Large-scale electrification of the transport sector – a knowledge base

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TRANSPORT ANALYSIS

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Summary

The task

The Swedish Government has assigned Transport Analysis the task[1] of preparing a knowledge base concerning a large-scale electrification of the transport sector. This knowledge base is to encompass a mapping of the consequences of this in terms of, for example, land use, the electrical grid and preparedness at the local, regional and national levels. The analysis will also cover the electrification of aviation and maritime transport. The knowledge base is also to include an updated analysis of how the ownership and regional distribution of electric vehicles (EVs) are configured, plus an analysis of market trends beyond 2030. This assignment is to be carried out in dialogue with the Swedish Energy Agency. It is to be reported to the Swedish Government Offices (Ministry of Rural Affairs and Infrastructure) by 30 November 2024.

The purpose of this assignment is to provide the Government with a knowledge base that describes how a large-scale electrification of the transport sector could impact various segments of our society. The aim is to shed light on key issues for consideration in the transition to an electrified transport system, thus supplementing the existing knowledge base.

Starting points for carrying out the assignment

Our approach to this assignment is to proceed from our current fossil-based transport system and analyse the changes that will occur once the transport system has essentially been electrified. We identify activities that will have ceased or arisen once the transport system is essentially electrified.

Our analyses are based on the climate policy objectives, pursuant to which we will have achieved the Swedish goal of net zero emissions by 2045.

The system boundaries are set based on the key components of the transport system, i.e. infrastructure, vehicles/vessels and fuels, along with their associated ancillary services in terms of manufacture, distribution, service, training and the other elements needed to maintain them. Our assumption is that, by proceeding based on these key components and their associated ancillary services, we will be able to identify the major consequences of electrifying the transport sector.

Our main conclusions regarding the various areas included in the analyses are summarised below.

On the way to large-scale electrification

The interplay between megatrends, policy instruments and technologies in existing systems will affect how the transition takes place, as will the levels of maturity attained by new technologies.

Clearly defined goals and long-term policy instruments leading to large-scale electrification are already in place, primarily via the EU Fit for 55 package, as are the technologies needed to electrify road transport on a large scale. However, sudden disruptions and new trends may result in deviations from the technology choices initially planned for by society.

[1] Swedish Government (2023). Appropriation document for fiscal year 2024 regarding Transport Analysis, www.esv.se/statsliggaren/regleringsbrev/?RBID=23954

It is essential that we apply the lessons learnt from previous transitions and the experience gained as the electrification process moves forward. Experience teaches us that such a process will not proceed at the same pace everywhere, but rather that consequences will arise at different speeds from a national, regional and local perspective, as well as for different segments of the population.

Current actors and systems compared to 2045

The electrification of the transport system will entail a greater need for cooperation between our energy and transport systems. These systems have traditionally been separate in terms of both actors and business models, a situation that will now change. New issues will arise as new markets are developed.

One potential consequence of these developments will be new areas of responsibility for government entities in terms of permitting and supervision. Considerations pertaining to resilience and preparedness will also need to be adapted to new circumstances. Favourable conditions will be needed to enable government entities to plan flexibly and update their planning as new needs arise.

A large-scale electrification process means that competence in handling the operation of electric vehicles, and vessels and aircraft using supplemental fuel types, will become more important. It will be essential to adapt pre-existing training and education and invest in competence development, to plan for sufficient ‘electrical competence’ across the transport system.

Public charging infrastructure for passenger cars has been expanded, and the so-called blank spots will soon be gone. Moving forward, it will be important to focus on charging infrastructure for heavy road vehicles, maritime transport and aviation.

The competitiveness of road transport may, at least initially, be enhanced as a result of that mode of transport being expected to achieve large-scale electrification sooner than other types of transport. This could lead to more tonne-kilometres by road.

The introduction of electric vehicles in the world market is taking place even as other major changes in the global economy are underway. This could in turn lead to changes in the established pattern of vehicle production and trade.

In the case of electric aircraft, it will, for example, be necessary to modernise the airspace – how can future regulations be configured to support such a modernisation process?

Current and future fuels

Decreased dependence on fossil fuels is impacting our society’s transport flows and the conditions and assumptions surrounding companies and the labour market. A changed labour market puts the emphasis on competence supply and altered conditions and assumptions surrounding employment.

Volumes and compositions of imports, exports and domestic flows are being heavily impacted by reduced fossil-dependence, which is in turn impacting the conditions surrounding maritime transport. Revenues from fairway dues and pilotage fees are expected to decrease, and it is likely that there will be changes in the conditions surrounding port operations, particularly in those ports that handle petroleum products. The transport of petroleum products by lorry will change as well. A more precise analysis of what this could entail – e.g. in terms of the financing of maritime infrastructure, the evolution of shipping, and long-term infrastructure investments – would be timely.

The breakdown in terms of charging options will likely look different compared to the current supply of fuels. Digital solutions that identify where and when charging is advantageous should increase in importance.

As the customer base for fuelling stations shrinks, challenges may arise in certain sparsely populated areas that have high levels of at-home charging with respect to other services such as package delivery, grocery sales and other vehicle services. Taking such progress into account and planning for potential solutions will constitute a key element of the transition process in such areas.

The distribution of liquid fuels via the transport infrastructure will be replaced by the transportation of energy via powerlines and pipelines (electricity and gas). The responsibility for expanding the infrastructure will thus be shifted to some extent from traditional transport policy to energy policy, which means that greater cooperation and integration between these policy areas will be needed.

Future costs for transport system users

A phase-out of fossil fuels and vehicles could necessitate changes in tax bases if the State is to be able to fund the welfare system. In such a revision process it is important, in order to achieve the set goals, that the taxes be formulated in a manner that promotes the continued introduction of electric vehicles.

A number of factors are of significance for the future cost structure: electrification will likely reduce the cost of driving, even though a constant or lower petroleum price is anticipated in the future as demand decreases. The price of emission allowances within EU ETS will have a major influence on transport costs, as it is assumed that the price of these allowances will increase in the coming decades. In addition, the price of electricity is expected to rise in parallel with increasing demand. These costs will vary during the transition process, something that is important to consider when formulating taxes.

If the prices of alternative fuels are changed as a result of the transition, that will in turn impact the financial situations of companies and private persons, both directly and indirectly. The impact of rising transport costs will be affected by the ways in which transport companies, transport buyers and private persons can adapt to such higher costs. This is also related to their ability to invest in new vehicles and/or change their travel habits and transport needs.

Actions undertaken within society can yield different results in terms of the introduction of electric vehicles at the regional level. The types of policy instruments introduced will play a role in the outcome. For example, the evolution of the transition process may vary in different parts of the country, based on the policy instruments chosen.

Land use, electrical grids and preparedness

One of the most significant problems with respect to land use concerns the consequences of mining for innovation-critical metals/minerals. Negative environmental impacts and different land use claims arise in connection with such extraction operations. Changes in resource use will require effective resource planning that balances flexibility with the goal of achieving our broader societal objectives.

Another problem relates to charging in urban areas. Studies of the relevant regulatory framework have been initiated, and some examples of how the charging infrastructure issue could be resolved are available at the regional and local levels. Promoting exchanges of experience gained and lessons learned at the local level may offer a means of streamlining the implementation process.

Yet another problem has to do with access to land in the right locations to enable the charging of heavy road vehicles, maritime transport and aviation. The development of strategies to facilitate the transition process can offer a suitable way forward.

The increased demand for electricity in the future will depend primarily on the production of hydrogen gas for various industrial applications. It is thus not the increased demand for electricity that will pose the greatest challenge to the electrical grid as a result of the electrification of the transport system, but rather meeting the demand for power that will arise in those places where heavy lorries, vessels and aeroplanes will recharge their batteries. It is difficult to predict or calculate geographical power demand or how and where the electricity will be produced. It would seem reasonable to connect the issues of power demand and access to land in a strategic context.

So-called energy hubs, which could play an important role for seaports and airports in the future transport system, will also play a role in terms of land use and the electrical grid. A closer study of the roles and function of energy hubs could contribute to the identification of specific measures that could support the growth of and streamline those functions.

Passenger cars can assume an important role in terms of energy storage. The conditions surrounding two-way charging have been described previously, but there may be further aspects to study with a view to identifying specific measures that could support and streamline the engagement between the energy and transport sectors.

Functions such as emergency stockpiles and reserve capacity, and the forms that they should take, need to be adapted to further developments, and to specific conditions and assumptions. Effective cooperation between civil and military defence, including the forces of other NATO countries, is essential. Further investments in the cooperation between these areas can enhance our preparedness.

Collaboration and cooperation will play a key role in the large-scale electrified transport sector. There are numerous examples of experience from which to benefit in this context. These come, among other things, from green industrial development in Northern Sweden, and from cooperation regarding plans and forecasts concerning demand, capacity and electric power. Promoting the exchange of experience at the regional and local levels can contribute to the implementation process.

Key areas from a policy perspective

Based on our closing discussion, we have identified a number of key issues that are of particular importance to emphasise in order to manage the consequences of a large-scale electrification of the transport sector.

- Clearly defined goals and long-term policy instruments that will lead to large-scale electrification are already in place in terms of electrifying road transport on a large scale, principally via the EU's Fit for 55 package. The measures that pertain to maritime transport and aviation are not steering us directly towards large-scale electrification. Is there a need for special policy instruments to promote electrification within maritime transport and aviation and, if so, how can they be created?
- Regarding electric aircraft, a modernisation of the airspace will be necessary – how can the regulatory framework of the future be formulated to support such a modernisation process?
- How can policy-makers implement measures to promote and maintain a balanced transport system in which all modes of transport fulfil an important function, even as we perceive that electrification per se could create imbalances (e.g. in that road transport is expected to transition sooner)?

- The introduction of electric vehicles on the world market could entail changes in the established pattern of vehicle production and trade. How will major changes in the global economy impact the conditions and assumptions that the Swedish automotive industry is facing?
- As the customer base for fuelling stations shrinks, challenges may arise in certain sparsely populated areas that have a high degree of at-home charging with respect to other services such as package delivery, grocery sales and other vehicle services. Given these risks, how can the transition process in sparsely populated areas be supported?
- Reduced petroleum dependency will have consequences for actors in the maritime transport sector, and will also affect the shipping of petroleum products by road. What might this entail, e.g. for the evolution of transport mileage for goods, and for long-term infrastructure investments?
- The electrification of the transport system will entail a greater need for cooperation between our energy and transport systems. These systems have traditionally been separate in terms of both actors and business models, a situation that will now change. New and as-yet unknown issues will arise as new markets are developed. Is it worth considering new solutions from the public sector in order to address new issues that arise? Such issues will not always have an obvious place to belong, so how can these new solutions be configured?
- In practice, the electrical power supply for the transport system is part of the power supply for the entire society. This means that, as opposed to the situation previously, the prioritisation of fuel use within the transport sector in crisis situations must be weighed against other needs within our society. How can the public sector take these and other aspects of vulnerability into account in the process of electrifying the transport system?
- A phase-out of fossil fuels and associated vehicles may necessitate changes in tax bases if the State is to be able to fund the welfare system. How should future tax policy be configured so that it continues to generate the needed revenues without hampering the introduction of electric vehicles?
- Innovation-critical metals and minerals are a basic precondition for the large-scale electrification process. How can such access be secured in such a way that our overall societal objectives are achieved?
- It will be important in the near term to focus on the electrification of heavy road vehicles, maritime transport and aviation. What types of strategies should the public sector embrace in order to address issues concerning power demand, road transport and access to land?
- So-called energy hubs and road vehicles could both assume important roles in terms of energy storage. What additional measures are required from the public sector to support this opportunity?
- Collaboration and cooperation will assume a major role in a large-scale electrified transport sector. The more efficient the coordination, the greater the resilience when crises arise. How can efficient cooperation be strengthened between actors from different levels and sectors?
- In a major transition to an electrified transport sector, continual monitoring will be essential to ensure that the process progresses in a manner consistent with our transport policy objectives. What new factors might be important to consider?

Transport Analysis is a Swedish agency for transportpolicy analysis. We analyse and evaluate proposed and implemented measures within the sphere of transportpolicy. We are also responsible for official statistics in the transport and communication sectors. Transport Analysis was established in 2010 with its head office in Stockholm and a branch office in Östersund.

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