Future-proofing the EV powertrain against cost volatility

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The true humanitarian impact of the Covid-19 pandemic is not yet known, but it is without doubt that lockdowns around the world have had an effect on the environment. Throughout the beginning of the UK's lockdown, most of its major cities saw a significant reduction in NO2 emissions (Figure 1). This was a direct result of reduced road traffic, as it accounts for 80% of NO2 emissions in the UK [1]. This rapid improvement in air quality will place increasing pressure on the automotive industry to accelerate the adoption of emissions-reducing technologies, such as electrification.

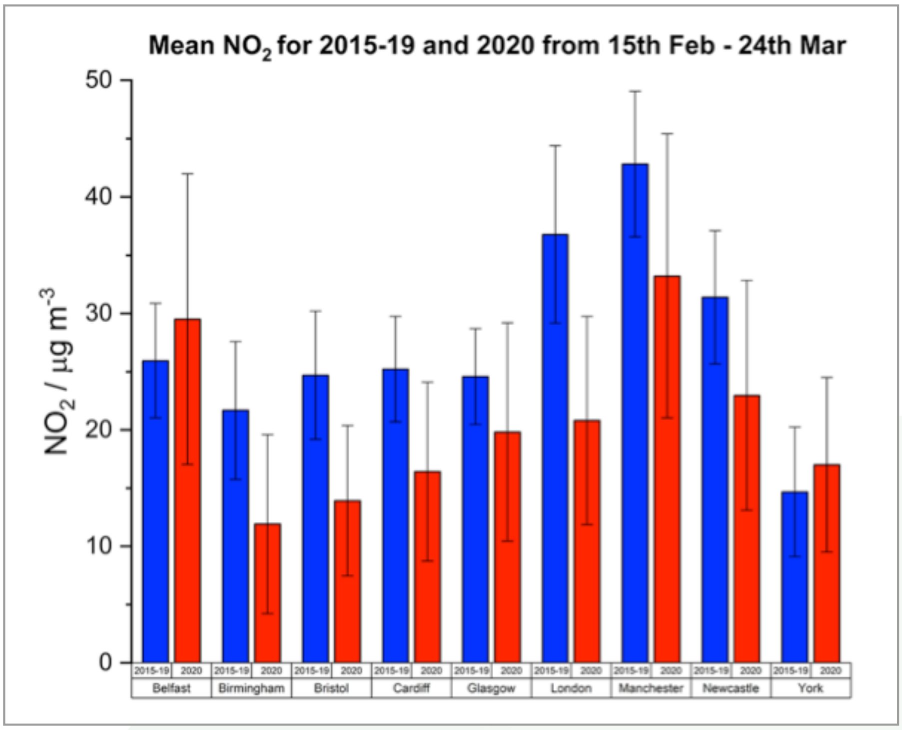

Figure 1: NO2 levels in major UK cities: red = 2020, blue = average for 2015-19 [2]

Accelerating the uptake of electric vehicles (EV) in order to create change will require progress in two key areas; increasing range and reducing their cost premium over conventional vehicles. The traditional tools and processes utilised to design and optimise powertrains remain time consuming and fragmented, often constrained by subjective views or an unconscious bias towards 'known solutions'. Whatever the improvements in individual technologies, such as motors or battery packs, the maximum benefit will only come from using a fully considered system level approach for the design of future EV powertrains.

DSD has developed such an approach, called ePOP (Electrified Powertrain Optimisation Process). It permits exhaustive mapping of the potential design space of electrified powertrain options, allowing the powertrain to be optimised for cost and range as a complete system, rather than focusing on the individual elements. By matching the powertrain characteristics to the requirements of specific applications, significant cost savings are possible without compromising the required vehicle performance or characteristics.

With the EV marketplace being so competitive and fast-paced, how can it be ensured that the right decisions today will still be the right decisions tomorrow? With rapidly advancing technology, regional divergence in demand, and uncertain supply chains, manufacturers must also consider future material availability and cost volatility alongside range and performance. ePOP not only enables objective system cost and performance analysis in today's context but can evaluate future scenarios based on alternative trends. These include the impact of potential raw material cost fluctuation (for example rare-earth magnet cost instability), the impact of alternative cost trajectories in battery and inverter technologies, and even whether the price of steel could result in new approaches to electrification.

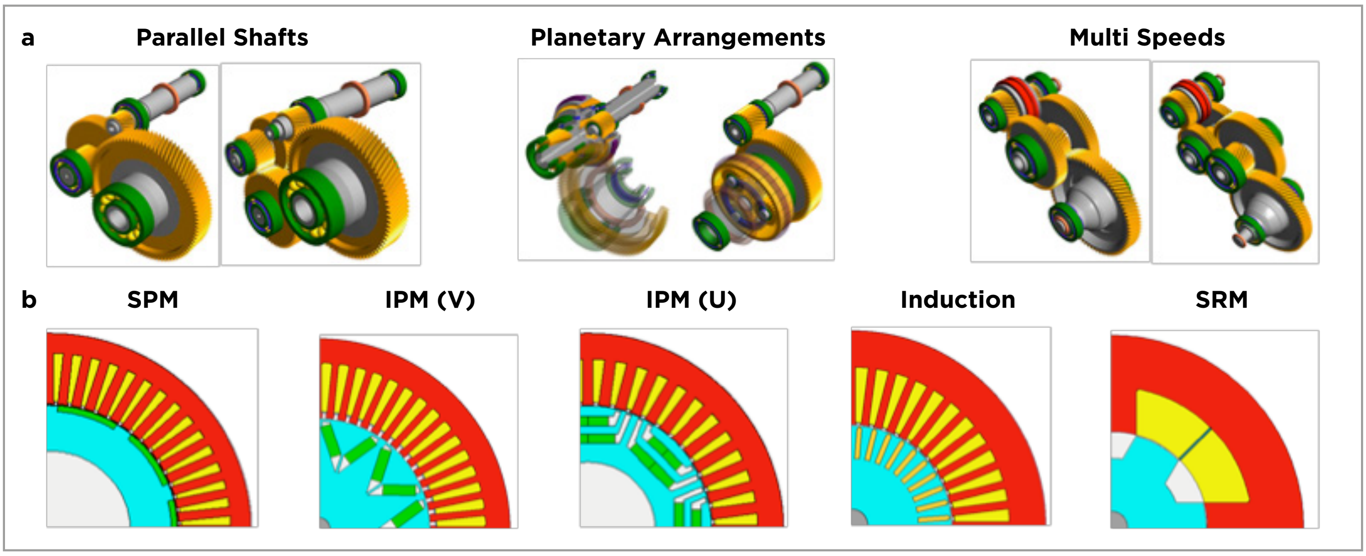

Figure 2: A range of transmission systems (a) and different motor types and topologies (b) can be considered using ePOP

The key enabler within ePOP is the characterisation of the various subsystem and component designs, allowing the building of complete powertrain variants for simulation. ePOP rapidly generates the necessary input data (masses, efficiency maps, etc) for each electric powertrain subsystem for a range of topologies and layouts. This rapid generation of input data allows the simulation of thousands of different powertrain configurations, each meeting the constraints set by the performance criteria of the particular application. These are compared through intelligent cost functions and trade-off algorithms to determine the optimum specification. The unprecedented scale and reach of the ePOP approach means unexpected or counter-intuitive solutions are often exposed, which might otherwise have been discounted.

In order to create robust long term product strategies, understanding potential future cost fluctuations for the key cost contributors is essential. Vehicle manufacturers must not only be aware of expected trends in future material costs, but also have the means to manage the risk that those trends change, or even reverse.

In a recent case study, DSD applied ePOP to an electric four-door sedan with a minimum top speed requirement of 160kph, acceleration of 0 to 100kph in 7.5 seconds or less and a fixed battery capacity of 100kWh. Over 17,500 viable powertrain options were analysed over the WLTP Class 3b drive cycle. Future trends in cost for battery, inverter and magnet technologies were included, based on industry consensus outlined in the technology roadmap published by the UK's Advanced Propulsion Centre.

The results clearly showed that battery costs dominate the overall system cost in the current market, affording a significant value to technologies that improve efficiency, such as silicon carbide inverters, multi-speed transmissions and permanent magnet-based motors. However, currently popular technologies do not necessarily provide the most robust solutions for the future.

If, as expected, battery costs continue to fall in the future, it is anticipated that technologies which add cost but increase efficiency will become less attractive over the next ten to twenty years. However, this assumes that current vehicle range expectations do not increase. If they do, then battery costs will continue to dominate, as the impact of increasing range will offset any potential saving per kWh. This will mean that technologies to improve efficiency will remain valuable.

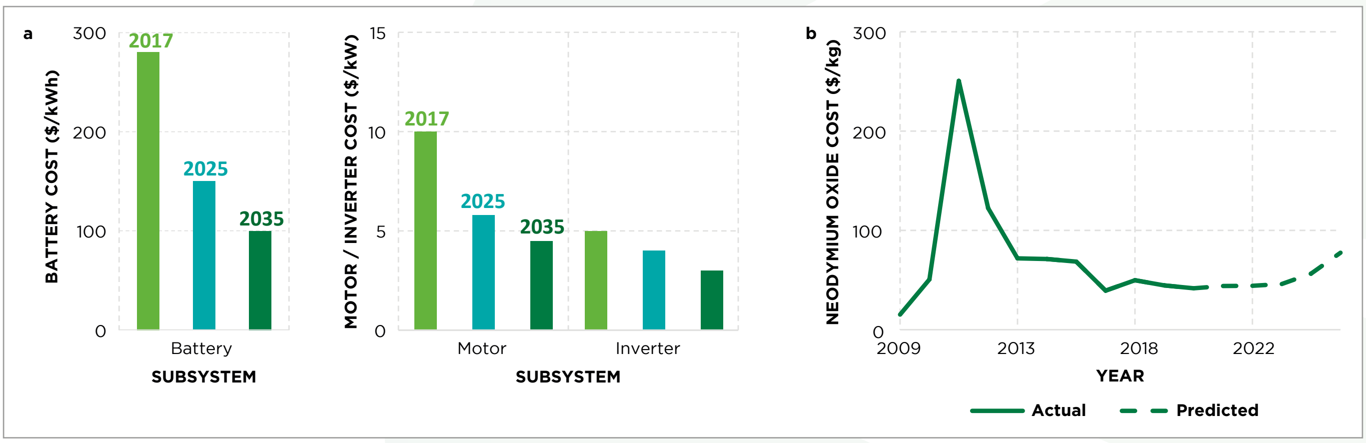

Figure 3: Cost trends in electrified powertrain subsytems and materials a) cost forecasts from the UK's Advanced Propulsion Centre [3], b) Neodymium oxide costs, 2009 – 2025 [4]

ePOP enables these different scenarios to be readily evaluated and the sensitivity of each of the technology options to the possible cost trajectories to be understood. The product strategy decisions made today will ultimately result in massive manufacturing investment that effectively commits vehicle producers to specific technologies for years to come. The more data that manufacturers can access to inform their decisions, as early as possible, the better. DSD's system approach using ePOP can help improve the robustness of those decisions however the future unfolds.

References:

[1] https://www.theguardian.com/environment/2020/mar/23/coronavirus-pandemic-leading-to-huge-drop-in-air-pollution

[2] https://ncas.ac.uk/en/18-news/3057-air-pollution-falling-across-uk-cities-latest-data-shows?eprivacy=1

[3] Advanced Propulsion Centre UK, "The Roadmap Report – Towards 2040: A Guide to Automotive Propulsion Technologies," Automotive Council UK, 2018.

[4] M. Bryant and T.Holdstock, "Gearing up for lower cost electric drives: accelerating the development of optimal electrified powertrain architectures," in 32nd Electric Vehicle Symposium (EVS32), Lyon, France, 2019.