ANNUAL REPORT 2022

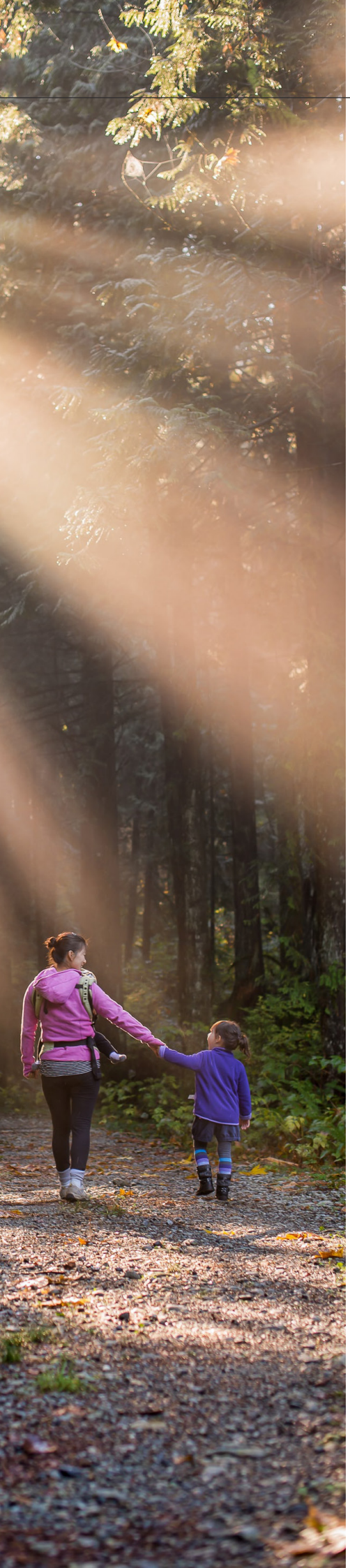
MISTRA ELECTRIFICATION
Programme Year Two

MISTRA ELECTRIFICATION

CONTENT

FUNDED BY
MISTRA
The Swedish Foundation for Strategic Environmental Research

This is the second annual report from Mistra Electrification, a reseach programme funded by The Swedish Foundation for Strategic Environmental Research.



MISTRA
ELECTRIFICATION

The vision of the Mistra Electrification programme is to accelerate the transition to a sustainable and efficient energy system, through the creation of actionable knowledge for a feasible and fair transition.

PROGRAMME PARTNERS

Svenska Kraftnät · stockholm exergi · fortum · Nordion Energi · Göteborg Energi · Vattenfall · Hitachi Energy · Energiforsk · Kiona · Utilifeed · Chalmers · ivl Svenska Miljöinstitutet · Lunds Universitet · University of Exeter · SLU

Karin Reuterskiöld, Chair of the Mistra Electrification Programme Board

CHAIR OF THE BOARD

Electrification is key for a sustainable Society

That the past year has posed many challenges, not least with regard to energy systems, is an under-statement. The situation has increasingly shone the spotlight on the basic research questions of Mistra Electrification.

Research and the general mutual understanding of basic facts are even more important today, and that is where our program is essential and can make a significant contribution.

Let me just take the example of electricity prices, where Mistra Electrification through its research has shown that a lower electricity demand would result in substantially lower prices. In September 2022, when the report was published, it became a major game changer within the Swedish energy narrative, and it contributed significantly to both understanding and future planning.

Given the dramatic and rapidly changing world events, it is interesting to note that the five project pillars of Mistra Electrification, that is the work packages, retain their relevance. For example, the roles of policies and decision-making and the various consequences of the transition to increased electrification remain as important topics. The Programme Board and I are really looking forward to hearing more about the findings and participating in the discussions.

Mistra Electrification enjoyed a good start during 2022, and it will be very interesting to see what the research and knowledge building will bring us in 2023 and onwards. One thing is certain – collaborations between academia, the business community and Society at large will be crucial for the success for the program and in defining the ways in which we can contribute to the transition to a more sustainable Society.

Karin Reuterskiöld
Chair of the Board
Mistra Electrification Programme

Filip Johnsson,
Programme Director,
Mistra Electrification

Helena Sellerholm,
Vice Programme Director,
Mistra Electrification

INTRODUCTION

Results coming in will help to emphasise the pressing need for transition

The need for a programme such as Mistra Electrification is greater than ever, as the transition to a sustainable and efficient energy system assumes greater urgency. Several interesting results that can help decision-makers have been published, and additional exciting results are yet to come.

This second annual report of Mistra Electrification covers the first 1.5 years of the programme. The seven academic partners and nine non-academic partners involved in the programme constitute a strong and influential network, capably exploiting the synergies among the partners.

The programme is now up to full speed, and the collaborations between the partners are yielding interesting results. In addition to the references made to the scientific papers and reports produced by the consortium, we present some of the results in the form of interviews with the researchers.

The dramatic developments during the last year, most notably Russia's war on Ukraine and the energy crisis in Europe, further underline the relevance of the programme. We are confident that the results from Mistra Electrification will help decision-makers in politics, trade and industry to accelerate the transition to a sustainable and efficient energy system. More results are yet to come.

Filip Johnsson and Helena Sellerholm
Programme Director and Vice Programme Director, respectively, of Mistra Electrification

Lowering prices in a hurry – how the Swedish energy discussion was transformed

At the start of 2022, the focus of Swedish energy discussions was on increasing the levels of electricity production. By the end of the year, saving electricity was on everyone's lips. A contributing factor to this evolution was the report titled Lowering prices in a hurry – Electricity Prices in the Wake of Russia's Invasion of Ukraine, from Mistra Electrification, which caused leading politicians to alter their rhetoric.

– The report received extensive media coverage and gained a lot of traction in the political debate. The analysis showed that a decreased electricity demand not only lowers the number of kilowatt hours of electricity used, but also drastically lowers market prices, says **Markus Wråke,** CEO of Energiforsk.

The report *Lowering prices in a hurry – Electricity Prices in the Wake of Russia's Invasion of Ukraine* showed that a 10% decrease in electricity demand in Europe would slash electricity prices in southern Sweden during the winter by some SEK 1.7 per kWh, or 50%. If the electricity demand in southern Sweden were to decrease by only 5%, prices would decrease by SEK 0.4 per kWh.

– I think the clear message that was delivered regarding the value of collective action and the very high policy relevance were the major reasons why the report had such a powerful impact. Leading politicians started talking about the importance of saving electricity in a way that we had not heard before. Over the following months, we saw large energy savings among Swedish consumers, and although there are of course many reasons for that, especially the high prices, I believe that our report played an important part in this change in Swedish Society, says Markus Wråke.

The report was published on the September 18th, a few days after the EU Commission set the goal of reducing demand for electricity by 10%.

– While our timing was extraordinary, the most important thing was that we showed how large an effect reduced demand has on electricity prices. The media coverage really was something else. I and other authors appeared on national television and radio and the study led to hundreds of articles in the press, says Markus Wråke.

He believes that the media coverage contributed to a change in the Swedish energy discussion.

– Before this, politicians refrained from mentioning energy savings and the positive effects of using energy as wisely as possible. They were afraid of being perceived as reactionary. So, during the spring, politicians could say "in Sweden we vacuum our homes whenever we want", whereas during the autumn they could say "it is important that we are cautious when and how we use electricity", comments Markus Wråke.

What have you learned from this?

– A key takeaway is the positive impacts that neutral and science-based analyses can have on the public debate. Moreover, I feel that we have strong support from Mistra that Mistra Electrification can and should participate in the public debate. The importance of that support is difficult to overestimate, says Markus Wråke.

More information

Lowering prices in a hurry – Electricity Prices in the Wake of Russia's Invasion of Ukraine can be found here.

"Social acceptance is a multi-faceted concept"

There is a lack of national guidance regarding the energy transition. That is one of the conclusions drawn by Dr Adam Peacock and Professor Patrick Devine-Wright, who are studying aspects of social acceptance within Mistra Electrification. Another conclusion is that the Swedish debate regarding wind power versus nuclear is viewed as simplistic and futile by many of those who are leading the energy transition.

Dr Adam Peacock at the University of Exeter is studying social acceptance within Mistra Electrification. As part of this research, he and Professor Patrick Devine-Wright (also at the University of Exeter) took a train journey to Sweden last year, performing interviews with stakeholders all over Sweden. Their itinerary included Luleå and Boden, where they explored communities that are affected by significant industrial projects related to the production of 'green steel', and Stockholm, Gothenburg, Gävle and Östersund.

– The aim of our work in the Mistra Electrification consortium is to understand the social acceptance of the energy infrastructure solutions that have been identified as necessary to achieve climate neutrality across Sweden. We seek to draw out if, where and why these different energy sources, technologies and infrastructures may or may not trigger place-enhancing or protective actions across Sweden, says Adam Peacock.

Social acceptance is a multi-faceted concept, states Adam Peacock.

– Where individual and community responses to siting new energy technologies and infrastructures were once understood through the lens of "Not In My Back Yard" responses – NIMBYism – social acceptance critiques this approach and takes a more holistic viewpoint. Instead, a social acceptance perspective focuses on how, where and why people may (or may not) engage in 'place-protective actions', consequently allowing or protesting against different proposals related to energy. This may not necessarily be close to where an individual lives but it could be an attempt to protect a landscape that is visited regularly, for example.

Adam Peacock and Patrick Devine-Wright are interviewing different stakeholders associated with the energy transition occurring in Sweden. Their interviews are enhanced by participatory mapping techniques, whereby participants can annotate different areas of Sweden according to the context of the conversation.

– We encourage participants to draw from their own experiences and perspectives on social acceptance and to annotate different parts of the map, indicating where social acceptance is higher or lower in different places and for different reasons, said Adam Peacock.

The map is pre-loaded with existing spatial data, including existing energy infrastructures, demographic data and spatial data with respect to protected landscapes.

To date, they have interviewed 18 individuals. The individuals with whom they engage operate in a variety of sectors, including those working for private companies, public organizations, anti-wind power organizations, and charities, as well as those working towards protecting the rights of indigenous people.

– We believe that it is important to recognize that energy transitions affect different people and different places in often unique and contextually specific ways, so it is critical to ensure that we capture a variety of perspectives in our data.

What have you found so far?
– Whilst we are still actively analysing our data, a few initial findings have emerged. First, the transition appears to be rather piecemeal. Whilst participants present a clearer narrative for driving the energy transition in the north of Sweden – pertaining to (re)industrialisation through renewables – this type of clarity is less-apparent elsewhere in Sweden.

Second, many of the stakeholders have indicated that there is a lack of national guidance to follow regarding:

- How to engage with host communities about project proposals
- 'Story telling' for the broader sustainable energy transition (i.e., why electrification is needed, where different technologies and infrastructures should go across Sweden and why)
- How to address critical local issues with municipal vetoes and using the permitting process.

– We have, however, also seen some excellent examples of innovative approaches to community engagement regarding planning decisions and municipal vetoes. While it can be tempting to focus exclusively on key challenges or objections, eliciting examples of good practice regarding engagement with communities is critical for building better practices across sectors. We hope to be able to contribute to this topic through our work. We will be publishing our full findings in due course!

In Sweden, wind power versus nuclear power has been a big issue in last year's election. Has it had any impact on your study?
– This debate has emerged in our data multiple times. It appears that whilst political and media circles are actively engaged in this debate, many of those who are leading the energy transition view this argument as largely simplistic and futile. With regards to decarbonisation targets and energy security, many of our participants expressed the view that there is a need for multiple, different energy sources and technologies.

Adam Peacock has also noted similarities between Sweden and the United Kingdom.

– There are striking international similarities – for example, the North vs. South tensions in Sweden regarding how energy transitions could unfold have also been observed in the UK between Scotland and England, as well as between the North and South of England.

When will you have the results and what happens next?
– We have now finished conducting our interviews. We expect our initial analysis to be completed later this spring. Our focus will then be on writing up our results and presenting our findings to the consortium and communicating back to the participants. However, our work will not end there. We will in fact be using these findings to inform a more local and community-centric project during 2023 and 2024.

"Technology isn't the challenge"

Sweden has the potential to increase its electricity production capacity by 140 TWh by Year 2030. The challenge is not technological, but instead relates to permitting processes, according to a PM by Mistra Electrification that was completed in the Spring of 2022. One year later, the situation is pretty much unchanged.

– The potential to increase fossil-free electricity production in Sweden by Year 2030 is as valid today as it was 1 year ago, representing a possible increase of 140 TWh. What has changed is the political rhetoric, whereby the polarization of opinions between wind power and nuclear power has diminished somewhat since the general election in September, says **Filip Johnsson**, who is Programme Director of Mistra Electrification and Professor in Energy Systems at Chalmers University of Technology.

In March 2022, a few weeks after Russia's invasion of Ukraine, the Swedish newspaper *Dagens Nyheter* published an opinion piece signed by Filip Johnsson and Markus Wråke, CEO of Energiforsk. The article was based on a PM about increased electricity production up to Year 2030 *(Ökad elproduktion till 2030),* issued by Mistra Electrification.

The PM concludes that magnitude of Sweden's potential to increase electricity production by Year 2030 is some 140 TWh, whereby off-shore and on-shore wind generation can contribute with 65 TWh and 52 TWh, respectively. Further capacity is derived from biopower (12 TWh), solar power (10 TWh), and nuclear power through increasing the capacity of two existing nuclear reactors (2 TWh).

– Technologically, this is possible. The main challenge is the permitting processes, says Filip Johnsson.

So, the main potential in the coming years relates to wind power, according to the PM. However, before the election, there was significant political polarization regarding the relative merits of wind power and nuclear power.

– The situation was unfortunate because there is no conflict between wind power and nuclear power. What has changed since the election is that there appears to be a consensus that Sweden needs more wind power. This aligns with what leading industrial representatives are expressing, comments Filip Johnsson.

One year has passed since the opinion piece was published and the war in Ukraine is still ongoing.

– The war is of course a tragedy, with terrible effects seen in Ukraine. A possible implication for Sweden and the rest of Europe is an increased need for security of supply when it comes to energy and electricity, says Filip Johnsson.

More information

The PM *Ökad elproduktion* till 2030 can be found here.

Wind farms are not always built at the windiest sites

Historically, wind farms have not always been built at the windiest sites. Rather, the placement of wind power installations often seems to have been somewhat random, according to a study from Mistra Electrification that looked at almost 30 states and countries. Moreover, the density of wind power in Swedish municipalities is often much lower than in many other regions.

– Sweden is a geographically large country that is sparsely populated. That is a relatively straightforward explanation as to why wind power density is low, says **Fredrik Hedenus,** who is Professor at Physical Resource Theory, Chalmers University of Technology.

During 2022, he together with co-workers published a paper titled *Historical wind deployment and implications for energy system models,* which covered 28 states and countries in Europe, the Americas and Australia. The study found no evidence of a concentration of wind power installations at the windiest sites, as is frequently assumed in energy system models.

– We found that wind power rarely has been deployed at sites with an average wind speed <6 m/s. However, we didn't find any evidence for a strategy that exploits sites with lower wind speeds only when windier sites are already exploited. Exactly where wind power has been allocated seems to depend pretty much on local and temporary considerations, concludes Fredrik Hedenus.

The study shows that the annual level of wind power production in Sweden is 62 MWh per square kilometre. This is low compared to the levels in many European countries, such as Denmark (379 MWh per square kilometre), Germany (367), and Belgium (427). However, it is higher than in Finland, which produces 24 MWh per square kilometre.

The average wind power deployment density in municipalities seldom exceeds 0.5 MW per square kilometre.

– In Sweden, the three most densely deployed municipalities produce between 0.2 and 0.3 MW per square kilometre, and most Swedish municipalities have wind power deployment densities, of <0.1 MW per square kilometre. In other countries, such as Germany, many municipalities have higher wind power deployment densities, says Fredrik Hedenus.

In Sweden, one argument in the public debate is that wind power should be built in cities like Stockholm instead of in the countryside. What is your opinion about that?

– Well, the total amounts of land in that type of area in cities are quite small, so the total amount of energy that could be generated is also small. However, it is interesting in terms of political and social acceptance. In Sweden, wind power has become a polarizing issue, and this could be a sign of that.

Have you found an explanation as to why wind power densities vary so much?

– No, we haven't. We have looked at factors such as population density, political preferences, and other underlying variables, but we haven't found any clear explanations. In some cases, wind farms have been built in quite densely populated areas. This will be a topic for further research. Within Mistra Electrification, we will now try to find out why certain municipalities accept more wind power than others.

More information

"Historical wind deployment and implications for energy system models" can be found here.

Price for electricity will determine the fate of Swedish fossil-free steel

The massive increase in electricity demand expected as a result of the production plans for fossil-free steel in northern Sweden will most likely lead to increases in electricity prices. If that is the case, it is highly unlikely that a fossil-free steel plant will be socially profitable, according to a paper from Mistra Electrification.

– To ensure that the production of fossil-free steel in northern Sweden is a success, the electricity supply needs to be increased significantly so that future prices for electricity become significantly lower than those currently expected. Otherwise, the production of "green steel" is unlikely to be profitable, says **Bengt Kriström**, who is Professor of Resource Economics at the Swedish University of Agricultural Sciences (SLU).

In the paper *Paying a Premium for 'Green Steel': Paying for an Illusion?,* Per-Olov Johansson and Bengt Kriström have looked at the economics of producing fossil-free steel using hydrogen in northern Sweden, in projects similar to those that are now planned. According to the study, the new plants are expected to require around half of Sweden's electricity production.

"It is difficult to see how such a huge expansion of demand can be met without price increases", conclude the authors of the paper. However, in locations with low electricity prices, fossil-free steel production could become competitive, according to the paper.

Bengt Kriström questions whether turning steel production fossil-free in Europe would lower total emissions. The reason for this is the EU Emissions Trading System, EU ETS. Lower emissions from steel production in northern Sweden would simply result in higher emissions in another part of the EU, the authors of the paper argue.

– However, if fossil-free steel from Sweden would outcompete traditional steel from countries outside the EU, say India, then global emissions would decrease, states Bengt Kriström.

Steel customers are assumed to be willing to pay a premium for fossil-free steel. However, if total emissions aren't reduced, but instead transferred to another part of the EU, they would be paying for an illusion, according to the paper.

– The question is whether customers will become aware of this.

The EU has sharpened the EU ETS system and increased the number of emissions allowances to be cancelled if emissions are reduced at a higher pace than expected. Have you considered this in your paper?

– That is true, and the answer is: 'No, we haven't'. The cap on emissions is to a certain degree stretchy, but the possibility to cancel allowances more rapidly will only be available for a rather short period of time.

But there are factors in favour of fossil-free steel, according to Bengt Kriström.

– Our paper doesn't consider whether the EU plans to impose carbon tariffs on steel imports, which if imposed would change the picture in favour of fossil-free steel from northern Sweden. In addition, in the future, a full stop will be imposed on emitting carbon dioxide within the EU ETS, so in the end no steel plants will be allowed to have any emissions.

More information

"Paying a Premium fors 'Green Steel': Paying for an Illusion?" can be found here.

Different aspects of fossil-free steel production analysed in Mistra Electrification

Will fossil-free steel production become a success for Sweden, and should investments in such plants and technologies be publicly subsidised? The public debate on these issues is ongoing – and it cuts right through Mistra Electrification. Professor Filip Johnsson, Programme Director of Mistra Electrification, outlines his reflections on this issue.

– There is a true demand for fossil-free steel from different industries, boosted by the belief that fossil-free steel will increase the value of their products. Furthermore, Sweden's competitive mining and steel industries and favourable conditions for fossil-free electricity production, together with higher prices for emissions allowances and the phasing out of the free allocation, are all factors that suggest that Swedish fossil-free steel production has a potential of being profitable, argues **Filip Johnsson**, Programme Director of Mistra Electrification and leader of Work Package 2.

His programme colleague Bengt Kriström, who is leader of Work Package 5, has a different view. In his paper titled *Paying a Premium for 'Green Steel': Paying for an Illusion?* Bengt Kriström has looked at the economics of producing fossil-free steel using hydrogen in northern Sweden. The paper questions whether making steel production fossil-free in Sweden will lower the total emissions in the EU, due to the EU Emissions Trading System, the EU ETS. Moreover, Bengt Kriström argues that if total emissions are not reduced, customer demand for the Swedish fossil-free steel might vanish.

– Bengt Kriström's paper demonstrates the strength of this programme. The interdisciplinary approach enables the electrification to be analysed through different lenses, which is desirable and healthy for the analysis of going forward, increasing the relevance and impact of the programme, says Filip Johnsson.

On the other hand, in the paper *Electrification of the energy-intensive basic materials industry – Implications for the European electricity system* submitted for journal publication by PhD student Alla Toktarova, it is shown how fossil-free steel production and electrification of other industries in northern Europe can contribute with important flexibility to the electricity system, thereby facilitating the integration of wind and solar power.

In the public debate, the public subsidies for fossil-free steel have been questioned. Filip Johnsson acknowledges this criticism as important but believes that more analysis is required to understand the relevant levels of continued subsidies for the further scaling up of fossil-free steel, the associated lead times, and how costs relate to the development of the EU-ETS allowance prices, as well as the extent to which steel customers will value fossil-free steel.

– An important topic for discussion is to what extent authorities should invest in a new technology. In light of the massive subsidies granted to industries in the USA through the Inflationary Reduction Act (IRA), how should European governments act? It is important that Swedish subsidies to produce fossil-free steel are thoroughly evaluated. Moreover, there may be problems if the USA and the EU start to compete in the area of governmental subsidies, says Filip Johnsson..

This is Mistra Electrification

The research programme involves a consortium of nine industry partners and five research partners. The consortium, which is funded by Mistra and the partners, is under the combined leadership of Chalmers University of Technology and Energiforsk and reports to the Programme Board.

Programme Board

- **Karin Reuterskiöld** (Chair), Partner, Forever Sustainable
- **Lise Nordin**, Climate Coordinator at Västra Götalandsregionen
- **Åsa Pettersson**, CEO at Energiföretagen Sverige - Swedenergy
- **Karl Bergman**, Head of Research & Development, Vattenfall
- **Stefan Savonen**, SVP Energy & Climate at LKAB

Research Partners

- Chalmers University of Technology, three divisions/departments:
  - Energy Technology
  - Physical Resource Theory
  - Division of Electric Power Engineering
- IVL Swedish Environmental Research Institute
- University of Exeter
- Lund University
- Swedish University of Agricultural Sciences (SLU)

Industry Partners

- Svenska kraftnät (Swedish TSO)
- Stockholm Exergi
- Fortum
- Nordion Energi
- Göteborg Energi
- Vattenfall
- Hitachi Energy
- Kiona
- Utilifeed

Programme Period

June 2021 – May 2025

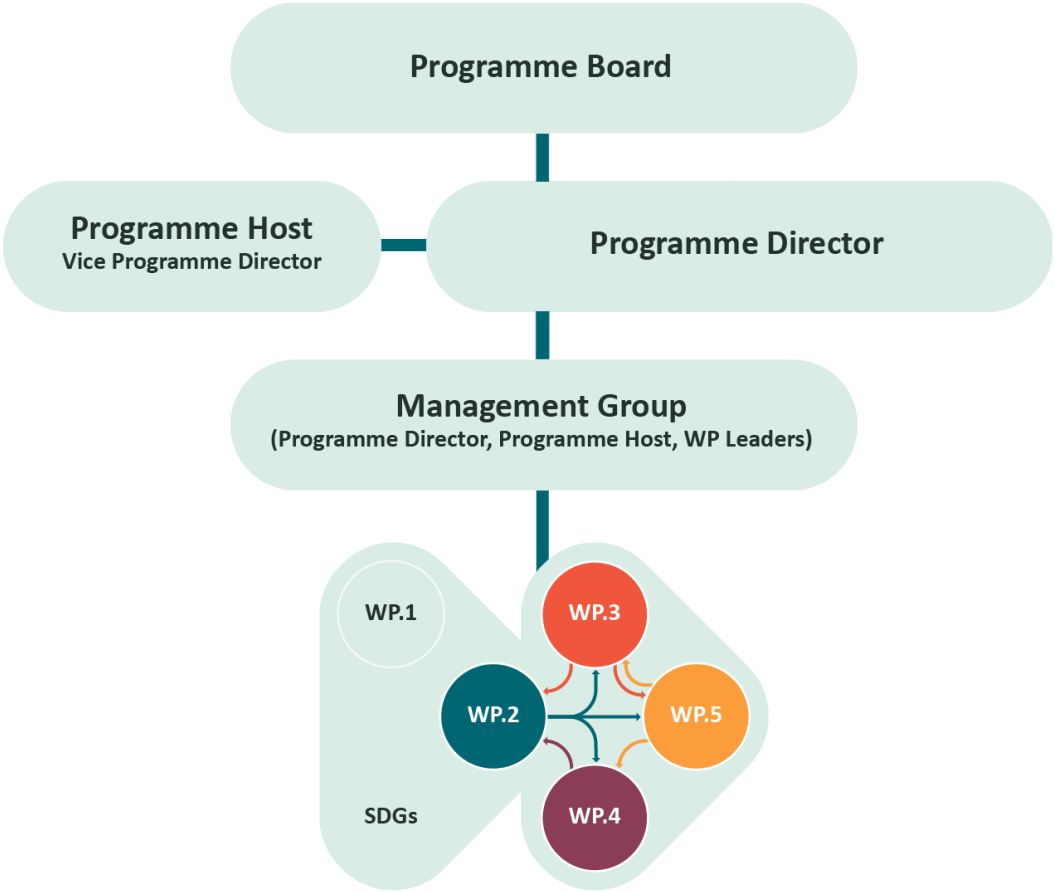
Budget and Funding

- In total, 67 MSEK, comprising:
- 50 MSEK from Mistra; and
- 17 MSEK as in-kind contribution from the research and industry partners

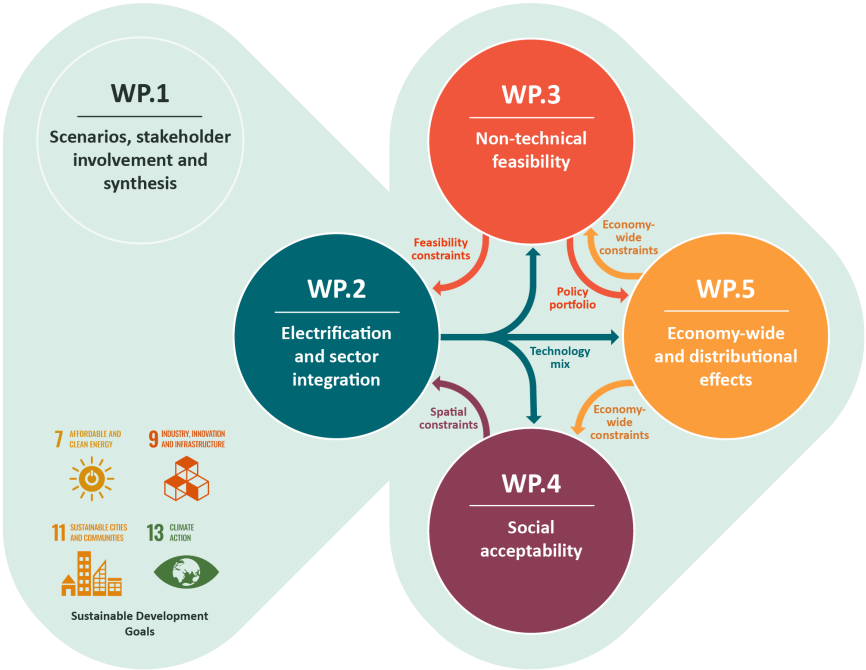
Work Packages

- **WP1** – Scenarios, stakeholder involvement and synthesis
- **WP2** – Electrification and sector integration
- **WP3** – Non-technical feasibility
- **WP4** – Social acceptability of energy infrastructure
- **WP5** – Economy-wide and distributional effects

Organisation of Mistra Electrification



Work packages and cooperation



WORK PACKAGE 1

Scenarios, stakeholder involvement and synthesis

The aim of WP1 is to provide a structured process for the interaction with stakeholders throughout the program, in order to formulate relevant scenarios and cases and to synthesize the results. An important novelty of the work is that it combines a relevant network of stakeholders with a participatory integrated assessment methodology.

Objectives of WP1

For the first 7 months of the programme, the main activities within WP1 have been to form the consortium and establish means of communication.

- To draw on the inputs of industry and societal actors (TSOs, DSOs, governmental agencies, Swedish EPA, NGOs) in developing scenarios for deep electrification and decarbonization.
- To explore key trade-offs and synergies between cost-efficiency, non-technical feasibility, social acceptance, and distributional and economy-wide impacts of the energy transition.
- To inform industry and societal actors as to the key trade-offs and how their actions can shape the unfolding energy transition.
- To synthesize the results from the research by means of outreach activities, such as a program web page, policy briefs, workshops, and social media including short video interviews (for e.g., YouTube channels).
- To arrange a yearly program conference, gathering academic and non-academic partners and invited selected external participants and fostering international networking (e.g., with visiting researchers).

WORK PACKAGE 2

Electrification and sector integration

The aim of WP2 is to analyze pathways for the Swedish and Northern European electricity systems that address the anticipated electrification of the transport and industry sectors and account for flexibility provision by sector coupling (including hydrogen production), as the basis for iteration with the other work packages.

Objectives of WP2

- To provide pathways for the Swedish and the Northern European electricity system, including electrification of industry and transport, infrastructure requirements and sector integration for different assumptions on external parameters (scenarios), including different target trajectories on carbon emissions towards zero emissions.
- To investigate the possibilities from distributed generation, including prosumer systems in urban areas, and the role of electric vehicles, including smart charging strategies.
- To develop novel approaches to integrating spatial constraints and political and institutional feasibility constraints in techno-economic modeling by means of a set of key indicators for quantifying the input and outputs from modeling with respect to quantities required for the subsequent analyses in WPs 3–5.
- To assess sustainability impacts, synergies, and trade-offs.
- To assess the potential role of IT as an enabler of sector integration, such as the role of virtual power plants (e.g., aggregated heat pumps bidding on electricity markets).
- To develop solutions to guarantee stable operation of the power systems when operated with a high penetration of non-dispatchable electricity generation (most notably, wind power), and compare them from the technical and economic points of view

WORK PACKAGE 3

Non-technical feasibility

WP3 aims to assess whether key elements of the electricity transition pathways, especially the rate of the transitions, modeled in WP2 are feasible. Whereas the models used in WP2 identify optimal electricity pathways based on technical constraints such as resource availability and intermittency challenges, WP3 draws on empirical material to identify non-technical constraints such as the rate of innovation, investment and institutional and social change. We will then go on to develop policy solutions, mixes and sequences that can relieve these constraints and enhance the feasibility of electricity transition pathways.

Objectives of WP3

Construct feasibility spaces for the rapid implementation of the most critical elements of the pathways, such as:

- Expansion of low-carbon power generation (onshore and offshore wind, distributed solar, the future of nuclear power).
- Expansion of hydrogen technologies, including production, supply, and storage.
- The phase-out of fossil fuels (coal and natural gas) in Northern Europe (e.g., coal phase-out in Poland).
- Translate the insights from first objective into benchmarks for interpreting parameters of the pathways produced in WP2, especially deployment rates, in order to identify, in collaboration with WP2, the feasibility constraints and trade-offs related to these key elements relevant for specific pathways and elaborating pathways that stay within these constraints.
- Identify and analyze policy mixes that can trigger the implementation of the transition pathways in the context of Swedish and EU energy and climate policies (e.g., the EU ETS) and strategies linked to the EU Green Deal.

WORK PACKAGE 4

Social acceptability of energy infrastructure

The aim of WP4 is to understand the social acceptability of the energy infrastructure solutions identified in WP2 as necessary to achieve climate neutrality.

Objectives of WP4

- To estimate future potential locations for wind power and levels of deployment density based on historical geospatial data (also to inform WP2).
- To identify the technological pathways and spatial locations for deployment that are expected by stakeholders and experts to be controversial with the public generally and local communities in particular.
- To investigate how the different technological solutions obtained in WP2 are represented and accepted by the public at the societal and local community levels and by officials and company representatives.
- To understand the roles that citizens are willing to play in enabling sustainable energy transitions, for example as prosumers or investors, and how these might vary across social groups, personal characteristics and spatial areas.
- To advance understanding of the socio-spatial aspects of technological pathways, specifically the compatibility between particular landscapes and specific technological solutions (e.g., large-scale wind power) using mapping methodologies.

WORK PACKAGE 5

Economy-wide and distributional effects

The effectiveness of Swedish measures and their effects on competitiveness, and ultimately welfare, depends on strategies chosen elsewhere and will, thus, influence Sweden's ability to be an early mover in decarbonization. The aim of WP5 is to shed empirical light on these issues, using the Comprehensive General Equilibrium (CGE) modeling approach and unique empirical data, a combination that makes this work novel and unique.

Through the iterative WP work managed by WP1, WP5 will inform WPs 3 and 4 on the overall distributional effects of the different transition pathways. As outlined in the description of WP1, this WP aims at incorporating stakeholder information knowledge to sharpen the analysis and place it in a realistic framework. The work in WP5 is novel in that we will contribute new theoretical results on the links between competitiveness metrics and exact welfare measures in a general equilibrium setting. This should be of great importance since, as mentioned in the introduction, the views in the public and political debates on the effect of the energy transition on the economy vary widely.

Objectives of WP5

- To quantify the effects on competitiveness of the energy transition pathways obtained from WP2–WP4, i.e., under different technology mixes and policy assumption in Sweden and internationally (cf. Figure 1).
- To quantify the distributional effects of the energy transition pathways obtained from WP2–WP4, i.e., under different technology mixes and policy assumptions.
- To understand the role of electricity trade with neighboring countries in the transition pathways, using inputs from WP1 and iteratively with WP2.

The results from the analysis will be iterated with WPs 2–4.

DELIVERABLES 2022

Scientific publications

- Hedenus, F., Jakobsson, N., Reichenberg, L., & Mattsson, N. (2022). Historical wind deployment and implications for energy system models. *Renewable and Sustainable Energy Reviews, 168*, 112813.
- Lowering prices in a hurry Electricity prices in the wake of Russia's invasion of Ukraine – Energiforsk report 2022-886
- Westander, H., Henrysson, J., Johnsson, F., (in Swedish) Förutsättningar och hinder för vindkraftsutbyggnad, Rapport, Mistra Electrification, Mistra Electrifcation Report 1, 2022
- Westander, H., Henrysson, J., Johnsson, F., Wråke, M., (in Swedish) Utökad elproduktion till 2030, Rapport Mistra Electrifcation, Mistra Electrification Report 2 (underlagsrapport till artikel på DN debatt "Hantera båda kriserna genom mer elproduktion") 2022.
- Göransson, L., Johnsson, F., (in Swedish) "Ett framtida elsystem med och utan kärnkraft – vad är skillnaden?" (preliminär titel), Mistra Electrification Report 3 (preliminary version due December 2022).
- Zetterberg, L., Johnsson, F., Elkerbout, M., Impacts of the Russian invasion of Ukraine on the planned green transformation in Europe, Report, 2022 (in co-operation with Mistra Carbon Exit).
- Johansson, P.-O & B. Kriström (2023) "Paying a Premium for 'Green Steel' – Paying for an Illusion?", Journal of Benefit Cost Analysis. Journal of Benefit-Cost Analysis (2022), 1–11 doi:10.1017/bca.2022.20.

Media appearances

There have been several media appearances from researchers in Mistra Electrification. Below is a list of media appearances from key researchers in the program. Other researchers from the programme have been co-authors of some the opinion pieces.

Christian Azar:

- Näringslivets medieinstitut: Fel i Aktuellt om svenskarnas utsläpp – "väldigt höga" sa Stenevi
- Aftonbladet: "Klimatforskaren om Europahettan: Vi kommer att se mer av det här"
- Dagens Nyheter: "IPCC kritiseras för orealistiska scenarier om tekniska lösningar"
- Dagens Nyheter: "Så slår kriget mot det globala klimatarbetet"
- Sveriges Radio Vetenskapsradion Klotet: "Krigets miljöskador i Ukraina – och den påskyndade energiomställningen"
- Dagens Nyheter: "Därför orsakar IPCC:s rapporter kontroverser"

Lisa Göransson:

- TV4 Nyhetsmorgon: Energiexperten: "Ett skitsystem ur effektivitetssynpunkt"

Jessica Jewell:

- Expressen: "Striden om världens största vindkraftverk i Jämtland"
- Svenska Dagbladet: "Skulle ta 26 år att göra oss av med Putins gas"
- Dagens Miljöteknik: "1,5-gradersmålet kräver minskningar av kol- och gasanvändning som saknar motstycke"

Filip Johnsson:

- Svenska Dagbladet: "Justerat Tidöavtal vore bättre för klimatet"
- Forskning & Framsteg: "Tidöavtalet verkar vara skrivet av en planekonom"
- SVT Agenda – specialprogram om energikrisen See also here.
- Dagens Nyheter: "Forskare dömer ut regeringens kärnkraftspolitik: "Spel för gallerierna"
- Dagens Nyheter: "Vindkraft motsvarande all kärnkraft på Buschs bord"
- Dagens Nyheter: "Osakligt om vindkraften – kraftslag ska inte ställas mot varandra"
- Dagens Nyheter: "Dagens politiker är livrädda för nödvändiga livsstilsförändringar"
- Dagens Nyheter: "Moderaternas plan för kärnkraft hänger inte ihop"

- Dagens Nyheter: "Stor utmaning att ersätta fossil energi med vätgas"
- Dagens Nyheter: "Marknadskrafter räcker inte mot klimatförändringarna"
- Dagens Nyheter: "Möjliggör snabb utbyggnad av elproduktionen"
- Dagens Nyheter: "Hantera båda kriserna genom mer elproduktion"
- Dagen Nyheter: "Den energipolitiska debatten är en dialog mellan döva"

Markus Wråke:
In September, the report "Lowering prices in a hurry", part of the NEPP project and supported by Mistra Electrification, was released by Energiforsk. The report was in September alone mentioned and discussed in some 400 articles, TV and radio clips in Sweden. A selection of media coverage based on the report is listed below:

- SVT: Elpriserna i södra Sverige kan sänkas kraftigt – om vi sparar på elen
- TV4: Minskad elförbrukning kan halvera elpriserna i vinter
- Sveriges Radio: Så kan elpriserna halveras i vinter
- Dagens Nyheter: Sparande kan halvera elpriset i södra Sverige
- Svenska Dagbladet: Energikris – och Sverige sticker ut igen
- Aftonbladet: Så får du ner din elkostnad – rejält
- Expressen: Elpriserna kan halveras redan i vinter

Programme Management Team and WP Leaders

- Filip Johnsson, Programme Director and Leader of WP2
- Helena Sellerholm, Programme Vice Director and Leader of WP1
- Aleh Cherp, Co-Leader of WP3
- Jessica Jewell, Co-Leader of WP3
- Patrick Devine-Wright, Co-Leader of WP4
- Magnus Hennlock, Co-Leader of WP4
- Bengt Kriström, Leader of WP5
- Daniel Hirsch, Communications Lead

Website

mistraelectrification.com

MISTRA
ELECTRIFICATION

mistraelectrification.com