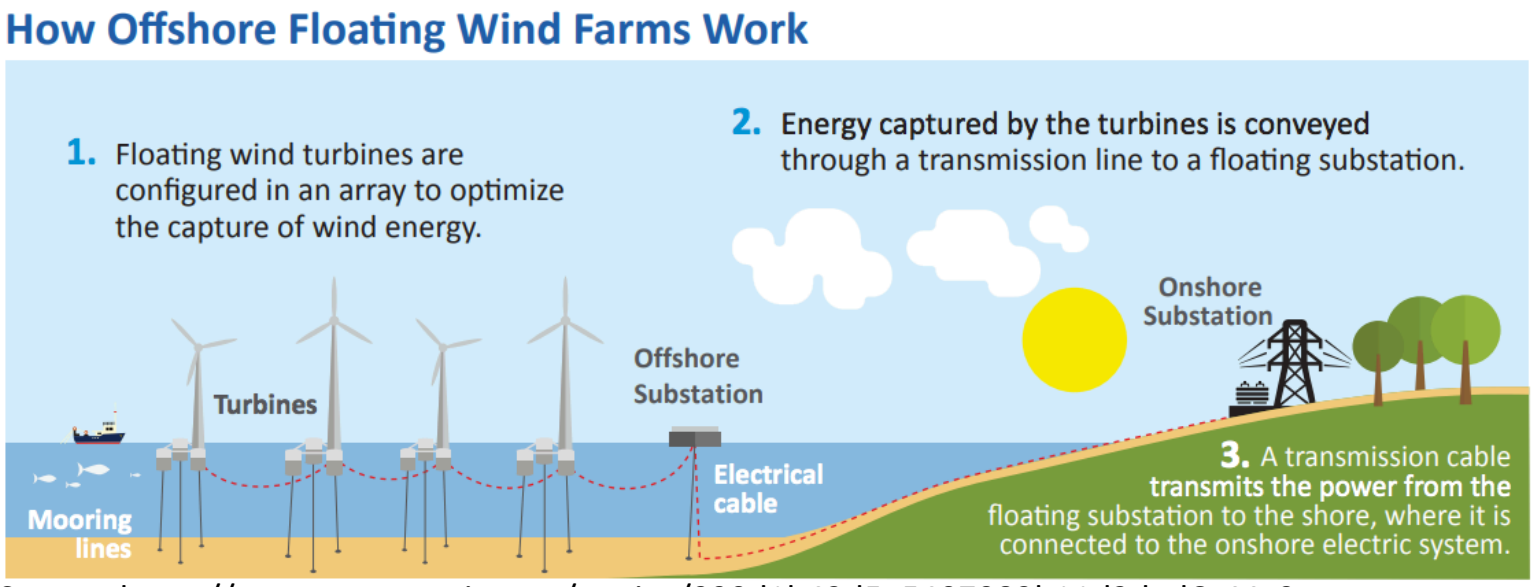
Onshore and offshore substations



Source: https://storymaps.arcgis.com/stories/990d1b42d5a5407083b11d3ded6c44c0

- Onshore substation: $47000\ m^2$
- Offshore substation: $400\ m^2$
- Power electronics converter in offshore substation should be smaller but with the same power rating.
- High power density converters
  - Power density = $\frac{Power}{Volumn}\ kW/L$

Offshore substation: $400\ m^2$

Source: https://www.windpowerengineering.com/making-modern-offshore-substation/#:~:text=With%20an%20area%20of%20around,foundations%20driven%20into%20the%20seabed.

Onshore substation: $47000\ m^2$

Source: ttps://www.tritonknoll.co.uk/onshore-sub/

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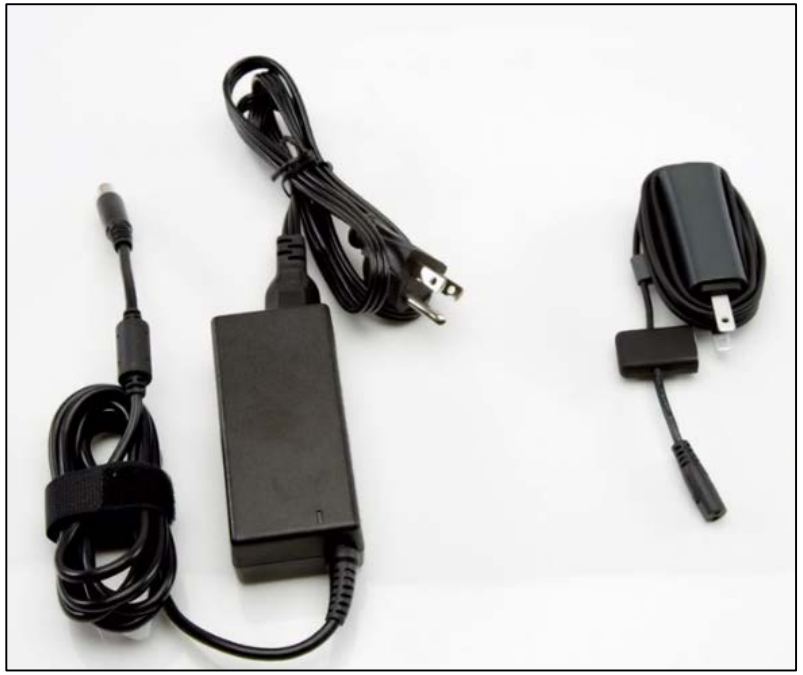
High power density converters

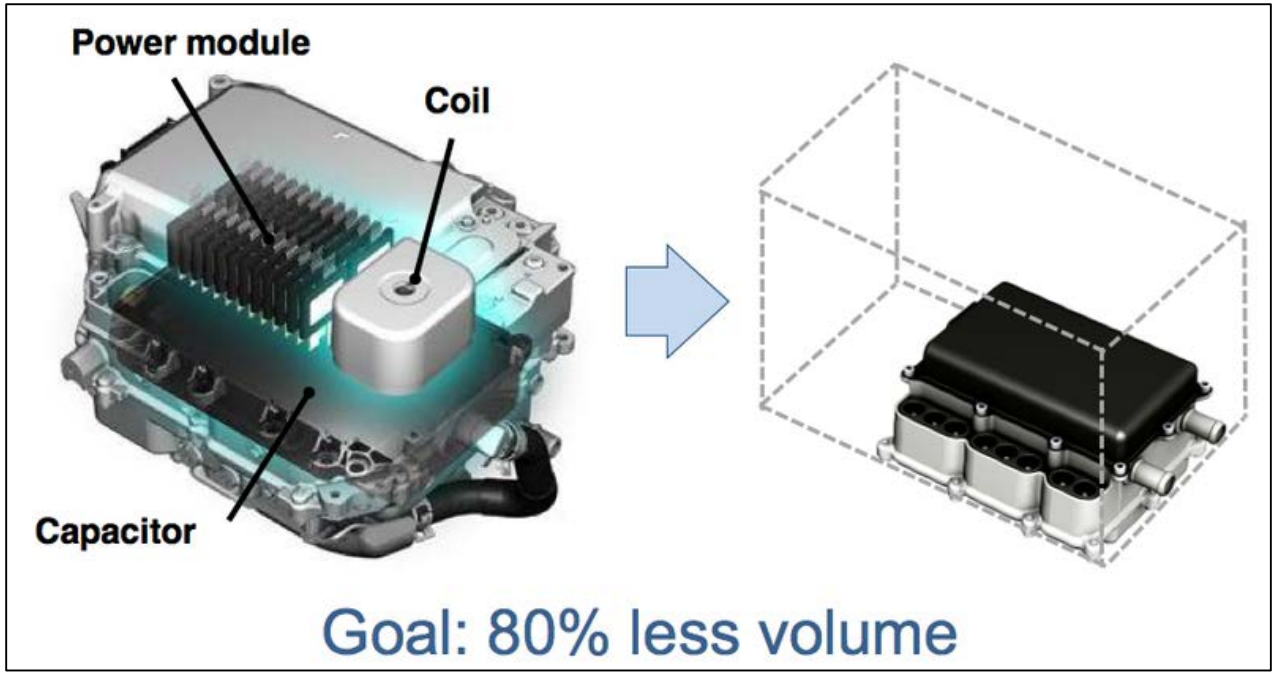
- High power density is an important consideration in power electronics.

Laptop charger



Source: https://www.marketingwords.com/blog/landing-page-review-innovative-laptop-charger-pre-launch/

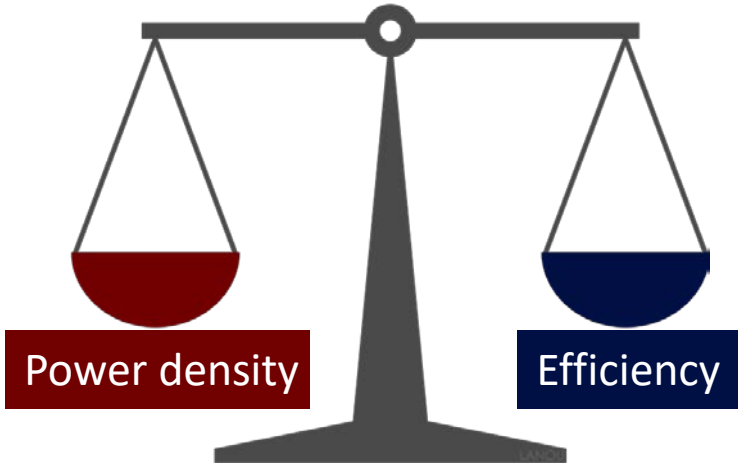
Electric vehicles

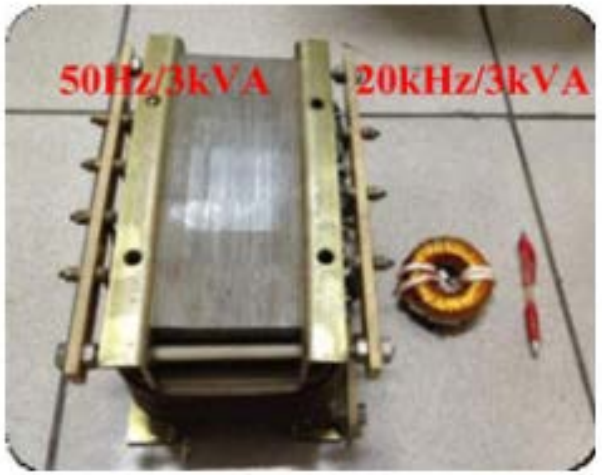


Source: https://www.greencarcongress.com/2014/05/20140520-sic.html

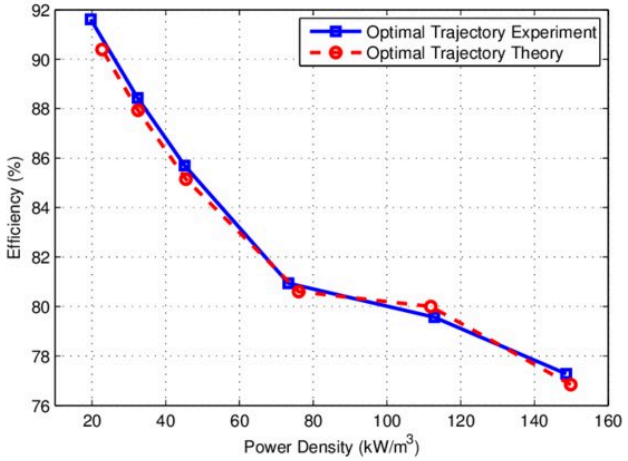
Technology to increase power density

- Reduce the components size by increasing switching frequency
- However, efficiency will reduce with increased switching frequency
- New semiconductor materials (Silicon carbide, Gallium Nitride) can achieve higher efficiency comparing to Si materials under the same switching frequency

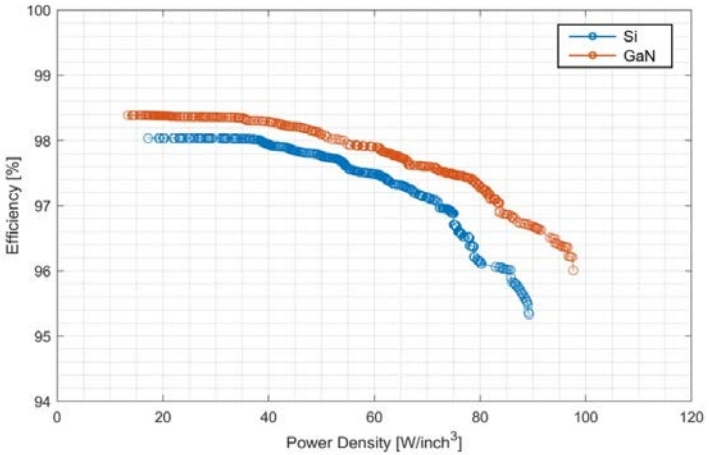




Source: B. Zhao, Q. Song, W. Liu, and Y. Sun, "Overview of Dual-Active-Bridge Isolated Bidirectional DC-DC Converter for High-Frequency-Link Power-Conversion System," *IEEE Transactions on Power Electronics*, vol. 29, pp. 4091-4106, 2014.



Source: Shirazi, Farzad & Saadat, Mohsen & Yan, Bo & Li, Perry & Simon, Terry. (2013). Optimal Control Experimentation of Compression Trajectories for a Liquid Piston Air Compressor. 10.1115/HT2013-17613.



Source: https://eepower.com/news/how-pareto-analysis-helps-determine-the-real-benefits-of-gan-for-power-supplies/#

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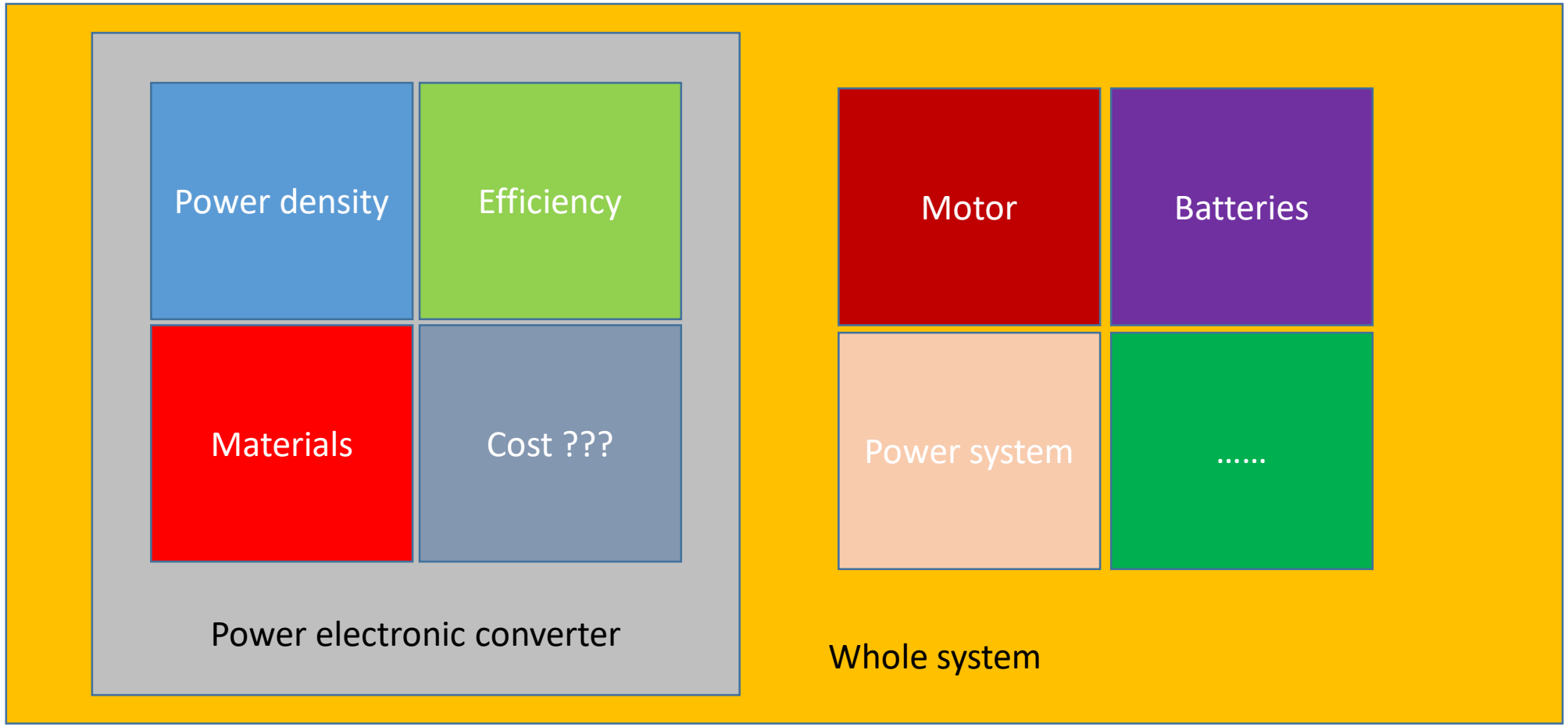
One step further …



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Summary

- High power density is a key consideration of power electronic converters
- But it is not the only consideration.
- New semiconductor material can improve the efficiency and power density of power electronic converters.
- Although the cost of new semiconductor materials is higher, the cost of the whole system might be lower due to the advantages brought by the new materials.
- What else do you think should be considered when designing a power electronic converter?