Newsletter No.06, January 2022

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Multidimension Readiness Index for Electrification of Transportation System in China, Norway, and Sweden 1.0.

Background

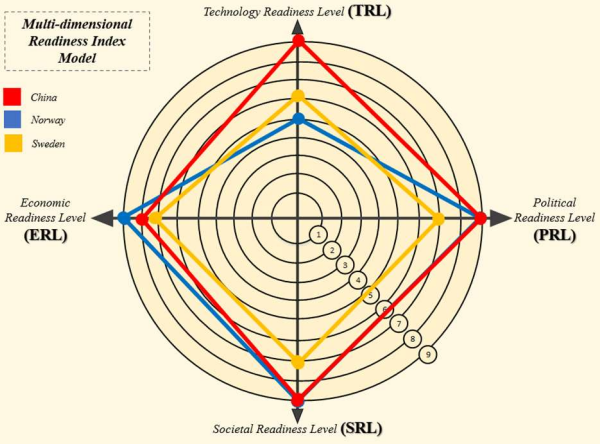
Worldwide, we see the transport sector is transforming towards electrification of the transportation system. Some countries have been early adopters, while others are latecomers. Some have extensive, while others have limited impacts of transport transformation. The electrification of transport is following different technological routes. However, the implementation, speed of development, and impact on industry, society, and citizens depend on different countries' contexts and conditions.

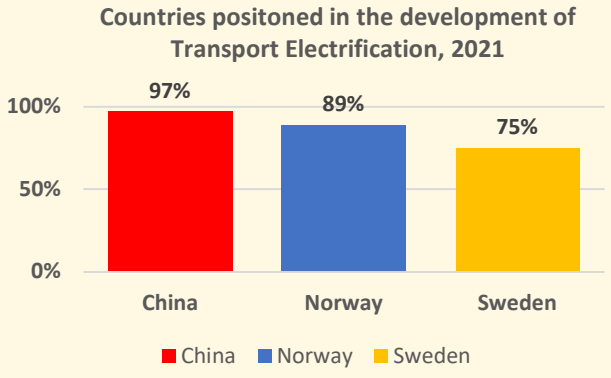
Purpose

The purpose of our research is to develop a readiness index model embedded with four dimensions, i.e., technology, political, societal, and economic. The idea of technology readiness is adopted from NASA, while the other three dimensions are empirically derived from our research on electrification of transportation system. Together these four dimensions, form the multi-dimensional readiness index model that we have used to analyze the development progress, evaluate the readiness maturity level, and determine the transitioning position of China, Norway, and Sweden in the electrification of transport.

Findings

- China is a leading country in the world in the electrification of the transportation system because of its robust technology advancements, control of the entire value chain, firm government support with decisive execution power in developing and implementing favorable EV policies, the willingness of the public sector to take the lead and citizens support to adopt clean technology.
- Norway has rapidly become one of the newcomers in electrification with large numbers of registered EVs, despite lacking EV manufacturing.
- Sweden is a rapidly growing country in the electrification of transport, with three vehicle manufacturers introducing EVs in 2021 and developing demonstration pilot projects for electric roads system for more than ten years. Sweden is also working on establishing battery manufacturing.





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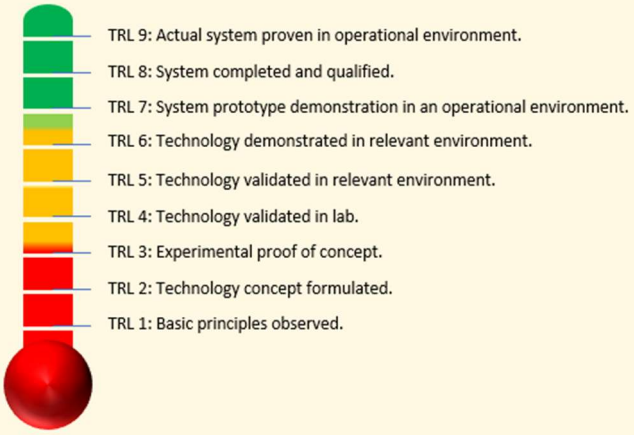
- The political processes and political decisiveness involved are the most important factors followed by the societal needs and economic ability, with the current technology available as the fourth.
- Without the participation of dedicated and determined political decision-makers being involved, the other three factors are challenging to obtain. Political decision-makers need to facilitate the use of economic means to support the transformation in the society and affected industries to balance the initial economic disadvantages of the electrically powered systems until they pass the cost disadvantage turning point.
- The development of the relevant technology is no longer a great barrier as it was in the beginning of this transformation, about 20 years ago. The technology for electrically powered transportation systems and devices is widely available now, although it is continuously evolving and being improved. Associated industries cannot be expected to initiate, finance, take the risk, and take the lead in this global societal transformation without clear and strong political support.

Multidimension Readiness Index Model

- The multidimensional readiness approach consists of four dimensions, technology readiness (TRL), political readiness (PRL), societal readiness (SRL), and economic readiness levels (ERL). These four dimensions form a web and, therefore, create a whole system where no one can be left out to gather a broader understanding of the electrification of the transportation system.
- The technology readiness levels can be used to evaluate the readiness of technology. The political readiness levels express the dedication and willingness of the government to adopt and promote the technology in the country. The societal readiness levels show the technology's adoption rate, and the technology has been supported by society. The economic readiness levels demonstrate the affordability of the technology for the buyers to consume the product.
- Thus, all the readiness levels are interdependent and interrelated to each other. However, the role of the political readiness levels is the most significant in holding all the other three readiness levels in one net to support the transformation.

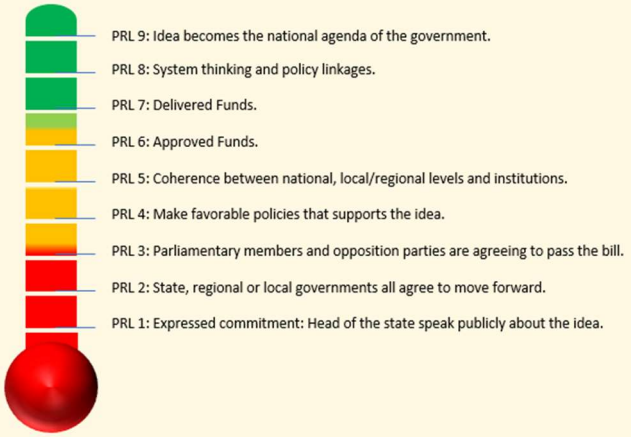
Technology Readiness Levels (TRL)

- TRL is an approach for conducting a logical analysis, assessment, and decision-making process when selecting an appropriate technological solution based on maturity of technologies.



Political Readiness Levels (PRL)

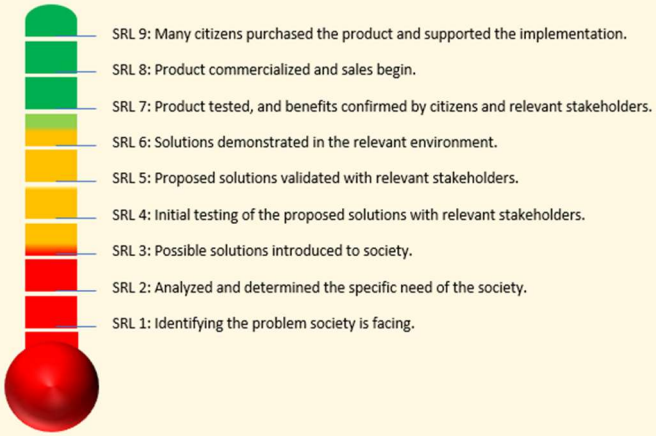
- PRL demonstrates the government's intension, willingness, and firm decisive move towards adopting innovation or invention and implementing new favorable policies for the relevant stakeholders to encourage them to embrace it.



Newsletter No.06, January 2022

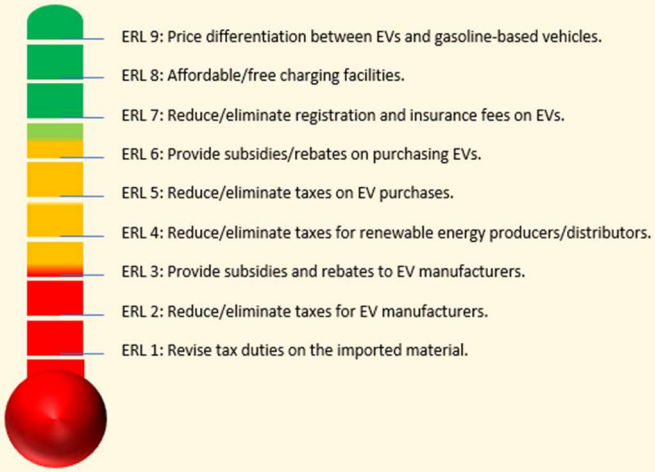
Societal Readiness Levels (SRL)

- SRL is a scale for analyzing and evaluating the readiness level of societal acceptance; for example, a product or a technology to be integrated into society needs to be accepted and desired by its citizens.



Economic Readiness Levels (ERL)

- ERL is a dimension for analyzing and evaluating the readiness levels of cost affordability of a technology or a product by the industry that impacts them and by the large number of citizens expected to adopt electric vehicles.



Technology Readiness

Electric Vehicle Manufacturers

- The top 10 brands of EVs sold in China in April 2021, among 9 of them are Chinese brands except for Tesla, which is also manufactured in China. Chinese brands are: Wuling Hong Guang Mini, BYD, Li Xiang One EREV, Tesla Model Y, GAC Aion S, Chery eQ, Great Wall Ora Black Cat, SAIC Roewe Clever, Hozon Neta V.
- The top ten selling brands of electric vehicles in Norway in September 2021 are imported from the Czech Republic (Skoda), Germany (Volkswagen and Audi), Japan (Nissan and Toyota), South Korea (Hyundai), and the USA (Ford and Tesla)
- The top ten selling brands of electric vehicles in Sweden in September 2021 are imported from various countries, such as the Czech Republic (Skoda), Germany (Audi and Volkswagen), Japan (Nissan), South Korea (Kia), China (MG), and USA (Ford and Tesla).

Infrastructure

In China

- By the end of June 2021 – 1.947 million EV charging piles available for public use in China.
- By the end of June 2021 – 716 battery swapping stations in China. In 2025 there will be 25,000!

In Norway

- August 2020 – 16 thousand public charging stations in Norway.
- Mostly people charge their EVs at home in Norway.

In Sweden

- September 2020 – 10 thousand public charging stations available in Sweden.
- Electric roads – Testing phase

Political Readiness

In China

- Incentives on purchasing EV (In 2009, subsidies were $5400 - $9000 and in 2021, subsidies were reduced and became $2000 - $ 2800 depends on vehicle's electric range).

- Nonfinancial Incentives (exemption from city license plate lotteries, EV license plates are free in Shanghai and special discounts on parking).
- In 2015, government released funds to build 4.8 million charging posts. In 2020, 14.1 million charging stations were built across the country.
- Battery swapping technology for cars and heavy trucks is now a national strategic development list.
- Reduced 30% subsidies on new EVs from 2022.
- Eliminate all the subsidies on new EVs from 31st December 2022.

In Norway
- No purchase/import taxes.
- Exemption from road taxes.
- Exemption from the 25% VAT on purchase.
- Access to driving on the bus lanes.
- Municipal charging infrastructure is launched.
- Exemption from the 25% VAT when leasing.
- Limited parking fees.
- Reduced 40% company car tax.
- Max 50% charges of the total amount on ferry fares.

In Sweden
- 2007 "Green car award" – To offer a tax credit of $1150 to new vehicles (emissions of 50 g CO_2/100 km or less).
- 2011 "Super green car premium" – To offer rebate up to $4500 to those who own a green vehicle.
- 2016 subsidies on fully EVs ($4500), Hybrid Vehicles ($2250).
- 2017 government allocated about $80 million to promote the adoption of EVs.
- 2015, for individuals 50% subsidy on actual cost of purchasing and installing charging pile at home and for companies 50% subsidy on the installation of per charging station.
- From 2015 – 2020 government awarded about $370 million budget for charging infrastructure.

Societal Readiness – Diffusion of EVs in the Society

- Sales of electric and hybrid vehicles in 2019-2020.

	2019		2020	
	BEV	**PHEV**	**BEV**	**PHEV**
China	972,000	232,000	1,115,000	251,000
Norway	268,024	116,042	346,921	142,858
Sweden	30,269	66,609	55,734	122,290

- Market shares of electric and hybrid vehicles in 2019-2020.

	2019		2020	
	BEV	**PHEV**	**BEV**	**PHEV**
Norway	42.40%	13.60%	54.00%	20.00%
Sweden	4.40%	7.00%	19.20%	30.10%
China	3.90%	1.10%	4.60%	1.10%

Economic Readiness – Cost of EVs and Operational Cost

In China
- Buying an electric vehicle is much cheaper than petrol or diesel vehicles.
- The cost of running an electric car is $0.31 every 10 kilometers, compared to $0.54 for the same distance traveled in a gasoline-based vehicle.

In Norway
- Buying an electric vehicle is cheaper than petrol or diesel vehicles.
- The cost of running an electric car is $0.21 every 10 kilometers, compared to $1.44 for the same distance traveled in a gasoline-based vehicle.

In Sweden
- Buying an electric vehicle is more expensive than petrol or diesel vehicles.
- The cost of running an electric car is $0.26 every 10 kilometers, compared to $1.38 for the same distance traveled in a gasoline-based vehicle.
- The operational cost of an electric vehicle (including maintenance cost, taxes and parking fee) is much lower than gasoline-based vehicle in all three countries.

Conclusion

- **First,** only focusing on technology will not lead us to the successful transformation of the transportation system. Technology is not a challenge for the electrification of transportation system!
- **Second,** political readiness is required to achieve a high level of diffusion of electrical transport systems that support developing, implementing policies, and promoting the electrification of the transportation system. We need political decisiveness and willingness to manage transformation.

- **Third,** societal readiness is required to be willing to switch from fossil to electric vehicles. People need to want electric vehicles. Start with public sector and public transportation! Charging infrastructure is equally important to establish as diffusion of electrical vehicles.
- **Fourth,** economic readiness is required to support by the subsidiaries to compensate for the price difference and motivate people until the scale of the economy makes the new technology priced on the same level or lower as old fossil-based technology. Society needs to finance and support the transformation cost.

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Newsletter No.06, January 2022

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