LEADERSHIP IN ENERGY TRANSITION –
What it is and how it works

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Eidesstattliche Erklärung

Ich erkläre ehenwörtlich, dass ich die Arbeit selbständig angefertigt habe. Es wurden keine anderen als die angegebenen Hilfsmittel benutzt. Die aus fremden Quellen direkt oder indirekt übernommenen Formulierungen und Gedanken sind als solche kenntlich gemacht. Diese schriftliche Arbeit wurde noch an keiner Stelle vorgelegt.

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Abstract

The main driver of global anthropogenic greenhouse gas emissions is the burning of fossil fuels. Thus, the key step to mitigate climate change is a radical decarbonization of the global energy supply, commonly referred to as energy transition. There is a lot of literature on the energy transition in general and how it is implemented in individual countries or at regional levels. However, there is neither a widely accepted definition of leadership in the context of energy transitions, nor do studies say much about the preconditions and characteristics of policy leadership in this regard. This thesis attempts to close this gap by means of a literature analysis for EU member states. It defines leadership in energy transition from a normative perspective, compares the concepts used in the literature to identify pioneer countries, and analyses explanations for the good energy transition performance of selected countries. Finally, the thesis analyzes policies that had a positive impact on the energy transition in Sweden, a country that stood out as a leader in several studies.

Keywords: energy transition, energy transformation, decarbonisation, energy policy, climate policy, Sweden, pioneers, leadership

Kurzfassung

Die Hauptursache für die weltweiten anthropogenen Treibhausgasemissionen ist das Verbrennen fossiler Brennstoffe. Deshalb ist die zentrale Herausforderung bei der Eindämmung des Klimawandels eine radikale Dekarbonisierung der globalen Energieversorgung. Diese Herausforderung wird allgemein als Energiewende bezeichnet. Es gibt zahlreiche Literatur über die Energiewende im Allgemeinen und darüber, wie sie in einzelnen Ländern oder auf regionaler Ebene umgesetzt wird. Die Literatur bietet jedoch weder eine weithin akzeptierte Definition von „Leadership" im Zusammenhang mit der Energiewende, noch bietet sie systematische Einblicke in die Charakteristika bzw. die Bedingungen, die so eine Pionierrolle begründen bzw. erklären. Diese Arbeit versucht, diese Lücken mit Hilfe einer Literaturanalyse für EU-Mitgliedsstaaten zu schließen. Sie definiert "Leadership" in der Energiewende aus einer normativen Perspektive, vergleicht Konzepte, die in der Literatur zur Identifikation von Pionierländern verwendet werden und analysiert, warum einzelne Länder als Pioniere der Energiewende klassifiziert werden. Schließlich analysiert diese Arbeit Politiken, die einen positiven Einfluss auf die Energiewende in Schweden hatten, ein Land das in mehreren Studien als führend eingeordnet wird.

Schlagwörter: Energiewende, Energietransformation, Dekarbonisierung, Energiepolitik, Klimapolitik, Schweden, Pioniere, Vorreiter

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Abbreviations

BRIICS	Brazil, Russia, India, Indonesia, China, South Africa
CAN	Climate Action Network
CCPI	Climate Change Performance Index
CCS	Carbon capture and storage
cf.	Confer/ compare
CMW	Carbon Market Watch
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COP	Conference of the Parties
e.g.	Exempli gratia/ for example
ECF	European Climate Foundation
EEA	European Environment Agency
EED	Energy Efficiency Directive
ESD	Effort Sharing Decision
ESR	Effort Sharing Regulation
ETI	Energy Transition Index
ETS	Emission Trading System
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse gas
Gt	Giga tonnes/ billion tonnes
HVO	Hydro treated vegetable oil
i.e.	Id est/ in other words
ibid.	ibidem/ in the same place
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
LTS	Long-term strategy
LULUCF	Land use, land use change and forestry
MJ	Megajoule
Mt	Megaton

NDC	National determined contribution
NECP	National Energy and Climate Plan
NGO	Non-governmental organisation
OECD	Organisation for Economic Co-operation and Development
PM2.5	Atmospheric particulate matter less than 2.5 micrometers
ppm	Parts per million
R&D	Research and development
RE	Renewable Energy
RPS	Renewable Portfolio Standard
SEI	Stockholm Environment Institute
SET	Sustainable Energy Transition
T&E	Transport and Environment
TPES	Total Primary Energy Supply
TWh	TeraWatt Hour
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WEF	World Economic Forum

1 Introduction

1.1 Problem analysis

2015 to 2019 have been the five hottest years on record (since 1880), 2020 will will likely continue this long-term warming trend making the past decade the hottest in human history to date (Climate Central, 2020; NOAA National Centers for Environmental Information, 2020). This rapid global warming is caused by human activity and is due to the increase of the concentrations of greenhouse gases (GHG) in the lower atmosphere (Mann & Kump, 2015). The consequence is a dramatic transformation of our planet consisting of; a rise in sea levels, acidification of the oceans, biodiversity loss and species extinction, an increase in extreme weather events and natural disasters, the degradation of air quality, a worsening of people's health and poverty, as well as food scarcity, just to name a few (cf. ibid).

Although climate change science has existed in some form since the 19th century (Kirby & O'Mahony, 2018), the associated problem did not make it onto the international political agenda until 1979 when the first world climate conference was held. In 1988, the Intergovernmental Panel on Climate Change (IPCC) was established, who in 1990, published its first report on the science of climate change and gave concrete policy recommendations. In this report, the overarching message was; greenhouse gas concentrations must be maintained at the 1990 level and reduced in the long term. With each new IPCC report published since then, the stated uncertainties regarding the possible consequences of climate change decreased, whereas the core statement of the urgency to reduce emissions has not changed in the last 30 years and has even been communicated with greater urgency due to the ever increasing emissions (Gupta, 2010; IPCC, 2020). This shows that the political response to tackle climate change can be described as modest or non-existent for many decades and that climate change remained a "low-level concern" (Kirby & O'Mahony, 2018, p. 8). In regard of delaying the climate crisis, Stokes (2020) calls the 1990s and the beginning of the 2000 "lost decades".

In order to limit the risks and impacts of climate change, as of today, 189 countries ratified the Paris Agreement which entered into force in 2016 (UNFCCC, 2020), and agreed to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (UN, 2015, p. 5).

The Paris Agreement was considered a tremendous achievement, the signature of almost every state signalled that climate change had finally reached a higher level of importance on the international political agenda. Still, the Paris Agreement has profound limitations and weaknesses. For instance, fossil fuels are not included in the agreement, leaving out a key cause of climate change. The fact that there will be no legal consequences for countries if the measures to achieve the objectives are not being implemented is also highly criticised. This agreement can be characterized as a bottom-up approach where national decision-making and policy processes are at the centre. Every country proposes its individual "national determined contribution" (NDC) which detail their emission reduction targets. But as there is no existence of a global policy (global carbon tax or a cap-and-trade system for instance), the country's ambitions and approaches to achieve a carbon neutral economy vary significantly (Arent et al., 2017, p. 6). Current national climate pledges under the Paris Agreement would, with medium confidence, lead to a 3°C temperature rise by 2100 according to the Intergovernmental Panel on Climate Change (IPCC, 2018). Thus clearly highlighting the inadequate approach the global community is currently taking in response to this severe threat to human life.

But what does carbon neutral mean? The term carbon neutrality is very often used interchangeably with the terms net-zero emissions or climate neutrality. However, there are differences in the definitions, which are defined in Annex I of the the IPCC (2018) report on 1.5°C as follows:

- Carbon neutrality or net zero CO_2 emissions: "when *anthropogenic* CO_2 emissions are balanced globally by anthropogenic CO_2 removals over a specified period"
- Net-zero emissions: "when *anthropogenic emissions* of *greenhouse gases* to the *atmosphere* are balanced by *anthropogenic removals* over a specified period. Where multiple greenhouse gases are involved, the quantification of net zero emissions depends on the climate metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential, and others, as well as the chosen time horizon)"

- Climate neutrality: "Concept of a state in which human activities result in no net effect on the *climate system*. Achieving such a state would require balancing of residual emissions with emission *(carbon dioxide)* removal as well as accounting for regional or local biogeophysical effects of human activities that, for example, affect surface *albedo* or local *climate*".

These definitions all refer to the fact that not all emissions from all sources are reduced to zero (which would be called gross zero emissions), but that they are brought into an overall balance by simultaneously removing emissions from the atmosphere or by storing emissions. By this means, residual emissions can continue to be emitted, especially in sectors where reducing emissions are not possible. These residual emissions are thus offset by natural or technical sinks through carbon capture and storage (Burke, 2019).

Nevertheless, despite technology and innovation being an important part of the transition towards a carbon neutral society, some critics warn of the dangers of relying on the development of technological solutions, especially those that are supposed to remove carbon dioxide from the atmosphere, as they do not yet exist at sufficient scale. These solutions could lead to a lock-in into a high temperature pathway. Two scientists Kevin Anderson and Glen Peters write: "Negative-emission technologies are not an insurance policy, but rather an unjust and high-stakes gamble. There is a real risk they will be unable to deliver on the scale of their promise. If the emphasis on equity and risk aversion embodied in the Paris Agreement are to have traction, negative-emission technologies should not form the basis of the mitigation agenda" (Anderson & Peters, 2016, p. 2).

So where should the focus be, in terms of mitigation, so that the above-mentioned 3°C warming by 2100 does not occur?

The main driver of global anthropogenic greenhouse gas emissions is the energy sector, accounting for around three quarters (74% in the year 2015). Furthermore, 90% of these energy-related emissions derive from CO_2 (IEA, 2018), of which again about 90% are due to the combustion of fossil fuels and the cement production. The remaining 10% are being released with net deforestation (Jackson et al., 2019).

Human-induced increases in CO_2 emissions are of course relevant, however, it is important to recognise other greenhouse gases and their effects. Other gases such as the carbon emissions from land cover changes such as deforestation, emissions of methane and nitrous oxide from agriculture and animal husbandry, and chlorofluorocarbons all contribute significantly to anthropogenic global warming. Nevertheless, the large share of CO_2 emissions due to the burning of fossil fuels highlight that a radical decarbonisation of the global energy supply is needed (Smil, 2016).

According to the latest *Global Carbon Budget 2019* report, the concentration of CO_2 in the atmosphere increased considerably and was at about 407 parts per million (ppm) in 2018, primarily due to fossil fuel combustion. This represents an increase of carbon in the atmosphere by 45% since the beginning of the industrial era (1750), when the global CO_2 concentration was at roughly 277 ppm (Friedlingstein et al., 2019). Converted into gigatonnes, the global fossil CO_2 emissions in 2018 have been at a record number of 37 Gt (billion tonnes) and this trend is expected to continue with sustainably peaking CO_2 emissions being rather elusive for the next years (Jackson et al., 2019).

The concept of the carbon budget indicates how much carbon dioxide can still be released into the atmosphere until a certain average earth temperature is reached. At the same time this demonstrates that the faster the emission curve bends and CO_2 emission decline, the easier it gets to stay within that budget. In this context, a report by the IPCC concluded that the amount of 420 $GtCO_2$ is likely the threshold for the atmosphere to absorb emissions staying below 1.5°C (compared to the beginning of the industrial revolution). To stay within these boundaries the report suggests emissions to peak by 2020 and warns that they must be halved within the next decade (IPCC, 2018). Furthermore, it is stated that even a half degree of warming between 1.5°C and 2°C matters significantly. If global warming continues to increase at the current rate, it "is *likely* to reach 1.5°C between 2030 and 2051" (IPCC, 2018, p.5). In contrast to these facts, it is estimated that governments worldwide will produce more than double (120%) as much oil, coal and gas by 2030 than can actually be burned to limit global warming by 1.5°C (SEI et al., 2019).

Notwithstanding, the concept of the carbon budget is associated with enormous inequalities at the international level and is linked to the question of which countries emit the most CO_2 emissions and thus consume the majority of the budget. Hubacek et al. (2017) researched global carbon inequality and concluded that 10% of the world population which represents the global elites with the highest income, caused 34% of household-related carbon emissions (direct and indirect ones). In contrast, Gore (2015) calculated that nearly half of total emissions (of lifestyle consumption) are attributed to the richest 10%, compared to roughly 10% that is emitted by the poorest 50% of the world population. These data points show that an increase in income goes hand in hand with an increase in emissions, thus highlighting that industrialized countries have the responsibility to cut their emissions the strongest.

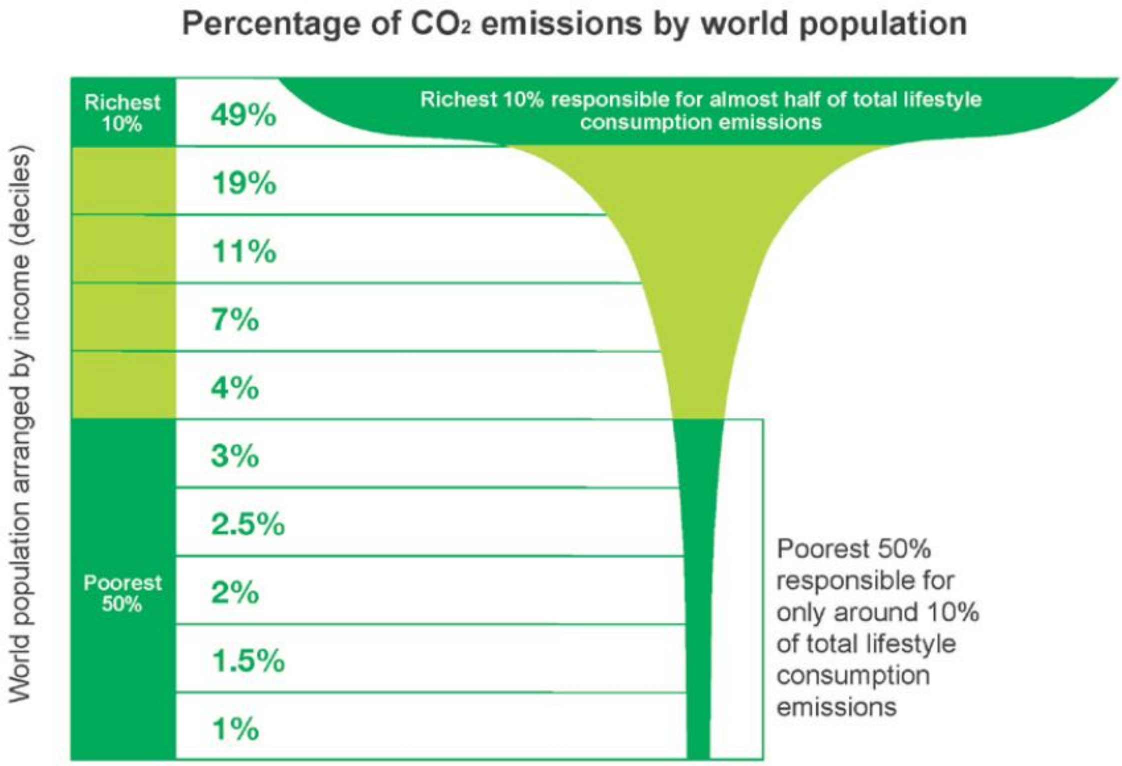


Figure 1: Global income deciles and associated lifestyle consumption emissions (Gore, 2015)

To cut CO_2 emissions, fundamental changes in the energy sector are urgently needed. The shift from fossil fuels to renewable energy as the main source of energy, combined with an increase of energy efficiency and the electrification of the sector is commonly referred to as Sustainable Energy Transition (SET). It is vital to move pass a low carbon economy and go to carbon neutral in order to keep temperature at the lowest possible level and counteract catastrophic consequences for humans and the environmenty (Global Commission on the Geopolitics of Energy Transformation & Van de Graaf, 2019). According to the International Renewable Energy Agency (IRENA) this pathway is not only economically, socially and environmentally favourable compared to the "business as usual"- approach, but also possible from a technical point of view. Science has shown that 90% of the carbon emissions could be reduced by renewable energy and energy efficiency measures (IRENA, 2018, p. 9).

The development of renewable energies to date show that despite an dramatic rise in technological innovation, these could only cover the overall increase of energy demand. The total share of renewable energies still remains small and only accounts for 13.6% of the Total Primary Energy Supply (TPES) worldwide in 2017. If biofuel, waste and hydro are excluded from these numbers, and only solar, wind, geothermal, and tidal are considered, the supply only accounts for 1.8%, while fossil fuels still dominate the energy mix. The largest renewable energy source of global renewable supply is solid biofuel/charcoal and the second largest is hydro power (IEA, 2019c).

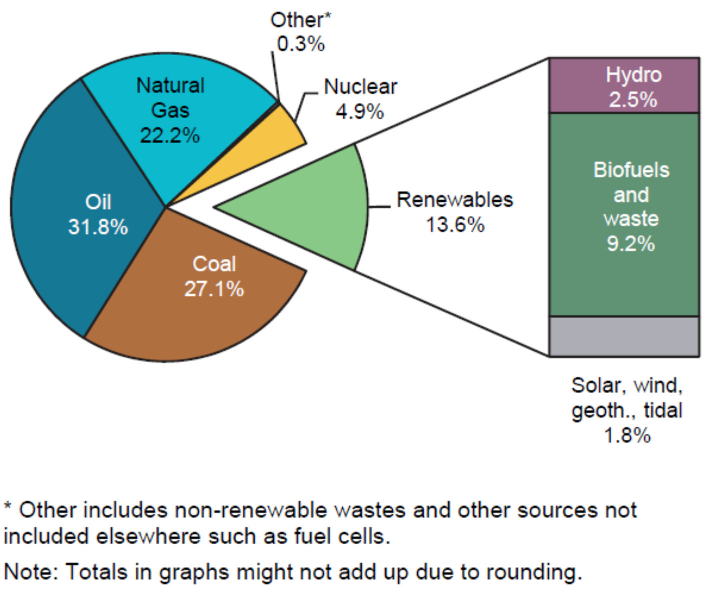


Figure 2: 2017 fuel shares in world total primary energy supply (IEA, 2019c)

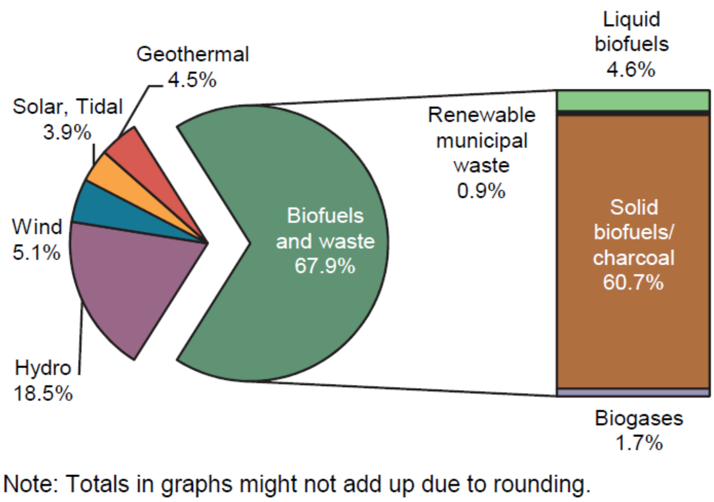


Figure 3: 2017 product shares in world renewable energy supply (IEA, 2019c)

Up to this point, no modern society was able to achieve a Sustainable Energy Transition (Sgouridis & Csala, 2014). Not one country is doing business in a way that it is both sustainable enough to respect the planetary boundaries and ensuring a high quality of life for all inhabitants on earth. Therefore, a structural change is needed that aims at "doing less bad" instead of just "doing more good". Especially for the privileged countries and individuals this would mean that "opportunities to actively shape our common future would have to be distributed much more widely". It is vital that communities of privilege recognize and accept their share of the problem, thus ensuring they can become part of the solution (Göpel, 2020, p. 11). However, from a global perspective, it is still a long way to go until we reach a climate neutral society and achieve a successful global energy transition (Sgouridis & Csala, 2014).

Significant differences exist in the terminology of what an energy transition consitutes in detail, how it should be implemented, as well as in methods and concepts to measure its progress. Therefore, it is also difficult to say which countries are leading in this context. There is extensive literature on the energy transition in general, how it is implemented in individual countries and at regional level. However, few studies use a ranking and compare several countries and their performance to each other, nor do they define policy leadership and its connection to energy transition. According to Hohenlohe-Oehringen (2016) it is important that countries can be compared and evaluated at international level on the basis of their success in energy transition. This is especially vital in ensuring the success of the Paris Agreement. However, currently "there exist just too many different numbers and measures, so that each nation can pick the one that is most convenient to present itself in the best light possible" (cf. ibid.: p.8). A measurement system in the form of a comprehensive energy transition index could allow best practice examples to be identified and serve as a model for other policy makers.

1.2 Research objectives and questions

This master thesis will identfy the meaning of policy leadership in energy transition and illustrate how different leaders in that field are outlined. Leadership examples will be taken from academic literature, as well as from different NGOs, think tanks, consultancy agencies or other important stakeholder within the field of low-carbon energy. The work will compare various approaches and criteria on how to define leadership in energy transition. It will analyse the reasons for success in countries that have focussed on their moral and political responsibility in addressing the climate crisis and implemented necessary meassures to set the energy transition in motion. This thesis will give a robust overview of the discourse of leadership in the conncection of energy transition and an understanding of what has been published about that topic to date by answering the following questions:

1. What is leadership in energy transition from a normative perspective? How are leaders defined?
2. Who are the leaders in energy transition in the European Union? What country is standing out in its performance to transform the energy sector?
3. What factors helped countries to achieve a pioneering role? What role do climate and energy policies play in that regard?

By answering these questions this research will achieve the following goals and therefore contribute to address the problem described in the former chapter:

- Define leadership in energy transition from a normative perspective
- Compare the underlying concepts used within the literature to define pioneering countries.
- Explain reasons for their leadership role
- Document the state of the art of countries that are perceived as good examples for the implementation of the energy transition, with a focus on member states of the European Union.
- Analyse policies that had a positive impact on the implementation of the energy transition in a country that stood out as a leading country in several studies.

1.3 Research design and structure

This work is based exclusively on a literature review. In order to answer the first research question "What is leadership in energy transition from a normative perspective? How are leaders defined?", the literature has been examined to present the state of the art of research in the two areas of energy transition and leadership. This should highlight the current discourse on the topic. Based on this review and a set of defined criteria the research focuses on eight case studies that have been selected because they include rankings of countries according to their progress on selected energy indicators.

There are individual rankings and indices that combine various energy indicators, but they often focus only on a specific area. The *Energy Development Index*, the *Multidimensional Energy Poverty Index* or the *Sustainable Energy Development Index* focus on access to energy and the development aspect, whereas the *Regulatory Indicators for Sustainable Energy* are specified on access to energy, energy efficiency and renewable energy. *The Energy Trilemma Index* examines energy security, energy equity and environmental sustainability. There is also the *Energy Security Index*, which examines energy security risks, and the *Climate Action Tracker*, which checks the "climate suitability" of the National Determined Contributions (NDCs) submitted by countries under the Paris Agreement. However, Singh et al. (2019, p. 2) argue that, "[a]ll the indices mentioned track specific parts of energy transition, such as sustainability, access, energy security, etc. Energy transition is more than the sum of these parts. A growing body of evidence highlights the broader implications of energy transition, which go beyond the boundaries of the energy system". In their opinion, there is a need to integrate other issues such as system inertia, political institutions, the financial system or that of human capital. According to Singh et al. "the most comprehensive energy transition index available due to its coverage of both energy transition system performance and transition readiness dimensions" is the one proposed by the World Economic Forum (WEF, 2019), namely the *Energy Transition Index* (ETI). The World Economic Forum is an International Organization for Public-Private Cooperation and its ETI is used for further analysis in this thesis. Furthermore, the following seven other studies have been selected for further analysis.

Since the ETI has not sufficiently integrated the principles for a just energy transition, this work also examines the framework provided by the Friedrich-Ebert-Stiftung (foundation) and investigates which other indicators are being defined to assess the efforts of countries to make the energy transition just (Hirsch et al., 2017).

Since the implementation of the energy transition at the national level is often related to not only energy, but also climate policies, studies that contain both components are also used for this work. The *Climate Change Performance Index*

(CCPI), which is published annually by the NGOs Germanwatch, the NewClimate Institute and the Climate Action Network, was selected as it is composed by important energy indicators and informs about countries' progress in raising climate ambition (Burck et al., 2019). Because part of this work also deals with the question of the extent to which policies are used effectively to implement energy transition, rankings were used that examine the political processes of EU countries more closely. Studies were selected that consider the political dimension and look at how energy and climate measures are planned to be implemented in political practice.

The Climate Action Network Europe (CAN Europe, 2018), which is Europe's largest NGO coalition working on climate and energy issues with over 170 member organisations has a ranking that tracks in equal ways how the EU countries perform in a set of climate and energy indicators to reach their climate and energy targets, as well as how they behave in setting and increasing both European and domestic targets.

A similar approach is followed by the European Climate Foundation (ECF, 2019), which is an international non-profit organisation which assesses the draft NECPs (National Energy and Climate Plans) of EU countries and investigates how they are on track regarding their long-term strategies (LTS) to 2050. The assessment analyses the adequacy of Member States' national targets, the completeness and detail of the policy descriptions, as well as the quality and inclusiveness of the drafting process (ECF, 2019).

The report by the European Environment Agency (EEA, 2019) which is an agency of the European Union whose task is to provide independent information on the environment to policy making agents and the public addresses European and national progress towards each of three energy and climate objectives: greenhouse gas emissions, energy from renewable sources and energy efficiency.

The two non-profit organisations Carbon Market Watch and Transport and Environment (CMW & T&E, 2017) rank EU countries according to where they stand on their negotiation process through the Effort Sharing Regulation, which, according to the report, is "Europe's Largest Climate Tool" that covers the transport, buildings, agriculture and waste sector.

Another chosen study is the one by the IRENA Coalition for Action (2019) that does not include a ranking per se, but instead a map showcasing which countries

pledged 100% renewable energy targets and within those countries how comprehensive the scope of these targets are. The IRENA Coalition for Action is is a coalition of over 100 renewable energy players including private sector companies, industry association, civil society, reasearch institutes and intergovernmental organisation, wheras IRENA (International Renewable Energy Agency) acts as thee Secretariat of the Coalition.
The criteria and indicators used in these studies to assess the countries on the basis of their performance will then be identified and discussed.
By comparing the rankings in the case studies, the second research question “Who are the leaders in energy transition in the European Union? What country is standing out in its performance to transform the energy sector?” will be answered. The third research question, "What factors helped countries to achieve a pioneering role? What role do energy and climate policies play in that regard?" will not only be answered by a general literature review on the one hand, but also by a more comprehensive analysis of an exemplary country.
The next chapter sets the conceptual framework on which this thesis is based. Energy transition and leadership are defined in general terms and then put into context. Furthermore, success factors for leadership in energy transition and challenges for its implementation are presented.
In the third chapter, terms which are important for the analysis of the eight case studies are introduced and differentiated. The eight studies are presented in greater detail, as well as an in-depth analysis on the criteria they compare the performance of different countries. Since it is not possible to go into detail about all the indicators used in the studies, the most important energy transition indicators, defined by the International Energy Agency will be explained. Building on this, the studies will be examined to see whether and which of these indicators have been taken into account. Furthermore, differences and similarities of the studies will be identified.
The fourth chapter will then summarise the general performance of the countries in the example studies and why which country or countries are ahead in the rankings. Although not all studies define "Leadership in Energy Transition" directly, they do at least cover aspects of it. The direct comparison of the rankings will give an idea of which European country is a pioneer in this area and appears particularly often in the top positions of the rankings.

Using Sweden as an example, the fifth chapter will explore which factors were decisive for Sweden's leadership position and what role Sweden's energy and climate policies have played in this regard.

In the sixth chapter, the discussion, the core results of the previous chapters are brought into context within the conceptional framework. Furthermore, any limitations of the work, as well as an outlook will be addressed.

The last and seventh chapter will summarise the results and provide concluding answers to the research questions.

2 Conceptual Framework

On the definition of energy transition itself and how it should be implemented, the viewpoints are strongly divided. In addition, how leaders and pioneers in energy transition could be defined is a highly controversial topic. Thus, the following chapter identifies what leadership in energy transition is, whilst acknowledging that these definitions and aspects cover only a small spectrum and are far from comprehensive.

2.1 Energy transition

"Energy transitions, like other forms of change, can be proactive or reactive. While transformations can occur at times in response to challenging circumstances, windows of opportunites also exist to not only optimize an energy pathway, reduce environmental effects, and encourage industries, but to advance society itself" (Araújo, 2014, p. 219).

History

Vaclav Smil, the "energy historian" was able to put energy transitions into a broader context of societal and economic changes, described in his work "Energy in World History" (1994) which paved the way for further research in the field. Humanity has experienced three energy transitions so far. The first was the discovery of fire, the second was the Neolithic revolution from the transition from gatherers and hunters to agriculture for food production, and the third was the industrial revolution and the resulting rise of fossil fuels. According to Smil, the world is on the verge of a fourth energy revolution, which will free itself from dependence on fossil fuels and switch to energy sources that emit no carbon dioxide (Sieferle et al., 2006; Voosen, 2018).

However, Sgouridis and Csala (2014, p. 2602) argue that "[p]ast energy transitions were never absolute in primary energy resource terms. For example, while it is commonly perceived that the fossil fuel era has supplanted the use of biomass, traditional biomass remains a significant primary energy resource exceeding nuclear primary energy on a global scale. The same is true for the transitions from coal to petroleum and natural gas. In other words, the transitions occurred in certain economic sectors […] but the resource remained in use in other sectors […] due to price and availability".

On the other hand, Sovacool (in Arent et al., 2017) who cites Fouquet and Pearson (2012) argues that "past energy transitions may not be the best analogies for a future low carbon energy transition". This is because today we have knowledge of social, political and economic implications of energy transitions which was not the case in previous transitions. This knowledge could be applied to the next transition.

Definition

Many scientists find it difficult to define the term energy transition because it cannot be applied universally and the definitions have changed over time (Edberg & Tarasova, 2016). It also can have different meanings for different countries and depends on the time frame (Şahin, 2020).

Cherp et al. (2018) emphasise that despite the wealth of literature on the topic of energy transition there are no uniformly used theories on the subject making it harder to define the term. The topic of energy transition is addressed by many different disciplines and depending on the discipline's approach there is a heterogeneity in the literature regarding its scope, used method and focus (e.g. energy transitions, low-carbon transitions or sustainability transitions). Additionally, because such a great variety of actors are involved in transitions, and because these processes are by their nature already highly "complicated, non-linear and multi-dimensional", individual theories and disciplines fail to address and describe these processes of change in their full form (Köhler et al., 2019, p. 2).

Despite these barriers, there are definitions of energy transition which capture the central goal of decarbonizing the energy sector and consequently the whole economy as defined by Şahin (2020, p.88): "Energy Transition as a form of major transformation aims to change the current status quo in the energy sector based on mainly fossil-fuel inputs […] to a low carbon […] structure".

The International Renewable Energy Agency (IRENA, n.d.) on the other hand defines it as follows: “The energy transition is a pathway toward transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century. At its heart is the need to reduce energy-related CO_2 emissions to limit climate change”. In this definition, a time frame was specified on when decarbonization should take place. The mid 21st century as a chosen point of time rests upton the fact that the IPCC forecasts in its report that it is necessary to reduce global net anthropogenic CO_2 emissions by 45% “well before 2030” and reach net zero by 2050 in order to limit the heating of the planet by the end of the century to 1.5°C (IPCC, 2018, p. 16).
However, this net zero target by 2050 is the subject of much debate and criticism, as it has different implications for different actors. Some of these points are analyzed in more detail by Broekhoff (2020), who argues that net zero emissions targets sometimes include all GHG, and sometimes only refer to CO_2 emissions. Also, the target date up to 2050 is clearly set too late for industrialized nations. From a development point of view, as well as from a perspective that considers the historical responsibility, a fair Carbon Budget states that industrialized countries will have to aim for an earlier net zero target. This is encouraged to avoid the delay of action, which is what some nations have already done. Norway, for example, is aiming for 2030, Finland for 2035 and Sweden for 2045 (Jackson, 2019). Still, even these targets are not ambitious enough for Extinction Rebellion supporters that call on governments to bring GHG emissions to net zero by 2025 to halt biodiversity loss (Extinction Rebellion International, 2020).
Another definition comes from Sovacool for whom an energy transition is an elapsing time in which “a new primary energy source, or prime mover” has been introduced while overtaking another source as the main share in the overall market. He refers in that context to O’Conner (2010) who describes a transition as a “set of changes to the patterns of energy use in a society, potentially affecting resources, carriers, converters, and services” (Sovacool, 2017, p. 17). This definition implies that change is not happening on a level of “individual energy technology or fuel source”, but rather as change in the overall energy system (Grubler et al., 2016, p. 18). Beyond that, these changes in the energy mix and innovation are generated “by a structural change in major subsystems of society” (Edberg & Tarasova, 2016, p. 170). This shows that an energy

transition is highly linked to social structures, as well as ecomomic operations. A transition to a low carbon economy is "not only a sustainable economic development pattern", but also "a new economy of having revolutionary significance, which will radically change the existing pattern of economic development and thereby produce a previously unknown major effect on socioeconomic activities of people" (Dou, 2015, p. 3).

The definition of the World Economic Forum (2018, p. 10) is covering many of the aspects that the previous mentioned authors have developed and defines an "effective energy transition" as a "timely transition towards a more inclusive, sustainable, affordable and secure global energy system that provides solutions to global energy-related challenges, while creating value for business and society, without compromising the balance of the energy triangle [security and access, environmental sustainability and economic development and growth]".

A definition that appears to be the most appropriate in the context of this work and which is based on the framework of the Sustainable Energy Transition (SET) by Sgouridis and Csala (2014, p. 2609) is the following: A SET it is a "controlled process that leads an advanced, technical society to replace all major fossil fuel primary energy inputs with sustainably renewable resources while maintaining a sufficient final energy service level per capita. […] A SET requires a coordinated transformation of both the energy supply and the energy demand side (economy) while the per capita energy serve levels (equity) are sufficiently maintained for the duration and the environmental constraints are met (environment)".

2.2 Leadership in energy transition

A term that is as vague and broad as 'energy transition' is the term 'leadership'. In the Oxford Handbook of Political Leadership it is concluded that "the study of leadership is a somewhat bewildering enterprise because there is no unified theory of leadership. There are too many definitions, and too many theories in too many disciplines" (Rhodes & Hart, 2014, p. 1).

The focus in the literature is predominantly on individuals in connection with leadership. However, in the context of this thesis the definition is not related to a person, but rather a social context or "the state" as an actor. The concept of "distributed leadership" presented by Peter Gronn (2000) has therefore been chosen as a basis. This concept assumes that the focus is no longer on the characteristics and actions of individual "leaders" but that leadership is rather understood as a collective social process through the interaction of different actors.

There are several terms being used to describe "actors of change" that are often used as synonyms in national and international environmental politics, such as *leader*, *pioneer*, *pusher state, first mover* or *pace sette*r which causes analytical confusion. Liefferink and Wurzel (2017) deliver a concrete differentiation between a *leader* and a *pioneer*. A leader has the urge to attract followers in contrast to the pioneer who is acting indifferent to the action of other actors however, the pioneer can still serve as an example for others, highlighting that the actor's motivations and positions are crucial to the classification. Nevertheless, in the following analyses of "leadership in energy transition" this will not be taken into account. This is due to the fact that the scale of the work does not allow the background to be explored as to whether and why a country wants a leadership position. The focus of this work is to identify countries that play a leading role in decarbonizing their energy system regardless of their intentions.

The next differentiation that is relevant in the context of the thesis is the distinction between leaders in energy transition and climate leaders. As the energy transition is an essential part to stem the climate crisis, publications that refer to climate leadership will also be examined, but with a specific focus on how energy indicators are implemented. Climate leadership is thus the overarching concept of leadership in the energy transition. Leaders of the energy transition, are above all, pioneers in the decarbonization of the energy sector. Whilst climate leaders are also exemplary in other sectors, for example in ending deforestation and restoring degraded forests or who promote the shift to less meat-intensive diets. A comprehensive definition of climate change leadership, which includes both the individual and the collective level, comes from May (2015, p. 47) who illustrates it as "a continuous, collaborative and transformational process with the purpose of overcoming the knowledge-action gap in adaptation and mitigation to the super wicket problems of climate change in order to sustain humanity within the planetary boundaries. A climate change leader then is everyone that works towards that goal despite an uncertainty in terms of methods and outcomes on a personal-local to a political-global level by applying interdisciplinarity and interpersonal skills in contextual change processes”.

Leadership is only possible if leaders are recognized by their followers, which is why the relationship between leaders and followers is also crucial for the analysis of leadership. The title is dependment on a subjective viewpoint, reliant on who is defining a leader and what they are using as evidence. Many actors describe themselves as leaders in a certain area, but the political practice of such rhetoric does not always confirm this. For example, a study analysed how potential leaders in the field of global climate change politics are perceived by prospective followers by interviewing 233 participants of COP14 in New Delhi. A clear finding showed that no single country solely wears the leadership mantle, but instead there are several actors simultaniously recognised. For example, the EU which declares itself as a climate leader, is accepted to be as such by almost two-thirds of respondents, wheras only 14% see the EU as the only leader in the field of climate change. It also stands out that respondents with an Asian, European, North American or Oceanic background identify the EU as a leader, whereas respondents with an African or Latin American background attribute a far greater role to China in climate protection. This shows that geographical belonging matters (Karlsson et al., 2011).

The question that now arises is; what kind of leadership is necessary to foster the energy transition? There is no clear definition in the literature that combines these two concepts on a theoretical level. A study by Meijerink and Stiller (2011) investigated what kind of leadership is needed for climate adaptation. They developed a framework to analyze leadership objectives, functions and tasks in climate change adaptation. Building on their framework, adapting it to the energy transition, the following paragraph lists the challenges which leadership must take into account in connection with the energy transition and what it needs:

“1. influence the policy process as to get [...] policies [that promote the energy transition] accepted and implemented;

2. enhance connectivity across different policy-making levels, sectors and actors” (Meijerink & Stiller, 2011, p. 5).

The challenges mentioned here indicate the so-called integrated policy design for rapid policy implementation. Coordinated actions are needed to ensure that the fight against climate change and the associated energy transition is defined as a priority in national policy and integrated into the various policy areas such as education, health or the economy. The way in which valuable resources such as land, energy and water are used can further fuel climate change. Therefore, the assessment of these resources must be integrated into political decisions in a holistic way. In addition it is of great importance that efficient resource management ensures that national climate and energy strategies are consistent (Gielen et al., 2019). However, there are also representatives who argue that the reduction of greenhouse gas emissions can only be attributed to a limited extent to national mitigation strategies or mitigation policies. In the past, reductions have been more likely to be due to the fact that the measures were not implemented at all; that the policies introduced were not related to national mitigation strategies; that they were caused by a switch to lower-emission energy sources and were generated more randomly; or that they were influenced by external factors such as the financial and economic crisis of 2008 or the relocation of carbon-intensive production abroad. Casado-Asensio and Steurer (2015) came to this conclusion and suggest that governments should instead realign their national mitigation strategies, using them primarily as a communication tool to build capacity. This would require a new approach to policy coordination.

2.3 Success factors for Leadership in Energy Transition

In the previous section it was discussed which characteristics define energy transition leader. The question now arises how such a leader gets there and what underlying factors lead to a pioneering position. The most important points for a successful change to a sustainable energy system will be presented here.

<u>Political condition</u>

The implementation of the energy transition depends on the political condition prevailing in a country. This includes good governance and accountability, but also the involvement of stakeholders in the process (Hirsch et al., 2017). Strong institutional and regulatory frameworks are prerequisites, which are especially present when the country is politically stable and when there are no geopolitical conflicts prevailing (WEF, 2019).

Political commitment

Achieving the objectives of energy transition, namely sustainability, security, affordability and inclusiveness require effective policy making and a high level of political commitment through supportive policy measures (WEF, 2019). Progress in terms of climate policy performance could be measured if strong commitments and ambitious positions were promoted at the international level. This would in turn have a positive impact on national energy policy and strategy (Burck et al., 2019a; WEF, 2019). According to the IRENA Coalition for Action (2019), the obstacles to change towards a 100% renewable energy system are not technical in nature, but mainly due to a lack of political will, sufficient government commitment and, above all, the mistaken belief that a 100% renewable energy system is not feasible.

This is also confirmed by a study of the Wuppertal Institute, which has investigated the possibilities that Germany has to keep the 1.5°C limit. The result shows that, from a technical and economic point of view, achieving CO_2 neutrality by 2030 is extremely difficult, but not impossible. The possibilities exist in all sectors to implement an energy transition, but this requires immediate action and, together with the willingness of society, the political focus. Nevertheless, the current climate goals of Germany's government are not compatible with limiting global warming to 1.5°C, but would lead to total CO_2 emissions that are more than twice as high (Kobiela et al., 2020).

Ambitious policy frameworks and targets

Combined with a strong political will for an energy transition, it is important to first set concrete goals and then formulate and implement stable, long-term and reliable policies. The energy system is characterized by a high level of complexity. Therefore, goals must be dealt with across sectors and precisely defined in their scope. This simplifies further planning, prevents greenwashing and ensures transparency and legitimacy. Such goals in turn motivate citizens, investors and other stakeholders to participate in the transformation and thus send them an important signal (IRENA Coalition for Action, 2019).

Net zero carbon targets alone are clearly not enough to delay global warming, but they are an important benchmark. The targets provide an end-date that governments can work with in order to formulate national strategy for a carbon-free future. Norway is a pioneer in this respect and was one of the first countries in the world to discuss climate neutrality. They declared that they would be climate-neutral by 2030 with international offsets and domestically climate-neutral by 2050. However, it is important to note that this agreement is not yet legally enshrined in law (M. Darby & Gerretsen, 2020).

The quality of the process in terms of stakeholder involvement or information provision is also given high priority. National stakeholders can provide vital inputs to the national plans and their expertise is of utmost importance for the implementation of policies. As many stakeholders as possible should be involved in order to ensure social approval for the measures defined in the implementation energy transition plan. This is key to sucess due to the interrelationships between the various sectors, because no single stakeholder group can manage the transition by itself (ECF, 2019).

Ultimately, the energy transition will be implemented at regional and local levels. Therefore, EU or national policies should be supported by regional/local energy agencies, business networks, consumer advice, and forms of citizen participation or citizen financing (Hennicke et al., 2019). Such a polycentric governance approach is based on the fact that several self-organized and independent decision-making centers coexist on several levels, but are subject to the same overarching set of framework. This perspective, which is much more flexible than a policy-centered approach, can help to make future energy systems more resilient and accelerate the transition to a carbon-free society (Bauwens, 2017). One example of how the local level can be integrated into the national and international levels is the creation of REScoop.eu (2020), an association of RE cooperatives that supports renewable energy development and represent a network of 1500 European “REScoops”.

Regional economic and social councils could also play a greater role. Various groups and movements that are committed to certain questions about the future have a growing urge to help shape political processes and are calling for greater participation and transparency. Examples of such movements include the worldwide "Fridays for Future" demonstrations by schoolchildren, or the struggle for the Hambach Forest in Germany to prevent further coal mining there. These movements often emerge against the background that "during legislative periods, the financially powerful influence of lobby groups for partial capital interests increasingly prevents proactive policies" (Hennicke et al., 2019, p. 122). It is necessary to consider how public welfare interests can be promoted through institutionally secured influence in order to create an equal negotiation process between stakeholders. One organizational concept could be the so-called "councils of social-ecological transformation" in which representatives of labor, capital, politics, and NGOs, as well as representatives of "sustainability-oriented science" are involved (cf. ibid.).

Cheung et al. (2019, p.641) define Germany as "a reforming outlier when compared to other nations within Europe and internationally" in regards to the energy transition. They have identified success factors for the German energy transition between 1990-2017 and argue that Germany has a very coordinated political style and relies heavily on stakeholder interaction. This enables citizens to strongly influence political decision-making processes, which in turn minimizes the influence of large energy suppliers. This tradition began during the anti-nuclear movement which promoted alternative renewable energy and led to the founding of the Green Party in 1980. Then as now, grassroots movements play a major role in shaping the energy transition discourse in Germany.

A further example comes from the UK which also "emerged as an international leader in the area of climate change" (Laes et al., 2014, p.13). It is the only country in the world to have implemented its long-term goals for emissions reduction in a legally binding framework, namely the "Climate Change Act", in which one of the focal points is also "institution building". A Committee on Climate Change (CCC) has been established for this purpose, which can independently give expert recommendations to the government. According to the NGO Client Earth, this has had a major impact on policies, for example in the introduction of the 80% reduction target by 2050, the introduction of five years carbon budgets, and the establishment of a clean coal technology framework (cf. ibid.).

Although many long-term goals for the sustainable modernisation of energy supply are set globally and then formulated in terms of regulations and guidelines, implementation at national level is carried out in cooperation with local actors who are also able to understand and take into account the needs and capacities of the population (ECF, 2019; WEF, 2019).

The IRENA Coalition for Action (2019) writes in this regard that “many of the national 100% renewable energy commitments and policies originate from community-led local and regional initiatives advancing comprehensive sustainability and development goals. Local-level policy development can shape and drive national governments to remove legal and institutional barriers. Conversely, local renewable energy policy-making processes are enhanced when the national government adopts an enabling framework including commitments to a clear, time-bound target" (ibid. p.7).

At the same time, the process must be transparent and the plan must provide sufficient details. This includes, for example, a precise description of the measures planned for implementation, the ambition to close certain loopholes in law (CMW & T&E, 2017), as well as a description of what impact this will have on the formulated energy and climate targets (ECF, 2019).

A coordinated approach and structural changes that transcend economic, technological and socio-political systems are needed to achieve the goals of the Paris Agreement and enable different economies to overcome their carbon dependence. To achieve this, a large number of non-climate areas must be linked together (WEF, 2019). The areas of development, social, educational, financial and energy policy must be brought together and a separate program for a just energy transition must be established. This could take the form of a program for sustainable rural development and social protection (Hirsch et al., 2017). In the long term, integration across policy areas must lead to more efficient planning processes, which requires interministerial coordination and investment in people and processes (ECF, 2019).

Country-specific circumstances must be taken into account too when implementing the energy transition, since the primary energy mix, the structure of the energy system, and the endowment with natural resources differ from country to country (WEF, 2019). Therefore, there is no uniform approach to how countries can achieve their 100% renewable energy target, thus requiring further analysis in terms of targets, policies and planning at the national level (IRENA Coalition for Action, 2019).

However, in the *IPCC Special Report on Renewable Energy Sources and Climate Mitigation* an effective policy is defined as "the extent to which intended objectives are met, for instance the actual increase in the amount of RE electricity generated or share of RE in total energy supply within a specified time period. Beyond quantitative targets, factors may include achieved degrees of technological diversity (promotion of different RE technologies), which is considered a crucial factor for dynamic effectiveness (long-term sustained growth that enables innovation and the development of manufacturing base), or of spatial diversity (gergraphical distribution of RE supplies)” (Mitchell et al., 2011, p. 883).

To make a policy efficient, it is necessary to model a sustainable energy policy, which is normally developed in a cycle of six processes, namely policy design, policy implementation, policy monitoring, policy assessment, policy feedback and policy amendment. Lu et al. (2020) show that modelling must be applied acrossed systems to reflect the complexity of the new technologies. They analyse and list various simulation studies with the most important methods for modeling energy policies.

Renewable energy policies

The expansion of renewable energies is hindered by two main types of market failure. On the one hand, there is a lack of internalisation of environmental externalities. The electricity market is liberalised, so that consumers who want to buy green electricity can also buy it from certain suppliers. While some do so, most consumers are not yet willing to pay a higher price for a public good from which the general public benefits. Incentives in the form of tax breaks for green electricity consumers are therefore needed. Furthermore, this market failure could be addressed by carbon regulations. Another market failure that occurs as a consequence of the first failure is the unequal competition between renewable and fossil fuel energies which needs adressing through the use of incentive systems. The government must counteract this market failure so that renewable energies can compete in the energy markets. Renewable energies have not yet reached their optimal performance in terms of cost and reliability, but “it is not because a particular technology is efficient that it is adopted, but rather because it is adopted that it will become effiecient” (Menanteau et al., 2003, p. 801).

There is an abundance of political instruments that promote the expansion of renewable energies and Sarti (2018) illustrates the most widely used ones using three categories, namely investment-based, operational support and consumer facing policies. Investment based policies are mostly composed of instruments that support companies focused on expanding renewable energy (e.g. through tax breaks) or they provide less support to carbon intensive companies. Investments, or rather fiscal and financial instruments are discussed in more detail here.

- Financial instruments: Large investment volumes are necessary to implement climate and energy strategies and to guarantee progress.

Therefore the state must be able to create investment opportunities and attract capital and financial resources on a large scale (WEF, 2019). Industrialized countries must also keep their promise and increase their financial resources for climate protection measures and resilience in vulnerable countries, in addition to reaching the target of US$ 100 billion annually (Burck et al., 2018). Hirsch et al.'s opinion on that is that "investments in the energy transition should be accompanied by investments in the world's rust and coal belts and their populations that help them to cope with unavoidable economic change and to maintain their dignity and make their regions properous again" (Hirsch et al., 2017, p. 8). However, it is not only the lack of access to capital or the lack of political measures that prevents the dissemination and progress of technologies. In the view of the WEF (2019), the supply of renewable energy (solar photvoltaic and onshore wind) only accounts for 1.6% of the world's energy, despite years of capital investment or a political environment that is positive about renewable energy and electric vehicles. It is therefore also important that countries identify their investment needs and financing measures and that the EU states define these in their national energy and climate plans (ECF, 2019).

Between 2015 and 2050, a total of 22.3 trillion USD will need to be invested in renewable energies. However, by 2050, about 6 trillion USD per year can be saved again through positive externalities such as reduced air pollution, improved health or mitigated environmental damage in these areas. Both public and private funds are important for funding, which must be attracted by additional pools of capital. These include large institutional investors, but also community financing groups that must be integrated into the renewable energy sector. In addition, financing in the fossil fuel sector must be channelled into renewable energy projects, which would also release significant investments (IRENA Coalition for Action, 2019).

Through grants or loans from public funds, governments can invest in RE projects to support them and encourage initial investment by reducing equipment costs and removing market barriers. Banks and other financial institutions, such as venture capital organizations, usually provide private sector funding, which is either in the form of favorable loans or structural funds (Abdmouleh et al., 2015).

A report by CAN Europe has shown that there is enormous potential in the EU regional development funds in particular, and that these are used by very few EU countries to invest in clean energy infrastructure. The countries should urgently review how the EU budget will be spent in the future and draw up long-term investment plans that give top priority to climate neutrality as "it is the EU's investments between now and 2030 that will make or break the bloc's response to the climate crisis" (CAN Europe, 2020, p. 27).

In order to attract private investors, policy-makers should use the existing instruments to minimize risks for them. These instruments include, for example, marketing and information campaigns aimed at making private investors aware of existing risk mitigation instruments for renewable energy projects. In addition, institutional procedures governing access to financial instruments must be optimized. For example, risk assessment templates and risk assessment methods could be developed that are replicable and thus applicable across projects (IRENA, 2016).

Furthermore, innovative financing systems are needed to ensure the development and market introduction of sustainable energies and there is great potential in citizens investing in renewable energies. Consumer ownership of renewable energies is not only essential for the acceptance of energy infrastructure projects but also for the success of the energy transition in general. For example, more than 40% of renewable energy in Germany is owned by private individuals, and so called mandatory participation programs, as they exist already in Germany or in Denmark could foster this development in other countries as well (Lowitzsch, 2019).

- Fiscal instruments: To ensure that energy from renewable energy sources is more competitive with fossil or nuclear energy, but also to include the additional external costs of conventional energy sources, the following fiscal measures can be taken: On the one hand, companies or individuals investing directly or indirectly in renewable energy can be granted tax exemptions, reductions or incentives, and on the other hand, carbon or energy taxes can be introduced on fossil or nuclear energy sources to change energy consumption (Abdmouleh et al., 2015).

According to the IMF, the most effective instrument to achieve the Paris climate targets is a carbon tax. It has been calculated that a global carbon tax of USD 75 per tonne of carbon dioxide could save 725,000 premature deaths from air pollution in the G20 countries by 2030 and reduce emissions by 35% (IMF, 2019).

Although it is often assumed that the taxation of carbon is a regressive tax and that people would resist and protest against it, the countermeasure is that the money collected through the CO2 tax is repaid as CO2 dividends. This is progressive because wealthy people spend much more on carbon than poorer people (Baker & Shultz, 2020). Such mechanisms are already being used successfully. In Switzerland, for example, one-third of the annual revenue from the tax goes to energy-efficient building renovation or a technology fund, and two-thirds of the taxes are returned to the population and the economy. In Canada, on the other hand, socially undesirable distribution effects are prevented by the fact that taxpayers are repaid a large portion of the tax revenues. There, 70 percent of households ultimately paid less CO2 tax than was refunded later. Acceptance can therefore be increased through effectively used refund instruments (Hennicke et al., 2019).

However, to avoid distorting the system and sending the wrong signals, it is important to levy the carbon tax on all uses (Bond, 2020).

Operational support strategies are divided into quantitative and price based approaches. Quantitative approaches are usually linked to a certificate trading system and have either a production level for renewable electricity (quota obligations/ renewable portfolio standards) or a limit for a total amount of greenhouse gas emissions (emissions cap). Companies that cannot meet the level of renewable energy then trade with companies that have exceeded their targets. The emissions cap is a political mechanism that is more comprehensive and covers not just the electricity sector, but also other sectors of the economy. However, this only indirectly strengthens renewable energy sources. In tenders, the provision of certain quantities of electricity from a certain technology is announced and the cheapest offer is then selected. In the case of price-based mechanisms, the instruments available are either feed-in tariffs, which set a price for renewable electricity, or a carbon tax, which increases the price of fossil fuel energy.

Consumer facing policies for renewable energy attempt to steer the behavior of electricity consumption by providing more options or information. These include mandatory green power options or disclosure programs. Net metering (also called billing policy), on the other hand, allows customers to feed energy generated by solar energy for instance, back into the grid (cf. ibid.).

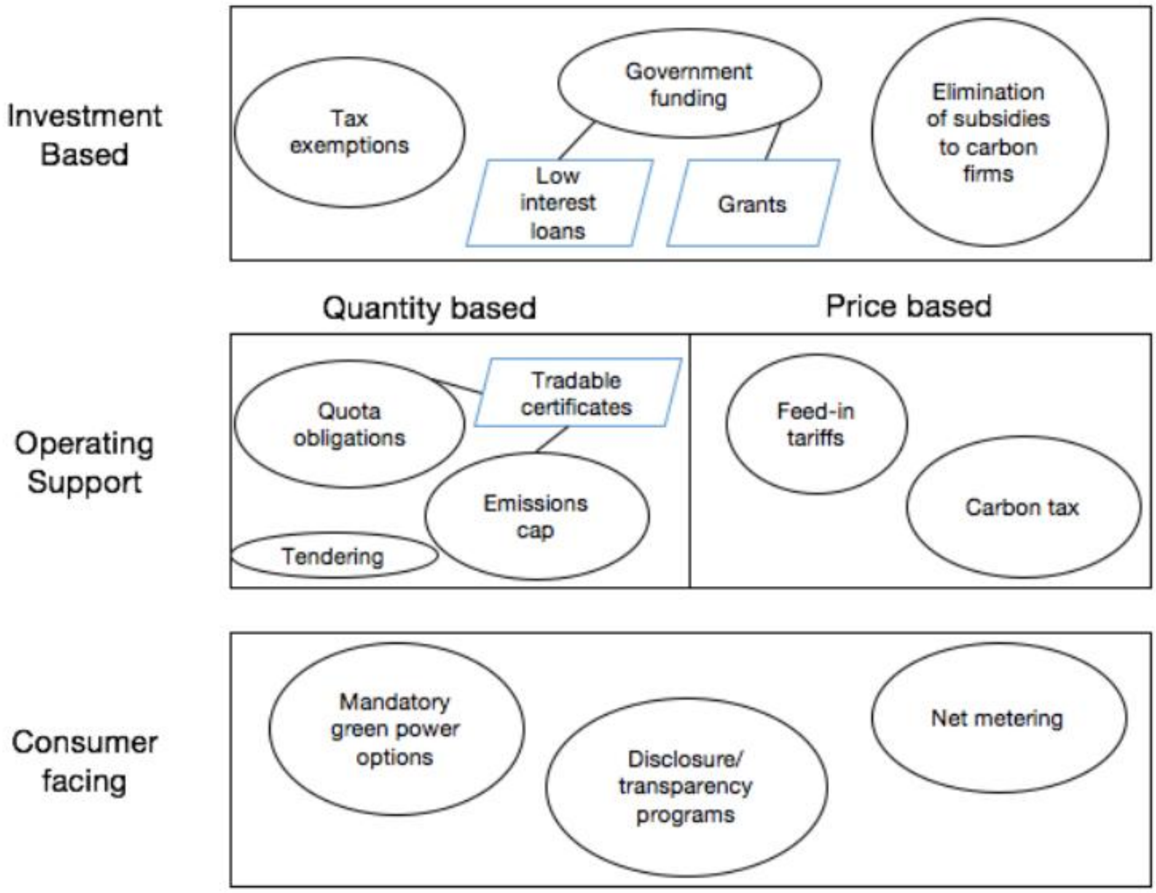


Figure 4: Renewable policy universe schematic (Sarti, 2018)

However, no single policy alone can be identified as having a positive effect on the integration of renewable energies in a country. Rather, most countries pursue a "policy package" approach or a mix of different strategies. Thus “success or failure of one individual policy will depend on the effectiveness of other complementary policies. Besides, several political, social and economic factors contribute to the impact of these policies” (Abdmouleh et al., 2015, p. 253).

Yet in the case of support systems, various studies have shown that price-based mechanisms are superior to quantity-based systems (Abdmouleh et al., 2015; IG Windkraft, 2015; Sarti, 2018). For example, countries such as Germany, Spain and Denmark, which have introduced a feed-in tarif (FIT) system, have achieved lower electricity prices and have thus been more successful in increasing their share of renewable energies than countries such as the UK and Italy, which have introduced a quota system (Abdmouleh et al., 2015).

There are some examples of how variable renewable energy can be integrated into electricity systems without compromising grid stability. The following figure (fig. 5) shows the top 10 countries that are at the forefront of wind and solar PV penetration and have achieved significant production levels. Among them are Denmark, Uruguay, Germany and Ireland (REN21, 2018).

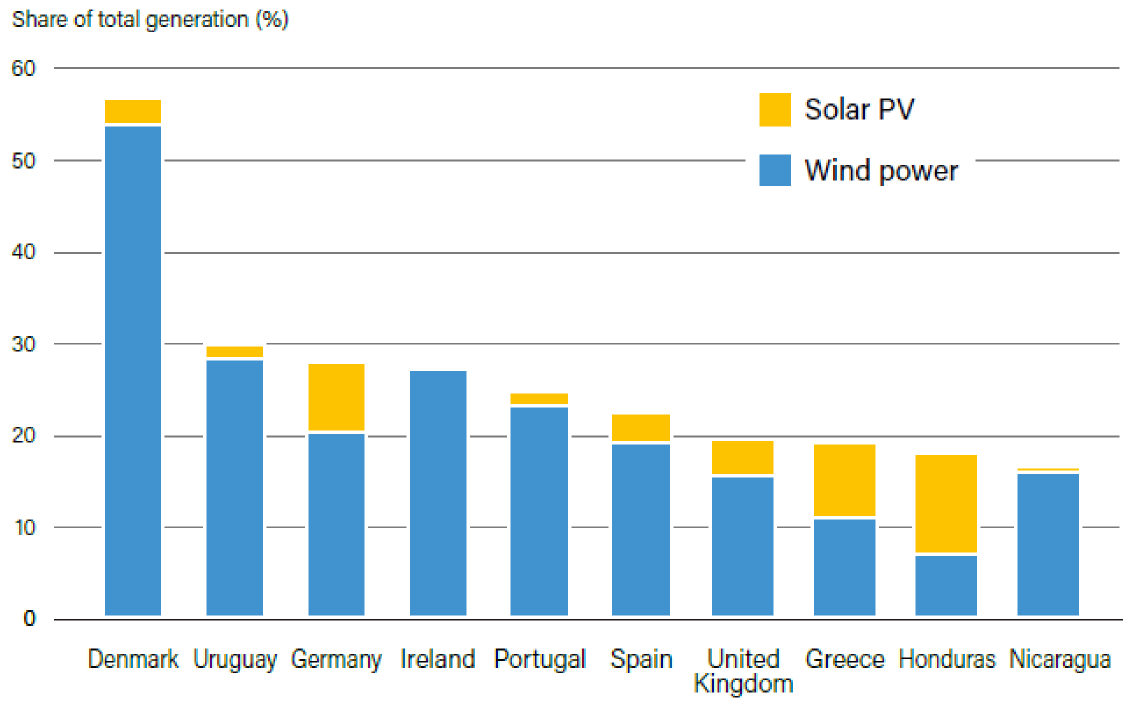
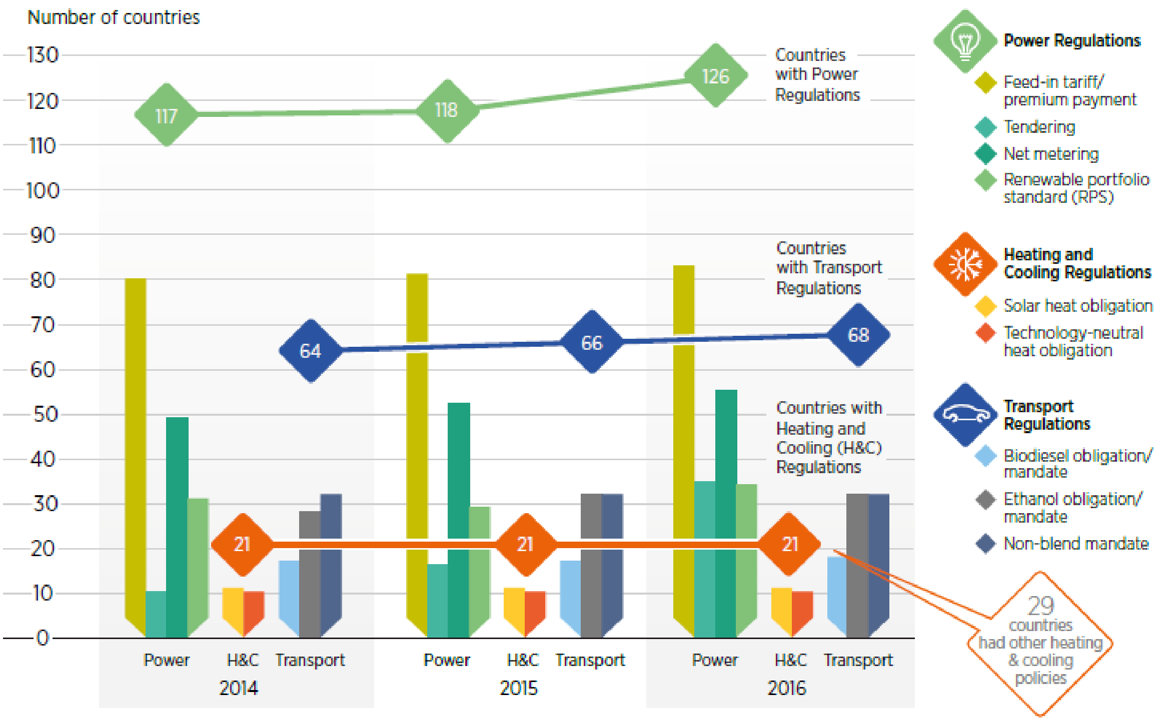


Figure 5: Share of electricity generation from variable renewable energy, top 10 countries, 2017 (REN21, 2018)

The graph shows that Denmark has a leading role when it comes to wind energy. A wide variety of actors, from scientists, municipalities, industry, NGOs, to public actors and interested citizens, have been responsible for the introduction of wind technology. The Danish society established a new industrial, market and energy pathway and was supported by the government with strategic policy adjustments. Innovative approaches in policy and planning have been used in the development of Danish wind power, and cooperative engagement has played an important role. For example, offshore wind projects are implemented in cooperation between project developers and the Danish Energy Agency, "while the character of offshore wind projects shifted from directly negotiatied/imposed governmental-utility deals to competitive auctions, an 'open door' policy in which a developer can propose an unsolicited project is also maintained".

The main responsibility for onshore wind power projects lies with the communities and a crucial innovative policy for clean energy was also the *community-level competition to mobilize regional demonstration* which makes the region that wins the competition energy self-sufficient (Araújo, 2014, p. 174).

In general, renewable energy targets and policy that cover all sectors and not just the electricity sector should be formulated (ECF, 2019; IRENA Coalition for Action, 2019; WEF, 2019). In the energy sector the energy transition is already more advanced, but it is time that we "move from an electricity transition to an energy transition". The heating, cooling and transport sectors is falling behind whilst they account for around 80% of total energy demand worldwide (REN21, 2018, p. 9). By now, only a few countries implement measures in these sectors as demonstrated in figure 6.



Note: Figure does not show all policy types in use. In many cases countries have enacted additional fiscal incentives or public finance mechanisms to support renewable energy. Heating and cooling policies do not include renewable heat FITs (i.e., in the United Kingdom). Countries are considered to have policies when at least one national or state/provincial-level policy is in place. A country is counted a single time if it has one or more national and/or state/provincial level policies. Some transport policies include both biodiesel and ethanol; in this case, the policy is counted once in each category (biodiesel and ethanol). Tendering policies are presented in a given year if a jurisdiction has held at least one tender during that year.

Figure 6: Number of renewable energy regulatory incentives and mandates, by type, 2014-16 (IRENA et al., 2018)

Energy efficiency policies

Not only do renewable energies need to expand in order to achieve climate neutrality, but also the increase in energy efficiency is of paramount importance. Countries will only be able to achieve net zero emissions if they are able to operate more energy efficiently and reduce the energy demand for products and services (Burck, 2019b). The IRENA Coalition for Action writes: "Policies for increased energy efficiency are paramount for achieving milestones and targets on the way towards 100% renewable energy. With reduced energy consumption and more efficient applications and standards, higher shares of renewable energy can be achieved with less new or upgraded capacity. This also helps acceptance problems in densely populated areas" (ibid. p.17).

A selection of important policies are presented in this section. However, these are only one part of the "perfect policy mix", which must always be further developed:

- Standards and regulations for products: Although the industries concerned are very strongly opposed to minimum standards, limit values or regulations on the production side, it has been shown that these are very effective instruments. According to Lu et al. (2020) so called Energy Efficiency Standards (EES) are the key policy to improve energy efficiency. Positive effects at the European level have been achieved by limiting CO_2 in passenger cars or the Ecodesign Directive for some energy-intensive products (e.g. lighting) (Hennicke et al., 2019).
- Feebates: "A 'feebate' is an incentive-based environmental policy instrument that combines fees on high-emission products with rebates on low-emission products to incentivise development and commercialisation of emission control technologies" (Johnson, 2006, p. 1). This system is also called "bonus-malus". In 2008, France successfully implemented such a system to improve vehicle efficiency while reducing both fuel consumption and CO_2 emissions. Buyers of new vehicles can either pay a fee (malus) if the vehicle is above a certain CO_2 emission level or receive a discount (bonus) if they buy a vehicle that is below this limit (Yang, 2018).
- Mandatory energy savings for energy suppliers: Distributors and suppliers of energy should be given binding energy saving targets (Energy Efficiency Obligation Schemes). Energy suppliers could benefit by the implementation of such program from cost recovery mechanisms and incentive regulations,

which are guaranteed returns on the program costs of promising energy saving programs. So far, 14 countries in the EU have implemented such programs, although most of them are still very modest. The countries that stand out positively here are Denmark, France and Italy (Hennicke et al., 2019).

- National governments should establish national energy efficiency agencies, which are given the responsibility to design, manage, coordinate, promote and evaluate energy efficiency policy processes to fill the implementation gaps of the efficiency targets. These agencies should be provided with the necessary personnel resources, as well as with a dedicated energy efficiency fund to provide resources for incentives and programs (Wuppertal Institut, 2013).

In order to analyse the growing trend in energy consumption in a national context, the European Commission set up its own task force in 2018 with the mandate to present solution proposals. This task force then identified as causes the "delayed implementation of energy efficiency policies within Member States; differences between estimated energy savings and actual energy savings achieved; insuffiecient consideration of the impact of behavioural aspects (e.g. rebound effects); the lack of funding for energy efficiency policies; and restictions related to EU state aid rules" (EEA, 2019, p. 54).

A study by Ecofys Germany (2017) on the other hand concludes that the policy packages for the various sectors in the field of energy efficiency at EU level have a few shortcomings and that the most important instruments are contained in them. However, shortcomings in the effectiveness of the existing instruments have been identified and priority should be attached to improving measures already in place by:

1. ensuring sufficient resources for an ambitious energy efficiency policy in the Member States
2. creating positive narratives on the numerous benefits of energy efficiency (policies) at EU and Member State level and
3. communicating these narratives and benefits more effectively.

However, the increase in energy efficiency is also strongly related to promising technological developments such as increasing costs for renewable energy technologies or advaned storage solutions (Burck, 2019a), as well as new innovation, which again is related to research and development.

What hinders the further expansion of renewable energies, is a still partially inflexible power grid, as this reduces the required grid capacity and leads to frequent limitations. However, this process could be accelerated by so-called sector coupling (IRENA Coalition for Action, 2019), which "encompasses co-production, combined use, conversion and subsitution of different energy supply and demand forms – electricity, heat and fuels" (IRENA et al., 2018, p. 93). Depending on the sector, sector coupling looks different. In the energy sector, it means electrifying transport, heating and other sectors of the economy where electrification has been slow to date. In sectors that are difficult to electrify, sector coupling means that lower-carbon gases are used in these sectors and connections are established through, for example, power-to-gas or storage facilities. In the construction sector, on the other hand, district heating networks will be set up and households equipped with electric heat pumps, solar panels, batteries or intelligent control systems. For some experts in energy policy in the EU, however, sector coupling means that the supply and demand of energy must be completely reconsidered and a centralised approach to energy production solely focused on supply is rejected (Simon, 2019). In the extension of sector coupling, the main obstacle is mainly the regulation, which establishes coordination between commodity markets and services. Pilot projects need more financial support and these should also exchange information with other projects and openly share their information and results. In addition, in order to speed up implementation, they should include the analysis of regulation and markets and involve cross-sectoral stakeholders so that synergies can be used efficiently (Münster et al., 2020).

Divestment from fossil fuel industry

Another important part of the energy transition is the requirement to abandon the further expansion of fossil fuel production and the managed phase-out of the fossil fuel industry (Oil Change International, 2016). One of the priorities should be to ensure that public subsidies for fossil fuels are channelled into renewable energies, thus eliminating the price distortions that currently prevails. According to the International Monetary Fund (IMF), the figures for fossil fuel subsidies (here defined as fuel consumption x the gap between existing and efficient prices) in 2017 amount to approximately \$5.2 trillion, or 6.5 percent of GDP

(Coady et al., 2019). On the other hand, a report by the International Institute for Sustainable Development (IISD) estimates that the oil, coal and gas industry is supported with $370 billion per year compared to renewables, which receive only $100 billion. If only 10-30% of the $370 billion is redistributed, it would be possible to finance the energy transition and drastically reduce emissions (Bridle et al., 2019).

For a long time the focus in climate and energy policies has been mainly on the demand side of fossil fuel, targeting renewable energy, energy efficiency or smart market signals, hoping that the supply side regulates itself. But there are some scientists (F. Green & Denniss, 2018; Lazarus & van Asselt, 2018) that argue that the focus should be at supply and demand side policies at the same time and that targeting just one side is not effective enough. Thus, it is necessary to not only close the emissions gap to stay within the carbon budget, but also the production gap. The production gap is the difference of between what countries are producing and what they actually can produce to stay below the 1.5°C pathway. Examples for such policies that restrict or redirect fossil fuel production and investment would be extraction or exploration limits, producer subsidy removal, production or export taxes or compensation for resources undeveloped (cf. ibid.).

Countries such as Denmark, France, New Zealand and Spain, but also countries from the Global South such as Belize and Costa Rica have already taken first steps to abandon its fossil fuel production by adopting supply-side approaches. "These 'first movers' in the area of supply-side action are critical for their demonstration effect, which suggests that such approaches can form a practically and politically feasible component of the climate policy toolkit" (Piggot et al., 2020, p. 4). However, among the largest producers, no country has yet been found that has effectively taken supply-side initiatives to reduce production. In all three fossil fuel sectors, of the ten largest producers, Germany is the only country that is showing the first signs of stopping production for climate-related reasons (Piggot et al., 2020).

Moreover, the expansion of renewable energy is slowed down by parallel subsidies for renewable energies as well as fossil and nuclear energy (IRENA Coalition for Action, 2019). This is why the main recommendation is to phase out coal as soon as possible and ban its combustion (Burck, 2019a; ECF, 2019).

Technical innovations

Better solutions must be found to solve the problem of intermittency in renewable energies from sun and wind and to guarantee an on-demand use of the electricity generated. This requires; storage facilities to be able to use the electricity generated at another time, a redesigned electricity grid, and an expansion of capacity for which investments are needed (Heinberg & Fridley, 2016). Furthermore, some sectors are particularly difficult to decarbonise. These include the energy-intensive industrial sector, for example in chemicals and petrochemicals or in the production of iron, steel and cement. In addition, road freight transport, shipping and aviation are facing major technological challenges and solutions are either not yet available or the costs for their implementation are too high. Therefore, innovations in these sectors are of high priority making a fundamental focus on research and development (R&D) and its finance is necessary. In particular renewable hydrogen and carbon capture and storage (CCS) for further electrification are areas where a lot of research is being carried out (Gielen et al., 2019).

However, low-carbon innovation will be spurred most of all if the government shows the necessary commitment and pursues ambitious climate targets and provides the framework to create new climate-friendly businesses, restructure old ones and address potential skills gaps in labour market policies. For example, if negative external costs are internalised through taxation, companies will be encouraged to develop or deploy lower-carbon technologies (OECD/ IEA et al., 2015).

Social innovations

Most of the time, a focus is placed on technological innovation by supporting the creation of new markets and jobs or by trying to make companies more competitive. However, social innovations that modify business practices, financial mechanisms, consumer practices or community activism are also important to recognise (Laes et al., 2014). Especially advanced economies with a high carbon footprint should focus on social behavioural change to reduce the general need and consumption of energy. "To avoid enormous over-all system costs for capacity reduncancy, energy storage, and multiple long-distance grid interconnections, it will be necessary to find more and more ways to shift electricity demand from times of convenience to times of abundant supply, and to significantly reduce overall demand" (Heinberg & Fridley, 2016, p. 8).

However, it is still a major challenge for countries to accelerate these socio-technological innovations. Some countries have already succeeded in achieving a relative decoupling of economic growth from resource consumption, but then this effect has been neutralised by the rebound effect, consumption has risen again through the use of more efficient technologies (Jänicke, 2012).

In order to counteract the rebound effect which negates the intended success in energy savings, the integration of sufficienct policy into energy efficiency policy is proposed, whereas energy sufficiency is defined as: "a state in which people's basic needs for energy services are met equitably and ecological limits are respected" (Darby & Fawcett, 2018, p. 9).

According to Bertoldi (2017), the mechanisms already mentioned above, such as energy or CO2 taxation, information campaigns, progressive minimum standards or the promotion of feedback devices that provide information on current energy consumption, are instruments designed to prevent the decreasing energy consumption from being compensated by the use of larger appliances, larger living spaces or changed usage behavior.

2.4 Challenges

Social and justice issues

The energy transition will have an enormous impact on industrial systems and thus on the social structures of society, various business sectors and on the economy. This will not only generate many winners but may negatively impact some people should the energy transition not be initiated in a just way. This would imply that the needs of the most vulnerable people are considered when implementing policies (Hirsch et al., 2017). The expansion of renewable energies should not repeat the exploitative measures of traditional energy industries. Instead it should focus to strengthen disadvantaged communities, by implementing the energy transition on a decentralized basis, meaning more citizen participation and transparency (Nava, 2019). The government, as a financier of renewable energy projects as well as of research and development in that area, must guarantee that these cash flows are distributed in a fair way and that the benefits of clean energy are available to anyone (Gearino, 2020). This for instance would mean including considerations of gender and rasicm into the

renewable industry by highlighting the challenges and power imbalance that minorities or discriminated people face in the connection of energy transition. It is important to address these obstactes. For instance, so far women have been underrepresented in the discourse, making up only 32% of the renewable energy workforce (IRENA, 2019).
Heffron and McCauley are trying to review what a "Just" Transition means in the three different scholar communities of climate, energy, and environment (CEE) in order to formulate a united concept of Just Transition. According to their definition "climate justice concerns sharing the benefits and burdens of climate change from a human rights perspective", "energy justice refers to the application of human rights across the energy life-cycle [...]; and [...] environmental justice aims to treat all citizens equally and to involve them in the development, implementation and enforcement of the environmental laws, regulations and policies" (Heffron & McCauley, 2018, p. 74). They highlight that research is mainly focused on economic factors and that the dominant neo-classical approach is prevailing policy-making which is impacting social justice. According to Weis et al. (2015) the British Centre for Sustainable Energy (CSE) proposed the use of the term energy justice on a national level and to use the term climate justice in an equivalent way on a global scale.
Hirsch et al. refer in their study to the "Guidelines for a Just Transition Towards Environmentally Sustainable Economies and Societies for All" drawn up by the International Labour Organization, which are summarized as the following;

"1) Strong social consensus on the goal and pathways to sustainability
2) Policies that respect rights at work
3) The recognition of the gender dimension of environmental challenges and opportunites, and the consideration of policies to promote equitable outcomes
4) Policy coherence across economic, environmental, social, education, training and labor portfolios to generate and enabling environment for the transition
5) The anticipation of impacts on employment, social protection for job losses and displacement, skills development and social dialog – including the right to organize and bargain collectively
6) The need to take into account specific conditions of countries, including their levels of development, economic sectors and enterprises – i.e. no "one size fits all" solutions.

7) The importance of fostering international cooperation among countries” (Hirsch et al., 2017, p. 17).

A global climate crisis and a Just transition cannot be solved by individual actors and states alone, making alliances necessary. Strategic partnerships and top-level alliances between actors are the key for sending a strong signal for greater ambition (Burck et al., 2019a). Cooperation between governmental and non-governmental actors are becoming increasingly important to meet the demands of climate and social justice (Burck et al., 2019a; Hirsch et al., 2017; WEF, 2019). In particular, the role of civil society in the process of energy transition should not be underestimated. The protests in Chile, Haiti, Ecuador and France show that "climate and social justice are two sides of the same coin". The principle of social justice must be central to climate protection measures in order to achieve social acceptance and a climate-neutral society (Burck et al., 2019a). The obstacles of equity and justice in the energy transition require that distributional aspects and unfavorable consequences for local societies are being closely examined. Those who experience negative impacts due to energy transition through energy extraction, production and generation, and thus face the negative externalities of a decarbonised economy, must be integrated into the process and dialogue, otherwise political resistance and social unrest can be expected (WEF, 2019). Social impact assessments for the energy transition, which also includes gender impact assessments, should therefore become an essential component of energy policy in order to build up the resilience of vulnerable social groups (Hirsch et al., 2017). Furthermore, consultation approaches such as standards for free, prior and informed consent (FPIC) could be used to minimize impacts on communities and ecosystems by promoting renewable resources (Westenberg & Kuai, 2018).

Aviation and shipping

The transport sector is currently responsible for the strongest growth in CO_2 emissions and, according to the International Transport Forum (ITF, 2019), the volume of freight and passenger traffic will triple between 2015 and 2050 if the current demand trend continues. This will increase the emissions share of the international transport sector in the future. It is expected that the domestic emission reductions can be achieved through the voluntary commitments of countries in the NDCs (Esmeijer et al., 2020). In general, there are still considerable gaps in the countries' NDCs and hardly any listed measures to reduce emissions in the transport sector. Only 8% of the countries have specific targets for reducing transport emissions and only 4 countries have measures planned to reduce emissions from the aviation industry (Sail to the COP, 2020). Therefore, more specific targets and measures anchored in the NDCs, including international air and freight traffic, are urgently needed.

The aviation and shipping sectors are not included in the UN Climate Convention because of their international character and the difficulty of allocating emissions to specific countries. However, they pose major challenges for emission reduction due to their dependence on oil-based fuels (Energy and Climate Intelligence Unit, 2018). Instead, the two UN agencies, the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) were mandated to regulate these sectors. However, for several reasons, these agencies are unable to do so and the presence of a strong industry lobby is especially hindering plans to reach a decarbonisation of the sectors in the next 20-30 years (Pape, 2019). The IMO's strategy, adopted in 2018 and addressing international shipping emissions, is totally inadequate. Its target to halve emissions by 2050 is not supported by policies, even though there is potential to fully decarbonize the sector by 2050. The same inadequate approach applies to CORSIA, the system for offsetting and reducing CO_2 emissions for international aviation. Between 2021 and 2025, this system covers less than 50% of international aviation emissions and will not allow real emission reductions elsewhere, even if offsetting takes place. Indeed, CORSIA is rather designed to allow for carbon-neutral growth than actually reducing aviation emissions (Climate Action Tracker, 2020).

Sustainable development

In order to ensure a balance between social, ecological and economic interests when implementing the energy transition and thus guarantee the aspect of sustainability, some experts suggest that the transition in energy systems and the transformation towards a low-carbon society should be understood as development that should be associated with development studies and analysis of development pathways. For instance, Kirby and O’Mahony (2018) have launched an attempt to draw on the knowledge gained from almost 60 years of international development research and the lessons learned from practical development efforts in order to link it to the challenges of climate change. Their argument is that the sole consideration of climate protection and climate policy is insufficient to generate serious progress towards a low-emission society. There is a need for a general change in development paths, which not only takes technological and economic factors into account, but also critically considers the characteristics of these development paths. This would mean that "the development path must be fully integrated across government policy from economic development, energy policy, tax and incentives, spatial planning and research and development, to environmental protection, sustainable development, industrial development, transport, agriculture, food and even related areas such as health and social policy" (cf. ibid.: p. 66f.). These policies should only consider the economy and technology as means to achieve a sustainable low-carbon transition and put human and environmental wellbeing at the center of the development pathways. Thus, the debate should also focus more on undifferentiated income growth and certain lifestyle and consumption patterns, instead of only addressing efficiency gains and technological advances (Hubacek et al., 2017). It is necessary to shift the focus from the cost of certain energy choices and technologies, to political processes and how power structures are manifested in the rhetoric by the elite. Therefore, Edberg & Tarasova (2016, p. 171) argue that "We need to understand how politicians frame energy and energy transitions in relation to their larger ideas about societal development in order to uncover the complexity of energy transitions from a socio-political perspective".

The Nordic countries of Denmark, Norway, Sweden, Finland and Iceland in particular have asserted themselves as global development leaders. They are far ahead in terms of happiness, health, income, or equality in the indices of human development, environmental quality or, for example, integrity. Their progressive social democratic model is referenced as a reason for success, with the priority given to positive social and ecological developments in politics rather than "economic efficiency". This enables them to be leaders not only in achieving climate protection, but also in social well-being and the environment (Kirby & O'Mahony, 2018).

3 Criteria and indicators for leadership in energy transition

The elaboration of the previous chapter and especially in the analysis of the factors that are crucial for the success of the energy transition, the following things have come to light:

In a number of energy transition studies the analyses only refer to individual countries. What stands out here is the vast amount of literature on the energy transition in Germany. This is mainly because it attracted worldwide attention after the nuclear disaster in Fukushima when it announced its withdrawal from nuclear energy and the switch to wind and solar instead. It is argued that the modern energy transition began in Germany and that "German reforms serve as an exemplar and catalyst for energy transition across developed and developing countries" (Cheung et al., 2019, p. 634), although this has now been disproved. Nevertheless, the German term for energy transition (Energiewende) is adopted in English language (Morris & Jungjohann, 2016) and Germany is often referred to as a "pioneer of the energy transition" (Vahlenkamp et al., 2016).

When it comes to leaders, most often the pioneering positions in the development of certain low carbon alternatives are presented, such as by Araújo (2018) who highlights the transition of certain "prime mover countries", namely Brazil (biofuels), Denmark (wind power), France (nuclear power) and Iceland (geothermal).

Alternatively, countries are also compared based on their performance in specific sectors (e.g. Climate Transparency, 2018; Hultman et al., 2012) or based on specific policies and regulations implemented in connection with the energy transition (e.g. Hirose & Matsumura, 2020; Timoseva, 2019).

What is missing, are much more comprehensive studies to compare several countries based on their performance in implementing the energy transition or studies that use rankings.

In this chapter eight studies, that address aspects of this, will be analysed in more detail. Even if the studies alone cannot depict pioneers of the energy transition, it is hoped that they as a whole will give a picture of which countries stand out as such.

In the follwing, the research question focused on how leaders are defined will be explored. First, general distinctions will be presented that are important when analysing studies on the energy transition. Then, on the basis of the eight selected studies, it will be shown which criteria and indicators have been used in these to compare countries with one another.

3.1 Distinction of terms

When analysing studies on energy transition, a number of points can make the comparison very difficult or influence the results in different ways.

Although some of the measurements used in the studies are similar, they are nevertheless different and and can lead to confusion.

In the context of the energy transition, as described above, mainly CO_2 emissions are of importance, but in many cases GHG emissions or CO_2 equivalents are used as a basis.

Human-induced emissions are measured mainly on the basis of production-based accounting, using the emissions of goods and services produced in a country as calculation base, regardless of whether they are ultimately consumed in that country or exported. However, there is criticism that this calculation method neglects trade as a major driver of emissions, which is why countries with emission-intensive export industries in particular are advocating for consumption-based accounting (Karakaya et al., 2019). However, it is also argued that emissions accounting based on consumption rather than production would be too complex and intransparent, and that manufacturers of emission-intensive goods should be held accountable, regardless of where they would be consumed (Baumert et al., 2005).

When it comes to CO_2 emissions, it is important to distinguish which energy source (oil, natural gas, etc.) or which sector (transport, electricity and heat production, industry, residential, etc.) is being talked about or which drivers for CO_2 are refered to (GDP per capita, population, carbon intensity, energy intensity, etc.).

It should also be distinguished whether absolute CO_2 emissions of a country or per capita CO_2 emissions are mentioned. China, for example, has the largest share of global CO_2 emissions in absolute figures with 28%, followed by the USA in second place with a share of 15% (as of 2018) (Union of Concerned Scientists, 2020). If the emissions per capita are considered, China is far behind other industrialised countries. The inhabitants of the USA with 14.6 tCO_2/capita emit more than twice as much as the inhabitants of China who only emit an average of 6.7 tCO_2/capita (2017) (IEA, n.d.-a). Financially strong states generally record higher per capita emissions mainly due “to higher rates of consumption and more energy-intensive lifestyles, although other factors such as energy endowments, trade, population density, and geography also influence a country’s per capita emissions” (Baumert et al., 2005, p. 21).

Another term similar to the per capita CO_2 emissions and often used synonymously is the so-called "carbon footprint". The difference is that it is defined by the total amount of greenhouse gases emitted by direct and indirect human activities in one year and is expressed in equivalent tonnes of carbon dioxide (Time for Change, 2007). However, there is criticism that the term was coined by British Petroleum (PB), the second largest non-state oil company in the world and spread as part of a large-scale PR campaign through the "personal carbon footprint calculator", presented in 2004 to distract responsibility for global warming from itself and transfer it to individuals (Kaufman, 2020).

The terms carbon intensity, emission intensity and emission factor are also not uniform, even though they are used interchangeably. While emission intensity refers to the amount of greenhouse gas emissions per unit of economic activity, carbon or CO_2 intensity excludes the other gases. Still, carbon intensity as a term is also used if the GHG emissions are aggregated into CO_2 emissions according to their emission factor. It should be underlined that despite increasing carbon emissions, a country's carbon intensity may decrease as its economy grows and/or energy consumption becomes more efficient, making the use of carbon intensity as a measure problematic (Baumert et al., 2005). In this respect, the reduction targets set by the countries also differ. While most industrialized countries have stated these in absolute figures, others refer to intensity (Karakaya et al., 2019). For instance, Australia that has an emission intensity higher than the EU could concentrate on the so called “low-hanging fruits” and can thus reduce its emission intensity easier. There percentage then seems larger than the actual emission reduction (Climate Council, 2015).

The energy intensity on the other hand, which is expressed in GDP per amount of energy consumed, is one of two variables of carbon intensity and reflects the energy efficiency and macroeconomic structure of a country. The other variable of carbon intensity is the carbon content of the energy consumed in a country, also called energy mix. For example, two countries may differ regarding their carbon intensity despite having the same energy intensity. This is the case if one

country uses lower-carbon energy sources (Baumert et al., 2005) . However, authors such as Braun and Glidden (2014) emphasize that energy intensity is not the same as energy efficiency. They point to the fact that in the USA, energy intensity was mainly caused by carbon leakage, i.e. the relocation of heavy industry to other countries.
As described above, energy efficiency is often measured with the energy intensity indicator. However, the term is a very ambiguous concept on a practical and conceptual level. Often energy efficiency measurements show a lack of qualitative information, which leads to a simplification of the term and thus to a negative impact on the choice of energy policy. Velasco-Fernández et al. (2020, p. 1) write in this respect: "Efficiency measurements are particularly problematic on a macroeconomic scale where a significant amount of meaningful information is lost through the aggregation of data into a simple ratio (economic energy intensity)".
Furthermore, attention must be paid to how the GDP is indicated. This can be done in the national currency, in US dollars or by means of purchasing power parity (PPP) conversion into international dollars (IEA, n.d.-a).

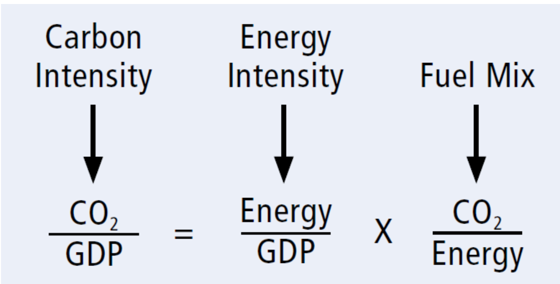


Figure 7: Drivers of Emissions Intensity (Baumert et al., 2005)

If a country is judged on its performance in terms of emission reduction in the energy sector, it makes a difference which emissions and which quantities are used as a unit of measurement. However, the analyzed time frame is also important. For example, it makes a difference whether the cumulative emissions over a longer period of time are considered or whether annual emissions are used instead (Lebling et al., 2018).
The terms energy use and energy consumption are also used synonymously even though they mean the same, whereas there is a difference between final energy consumption and total primary energy supply (TPES). Total final energy consumption "is the aggregate of all of the end use energy that is used for providing various energy services […and…] is made of energy that can readily be

used by consumers to serve their energy needs, while TPES is an aggregate of all of the energy going into the energy sector" (Donev & Hanania, 2020).

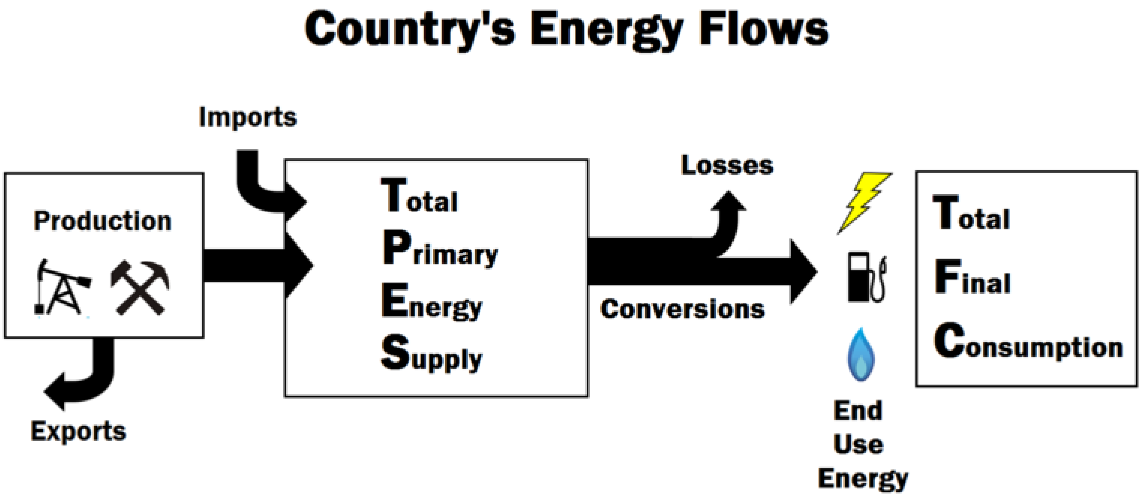


Figure 8: Energy Flows (Donev & Hanania, 2020)

It becomes clear that the terms in the examined studies are mainly of a technical nature and do not show how the general demand and consumption of energy is minimised by social behavioral changes.

3.2 Criteria of energy transition

The decarbonisation of countries is the overarching goal of the energy transition, which is the desired outcome. In order to be able to evaluate the progress, criteria is needed which can illustrate the concretisation to this goal and provide important characteristics for evaluation (Beywl & Niestroj, 2009).

The following section presents the criteria of eight selected studies that compare countries on the basis of certain parameters in connection with the energy transition.

The Energy Transition Index (ETI) benchmarks countries on the performance of their energy system and their readiness for energy transition, having nine criteria that they call "dimensions": Economic development and growth, Environmental sustainability, energy security and access, capital and investment, regulation and political commitment, institutions and governance, infrastructure and innovative business environment, human capital and consumer participation, as well as energy system structure. The criteria of economic development and growth, environmental sustainability, and energy security and access each receive a

higher weighting (33%) than the other criteria with only 17% weighting each (WEF, 2019).
The criteria of the just transition index is categorized within the climate, socio-economic and political dimension and are based on eight just transition criteria, namely climate ambition, NDC-SDG alignment, decent work & resilience, social equity, gender equality, due participation, good governance, and human rights. The criteria climate ambition and NDC-SDG alignment are weighted at the heighest with each at 25%, but in general this index focuses more on social justice and is less technical than all the other studies (Hirsch et al., 2017).
The Climate Change Performance Index (CCPI) evaluates a country's performance according to the criteria of GHG emissions (40% weighting), renewable energy (20%), energy use (20%), as well as the performance regarding its national climate policy framework and its international climate diplomacy (20%) (Burck et al., 2019b).
The IRENA Coalition for Action (2019) did a global mapping of 100% renewable energy targets. When countries pledged to achieve some sort of 100% renewable energy target, they distinguished them according to three criteria: "not specified" which refers to countries that did not give further indication of the scope and boundary of their pledges, "energy only" if countries adopted their target specifically for the electricity sector, and "all sectors" if the renewable energy target encompasses all sectors, namely electricity, heathing and cooling, and transport.
The Climate Action Network Europe (CAN Europe, 2018) has two criteria to check the EU countries' ambition and progress in fighitng climate change. The first is how countries perform in reaching their climate and energy targets and a set of climate and energy indicators; and the second is how countries behave in setting and increasing both European and domestic targets.
The European Climate Foundation (ECF, 2019) evaluated the draft National Energy and Climate Plans (NECPs) that EU Member States had to put forward by the end of 2018. They assessed on what extent the NECPs put countries on track for the long term goal of net zero emissions by 2050 according to three criteria: the target adequacy, the policy details (each weighted 45%), and the process quality (10%).
The European Environment Agency (EEA, 2019) analysed the progress in EU member states towards their 2020 and 2030 targets for climate and energy

according to the three criteria of greenhouse gas emission, renewable energy, and energy efficiency.

Carbon Market Watch and Transport & Environment (2017) examined the position of EU countries in the negotiation process on the Effort Sharing Regulation (sets out annual GHG emission reduction targets for the period of 2021-2030) which is covering 60% of EU's greenhouse gas emission for sectors such as transport, buildings, agriculture and waste for which they used five criteria: (1) the starting point from which the emission reduction targets are applied (2) how carbon sinks in the land use and forestry sector are addressed (3) whether surplus permits from the EU Emission Trading System (ETS) can be used (4) the governance system to ensure countries comply with their targets and (5) whether the ambition level of the 2030 and long-term targets is compatible with the Paris Agreement objectives.

3.3 Energy transition indicators

In order to make the criteria tangible, indicators are suitable. An indicator is a fundamentally incomplete clue to the existence of a situation and by applying several indicators in an aggregated way, they can capture complex circumstances (Beywl & Niestroj, 2009). The weighting of the indicators has a decisive influence on the result. The authors of different studies decide which indicators are most important and which criteria are given priority, a characteristic that is, however, inherent in all rankings. Braun and Glidden (2014, p. 7) summarise this problem as follows: "Note again that what we choose to measure tells us different stories about what the problem is and who is responsible, and gives us differing policy prescriptions".

Since not all indicators of the studies can be examined and analysed in detail within the scope of this work, the most important energy transition indicators, defined by the IEA, should be presented here because they "unpack the main underlying drivers of energy supply and demand that ultimately determine the energy sector's contribution to CO_2 emissions" (IEA, 2019b). Then this work will examine which of the indicators identified by the IEA were used directly or indirectly in the selection studies.

The indicators defined by the IEA represent the main drivers of CO_2 emissions, both in terms of energy supply and energy demand in the energy sector and

should "set up an accessible and comprehensive tracking framework that contributes to effective and well-co-ordinated policy-making" (IEA, 2019b).
The indicator that is superior to all other indicators is defined by the energy-related carbon emissions of a country. All other indicators refer to subordinate activities that are generally aimed at reducing these emissions. These include the final energy carbon intensity. This indicator gives information on how much CO_2 is emitted per unit of total final energy consumption (TFC). The unit used by IEA to express final energy carbon intensity is CO_2 in tonnes per tonne of oil equivalent [tCO_2/toe].
An indicator that reduces the carbon intensity of energy demand is the electrification of final energy consumption in the sub-sectors, provided it is based on low-carbon electricity generation. For the power sector for instance the carbon intensity is expressed in grams of CO_2 per kilowatt hour [gCO_2/kWh].

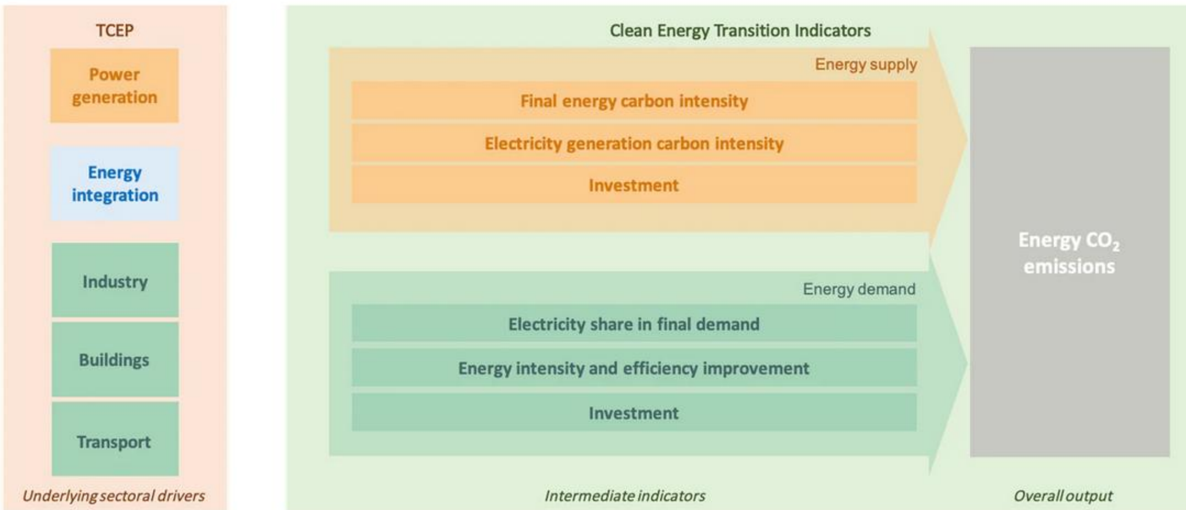


Figure 9: Clean Energy Transition Indicators (IEA, 2019b)

It is also important that economic growth is decoupled from energy demand, which is expressed by the energy intensity indicator. This indicator measures how much primary energy is needed per unit of GDP generated and should represent the energy efficiency of a country. A further indicator is defined by the investment in clean energy, as this is crucial for the development and expansion of energy technologies in the long term (cf. ibid.).
In this context, it is important to mention that IEA talks about indicators, although according to the definition used as a basis for this work, they are rather weak criteria, since the indicators still lack precise units of measurement. Accordingly, the criteria of emissions, final energy carbon intensity, low carbon

electricity generation, energy intensity and clean energy investment are used to examine whether and which precise indicators the eight studies use to describe these criteria.

Indicators related to emissions

Differences can be found in the studies regarding the emission approach. The World Economic Forum (WEF, 2019) for its Energy Transition Index (ETI) only studies CO_2 emissions per capita as an indicator for its analysis. All the other studies refer to greenhouse gas (GHG) emissions.

In the Climate Change Performance Index (CCPI) it is argued that the consideration of the emission level at a certain point in time and the recent development of greenhouse gas emissions is not sufficient for analysis. In their opinion, the level of per capita GHG emissions changes only in the longer term, despite ambitious climate measures, which means that more recent climate protection efforts cannot be depicted. Therefore, a wider perspective is indispensable and three additional indicators have been included in their index, namely the past trend of GHG emissions per capita; the current level of GHG emissions per capita compared to a well-below-2°C compatible pathway; and GHG emissions reduction target for 2030 compared to a well-below-2°C compatible pathway (Burck et al., 2019b). Even if this determination concerns GHG emissions, this objection could also be considered in other emission calculations.

Hirsch et al. (2017) included the country’s share of global GHG emissions as an indicator within their criteria of climate ambition.

Indicators related to energy carbon intensity

The ETI is the only ranking that incorporated CO_2 intensity, measured in CO_2 per total primary energy supply (TPES) as an indicator. Some others refer to it indirecty. The CCPI instead evaluates the extent to which a country increases in the share of renewable energy by using indicators to express not only the current share of renewables, but also past developments and future projections with a pathway that is compatible with the “Well-Below-2°C” target (Burck et al., 2019b). CAN Europe included the share of renewable energy too.

Indicators that refer to renewable energy targets have been incorporated by CAN Europe, the European Climate Foundation (ECF), the European Environment Agency (EEA), as well as the IRENA Coalition for Action.

Indicators related to low carbon electricity generation

The approaches regarding meassuring the low carbon electricity generation differ remarkable. Included in the ETI are indicators such as the share of electricity from renewables or the quality of electricity supply that provide an adequate description of the nature of renewable electicity supply of a country.

For the CCPI for the criteria of "renewable energy", the percentage share of renewable electricity targets for certain countries was used and translated to the renewable share in TPES as they assume that the input of renewables would increase proportionally to the share in electricity production and that "replacing fossil fuel electricity reduces TPES by a factor one to two" (Burck et al., 2019b, p. 28).

The ECF has an indicator that checks if a country that has coal in its electricity mix plans to phase-out coal use for electricity generation. They chose this indicator because according to IEA the member countries of the Organisation for Economic Co-operation and Development shoud especially phase out coal for electricity generation rapidly in order to stay on the below 1.5°C pathway (ECF, 2019).

The EEA tracks the renewable energy share in the electrity sector as well and checks if countries meet their renewable energy targets in the electricity sectors.

The IRENA Coalition for Action analysed 100% renewable energy targets and how clearly they are defined. They did this in terms of sectoral and geographical scope, including the adoption of the 100% renewable target specifically for the electricity sector.

Indicators related to energy intensity

The ETI included an energy intensity indicator measured in MJ/PPP GDP, whereas the CCPI does not measure energy intensity, but instead measures the energy consumption level per person in a country, based on four indicators within the criteria of "energy use". These four indicators are defined as the current level of energy use (TPES/Capita); past trend of TPES/capita; current level of TPES/capita compared to a well-below-2°C compatible pathway; and TPES/Capita in the country's 2030 target compared to a well-below-2°C compatible pathway. According to Burck et al. (2019b), measuring energy efficiency improvements requires a sector-specific approach, which is not always possible in a country comparison and which is why they used this indicators in the CCPI instead. CAN

Europe likewise uses per capita final energy consumption as a measure, whereas ECF and EEA assessed the energy efficiency targets of EU countries.

Indicators related to clean energy investment

The Energy Transition Index within their criteria category "Capital and Investment" introduced four indicators related to clean energy investment, namely investment freedom; acccess to credit; new renewable capacity built; and energy efficiency investment.

The European Climate Foundation has an indicator that checks if the draft national energy and climate plans of EU countries contain sufficient and robust information on the additional investments required and the financing of policies.

CAN Europe on the other hand has an indicator to assess what percentage of European structural funding is allocated to low-carbon development by EU countries.

The following table 1 summarises clearly which studies also use the energy transition indicators identified by the IEA as a basis for measurement (marked green) or if they use other, but similar indicators (marked orange).

Reference	***Emissions***	***Carbon intensity***	***Low carbon electracity generation***	***Energy intensity***	***Clean energy investments***
Burck et al., 2019b (CCPI)	GHG emissions/ capita	Renewables per TPES; Renewables 2030 target; Development of renewable energy supply,…	Renewables per TPES; Renewables 2030 target; Development of renewable energy supply,…	current level of energy use (TPES/Capita); past trend of TPES/capita;…	
CAN Europe, 2018	GHG emissions/ capita	Share of renewable energy		Per capita final energy consumtion	Percentage of European structural funding allocated to low-carbon development
ECF, 2019	GHG emission target for 2030	2030 Renewable Energy (RE) target; Policies for achieving RE target	Plan to phase-out coal use for electricity generation	2030 Energy Efficiency (EE) targets; Policies for achieving EE targets	sufficient and robust information on the additional investments required and on financing of policies; phase-out of fossil fuel subsidies
EEA, 2019	GHG emissions	Share of renewable energy; RE energy 2020 and 2030 targets	Renewable energy share in the electrity sector	EE 2020 and 2030 target	

Hirsch et al., 2017	Country's share of global GHG emissions	Availability, quality and level of ambition of a Renewable Energy roadmap			
IRENA Coalition for Action, 2019		Pledged 100% RE target for all sectors	Pledged 100% RE target fo electricity sector		
CMW & T&E, 2017	GHG emission reduction targets for 2030				
WEF, 2019 (ETI)	CO_2 per capita	CO_2 intensity [CO_2/TPES]	Share of electricity from renewables [% of total]	Energy intensity [MJ/PPP GDP]	Energy efficiency investment; Energy subsidies [% of GDP]; new renewable capacity built

Table 1: Implemented energy transition indicators

What Table 1 shows is that only the Energy Transition Index directly uses all the energy transition indicators declared important by the IEA. All other studies have only used selected IEA indicators or have used completely different ones for their analyses.

The two studies that refer directly to the measurement of progress in the energy transition at the state level are those by the World Economic Forum (WEF, 2019) and Hirsch et al. (2017), while both focus on totally different criteria. The "Energy Transition Index" by the WEF has more indicators in total (40) and has a much more economic focus, while more indicators on social justice are missing. The only indicators that could fall under the category "social justice" are the indicators "jobs in low-carbon industries" and "education quality" under the criteria "human capital and consumer participation".

In contrast, Hirsch et al. (2017) have indicators that are supposed to measure aspects of a just energy transition and have a strong social justice component while not having a strong techno-economic focus. However, they often use the ranking level of a country in a certain area from another ranking as an indicator, for instance the general status of gender equality according to the Gender Inequality Index (GII) and Gender Quality Index (GQI); the general human right situation in the country according to the rating of the Human Rights Risk Index; the general status of distribution of family income accoring to the GINI Index or the level of climate ambition according to the Climate Action Tracker, the Climate Change Performance Index and the Climate Performance Ranking of Climate

Transparency et al. Furthermore, Hirsch et al. (2017) argue that climate protection and sustainable development measures must be considered together, which is why they look within their NDC-SDG Alignment criteria. They look at what extent the NDCs are aligned with the SDGs during implementation. Both indices have very well developed approaches to reflect the progress of energy transition in individual countries, but an index combining the criteria of both indices could do this better.

The other studies on the contrary refer in their rhetoric to the climate rather than energy dimension, although they use energy indicators as a reference. However, it is noticeable that common to all studies is the political component in the composition of the indicators. This shows that all authors of the studies attribute an important role to political decision-makers in the implementation of the energy transition and climate protection measures. Ambitious climate and energy policies and their effective implementation measures will have a positive effect on developments in the categories "renewable energies" and "energy use" after a time lag of several years, which in turn will lead to a delayed reduction in a country's greenhouse gas emissions (Burck, 2019b).

The expansion of renewable energies (RE) as an important basic component to initiate the energy transitionis is also reflected in the selection of indicators in the studies. Seven of the eight studies have a RE indicator. The CCPI has four indicators within the category "Renewable Energies"; the WEF has two indicators that refer to the "new renewable capacity built" on the one hand and "RE regulations" on the other hand. The IRENA Coalition for Action, CAN Europe, ECF, Hirsch et al. and EEA also relate their assessments to renewable energy targets and roadmaps.

The same applies to indicators for evaluating energy efficiency. Four of eight studies have formulated specific indicators for this purpose. However, measuring progress towards energy efficiency and energy consumption targets is not so simple, because countries do not use standardised units, making them difficult to compare. Some state them as efficiency gains for a particular baseline scenario and others in energy intensity (Burck, Hagen, et al., 2019b). For instance, national energy efficiency contributions that member states determine under the EU Governance Regulation is a clear example. The states are autonomous whether they achieve these 2020 or 2030 targets for the EU, based on primary or final energy conumption, primary or final energy savings, or energy intensity.

Consequently, they all are indicators for energy efficiency within EU regulations (EEA, 2019).
In addition, all studies refer to certain climate and energy targets in their assessment. The Energy Transition Index, the Climate Change Performance Index and the Just Transition Index refer to the Nationally Determined Contributions (NDCs) under the framework of the Paris Agreement and the other four studies address the EU climate and energy targets of EU member states.
The European Environment Agency and the Climate Action Network assess the improvement on the implementation of 2020 targets, as well as the development and promotion of more ambitious EU targets and strategies for 2030 and/or 2050, while the European Climate Foundation and Transport and Environment/Carbon Market Watch only focus on the 2030 targets.
While the focus on the 2030 targets is important, they do not yet tell how a country has performed so far and they say nothing about whether action will follow and whether the targets will actually be achieved. Thus, the CCPI developed for each of the criteria some indicators, which display the current level, the past trend, the current level compared to a well-below-2°C compatible pathway, and the 2030 target compared to the well-below-2°C compatible pathway. This should reflect the performance of a country more comprehensively (Burck et al., 2019b).
Another problem in this context is that some countries that set very ambitious targets at EU level tend to miss them. Whilst in contrast, countries that are on track to reach their targets or even exceed them, are doing so because they have set their targets far too low from the beginning which gives them a higher score on "progress" (CAN Europe 2018).
Nevertheless, "Net zero emissions economies will not come about by chance: dedicated focus and planning, with a clear eye to the end goal, will be needed" and "Clear and robust NECPs [National Energy and Climate Plans] can serve as advertisement to large and small investors and engage stakeholders in implementation, as well exposing where additional efforts will be needed" (ECF, 2019, p. 3).
Another observation that clearly emerges is the fact that the majority of studies does not specifically refer to nuclear energy and do not comment on how its use is related to the energy transition and if it is considered as "clean". However, two studies mention nuclear energy as a negative point. CAN Europe (2018) criticises

France’s high dependency on nuclear energy or Belgium’s lack of implementation of its announced nuclear phase out. The IRENA Coalition for Action (2019) refers to the fact that commitments for fossil and nuclear energy parallel those for renewable energies which would have a negative impact on its 100% expansion. They use Japan among others as a case study and illustrate its pathway after Fukushima to achieve its 100% renewable energy target by 2040 (which other organizations such as CAN International (2020) or the OECD (2017) would not declare a positive example due to its parallel expansion of coal plant constructions).

4 The leaders

In this chapter the research questions “Who are the leaders in energy transition in the European Union?” and “What country is standing out in its performance to transform the energy sector?” shall be answered. The eight studies presented in the previous chapter will serve as the basis for answering these questions and will be used to explain how the different countries perform in general and which countries are at the top of their rankings.

4.1 Overall performance of countries

The performance of countries in accelerating the energy transition is very modest and it is clear that there is no real winner, only countries that perform better than others. According to the World Econmic Forum, the annual increase in global averages of the Energy Transition Index in 2019 was lower than the five years before, which shows that there has been little progress and a clear slowdown in energy transition. The 115 included countries make only a few leaps or tend to move only a few places in the ranking, which is made clear by the fact that the countries that have had positive developments in the past are still at the forefront, due to technological progress, effective policy design and implementation. Another striking feature of the ETI 2019 is that the best performing countries come from Western and Northern Europe (WEF, 2019).

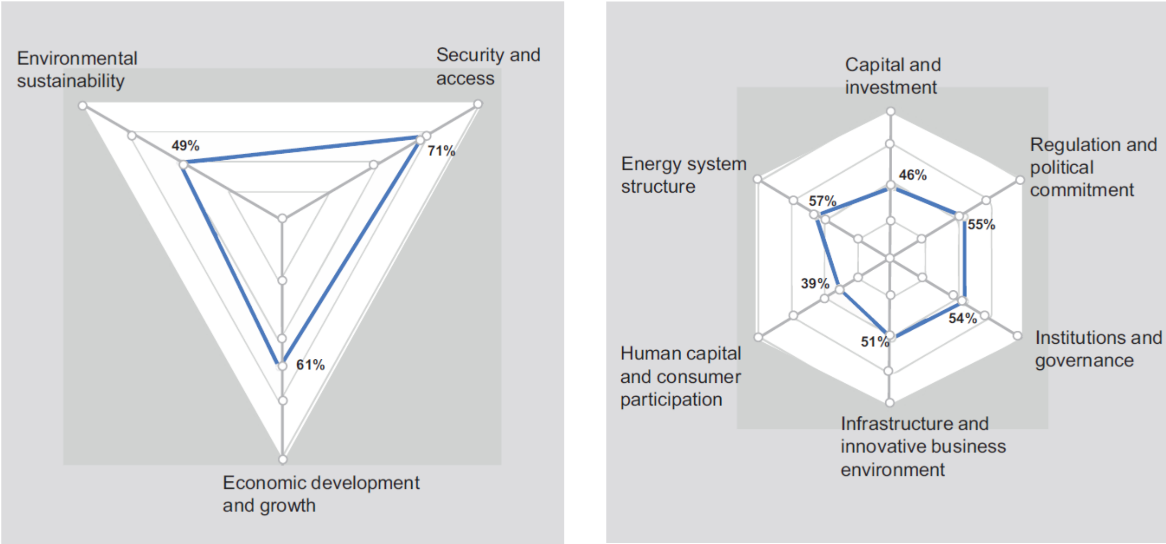


Figure 10: Global aggregate system performance and transition readiness scores, 2019 (WEF, 2019)

The conclusion of the report for the Climate Change Performance Index 2020 also shows that countries' efforts to transform the energy system are not good enough and that "even if all countries were as committed as the current frontrunner, efforts would still not be sufficient to prevent dangerous climate change". No country achieves a "very high" score on the Index, and of the G20 countries only two can achieve a better ranking (the UK and India), while eight of them are rated very negative and underperforming (Burck et al., 2019, p.8). The rating "high" in figure 11 refers to countries that score over 60 of 100 points, while "medium" refers to countries that score over 48 of 100 points, "low" to countries that score over 41 of 100 points and "very low" to countries that did not reach 41 points (Burck et al., 2019a).

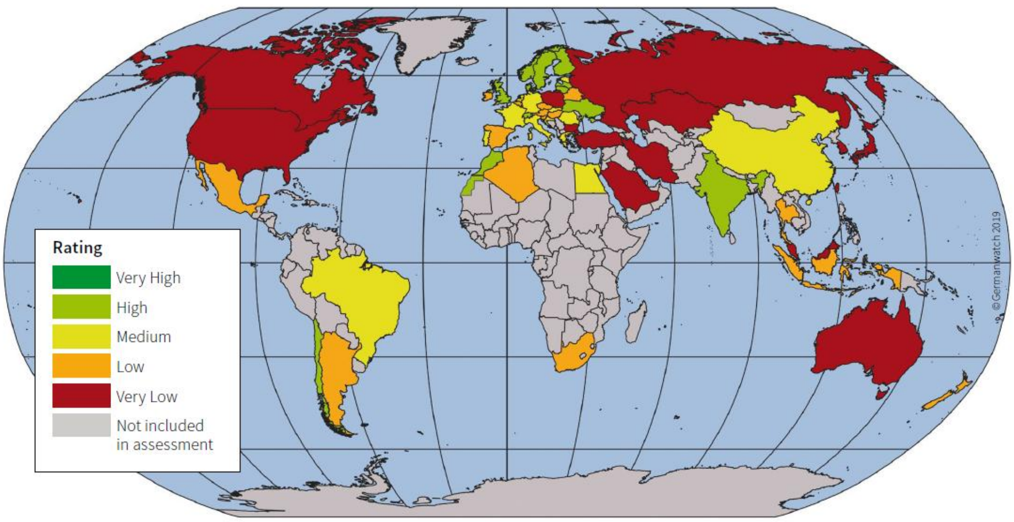


Figure 11: Overall Results CCPI 2020 (Burck et al. 2019a)

The study on just energy transitions that assess the energy transitions in twelve countries of the Global South did not rate a single country within the category "Good". They concluded that "neither do those countries which claim to be pioneers of the energy transition necessarily perform better in terms of the social and political dimension of a just transition, nor are those who claim to be pioneers regarding justice automatically in the lead when it comes to climate ambition" (Hirsch et al., 2017, p. 6).

The IRENA Coalition for Action (2019) objects that countries do not put enough effort into defining and implementing 100% renewable energy pledges and that especially targets are missing that are covering all sectors.

The studies on the ambitions of the EU member states show that they all fall behind on delievering their share to reach carbon neutrality by 2050 at the latest (as declared in the European Green Deal) and that the implemented climate and energy measures are not yet in line with the goal of the Paris Agreement. The ambitions clearly do not go far enough to reduce CO_2 emissions significantly and the countries still have a long way to go to enable a deep decarbonization. This is the conclusion reached by CAN Europe (2018), the European Climate Foundation (ECF, 2019), the European Environment Agency (EEA, 2019), as well as Carbon Market Watch/Transport and Environment (CMW & T&E, 2017). According to the ECF (2019), not a single country has emerged as a clear leader and the draft national energy and climate plans presented are not credible and robust enough. According to the EEA (2019), the efforts of the EU states will not even achieve the targets set for 2030 and according to CMW/T&E (2017) who assessed the EU countries's ESR efforts, also highlights that "No country is doing enough" (CMW & T&E, 2017, p. 19).

The general lack of ambition is reflected differently in the studies. Burck et al. did not fill the first three positions, CAN Europe did not fill the first one, in the study by ECF the best two categories are unfilled. In Hirsch et al. no country was placed in the best category "very good" and in the study CMW/T&E no country was placed in the category best category "excellent".

The countries perform generally poorly in terms of expanding renewable energies, although this measure would significantly accelerate the reduction of emissions (Burck et al., 2019a). In the study of the ECF this "general lack of ambition in terms of renewable energy is reflected in the average score of EU Member States that is only 1.7 out of 12.5 points" (ECF, 2019, p. 19). Thus, it is

rather unlikely that the EU’s 2030 target to reach at least a 32% renewable share will be met with the current rate to expand renewable energy deployment (EEA, 2019).
Negative developments can also be observed in the area of energy efficiency enhancement. In 2018, according to the IEA, there was a comparatively historical slowdown in energy efficiency improvements due to social and economic trends as well as specific factors such as extreme weather events. Although low-cost technologies are available, the ever-increasing energy demand cannot be offset by policial measures and investments currently in place (Burck et al., 2019a). Final energy consumption has increased in Europe in recent years, with the greatest rise observed in building and transport. In order to reverse this trend and to reach the 2030 targets, further measures and more innovative strategies are needed from the EU member states (EEA, 2019).
Apart from this, the energy efficiency target for 2030 of 32.5%, just like the target for renewable energies, is at a incredibly low level compared to targets required to reach the Paris Agreement. The target adequacy for energy efficiency of the EU member states which is one of ECF’s indicators, averaging only 0.9 out of 12.5 points is even worse than the adequacy of the GHG emissions reduction and the RE targets (ECF, 2019).

4.2 Country rankings

Nevertheless, the rankings of the eight selected studies show which countries are at least moving into the right direction and which are doing better in comparison. These are to be presented here. The top ten out of 115 countries in the Energy Transition Index 2019 are Sweden, Switzerland, Norway, Finland, Denmark, Austria, United Kingdom, France, Netherland and Iceland. All these countries are from “Western and Northern Europe, and are diverse in their primary energy mix, energy system structure and natural resource endowments. High-ranking countries also show high scores on transition readiness due to their strong institutional and regulatory frameworks, ability to attract capital and investment at scale, innovative business environment and high-level of political commitment on energy transition”. In the over-category "System Performance" the countries Norway (82%), Sweden (81%), Switzerland (78%), France (77%) and Iceland (75%) achieve the highest score and in the over-category "Transition Readiness" the countries Finland (74%), Denmark (73%), Switzerland and Austria (71%

each) and Sweden (69%). Unfortunately, it is not possible to deduce from the ranking how the countries performed in each criteria and in the individual indicators (WEF, 2019, p. 10). Also, this index is not mainly focusing on progress made by countries, but instead highlights the potential of countries to transform their energy system. For instance, the ranking contains countries such as Austria in its top positions, which due to its geographical location has a high proportion of hydropower and a high share of renewables as a source for electricity generation, but has rather rising emissions since 1990 (IEA, n.d.-a) and is not on track to meet its 2030 target (cf. figure 12).
The top ten out of 57 countries in the Climate Change Performance Index are Sweden, Denmark, Morocco, United Kingdom, Lithunia, India, Finland, Chile, Norway and Luxembourg (Burck et al., 2019a). In the criterion "GHG emissions", which is weighted most strongly with 40%, Sweden and the United Kingdom come off best. Sweden has the lowest per capita consumption-based emissions and is rated "very good" for its "well-below-2°C compatibility". The United Kingdom has a comparatively "very high" rating on its well-below-2°C comaptiblity of its 2030 GHG target and also performs well on the other indicators on the GHG emission criterion. Sweden and Denmark are among the top performers in the "Renewable Energy" criterion. Sweden has a "very high" score on the "share of renewable energy" indicator and is among the countries with a "high" rating for well-below-2°C compatibility. Denmark has a "high" score for the well-below-2°C compatibility of the current share of renewable energy, as well as for the rating for its 2030 RES target. Morocco stands out among the top performers in the "Energy Use" criterion, mainly because of its "very high" score for its well-below-2°C compatibility. The United Kingdom, Lithuania and India also scored well in this criteria. Finland scores relatively well in the criteria of "Climate Policy", due to the positive developments resulting from its newly elected government, which wants to make Finland climate-neutral by 2035, and in addition the parliament decided in early 2019 that coal should no longer be burned from 2029 onwards. Morocco, on the other hand, is on a "high" rank in climate policy because it has set itself very ambitious 2030 targets (cf. ibid.).
Hirsch et al. (2017) assessed twelve counties of the Global South from which the only country that reached the category "good" and scored highest in the ranking was Costa Rica. The electricity sector in Costa Rica is already almost entirely based on renewable energies. Iit also recieved high scores because it has set

itself very ambitious and unique goal regarding climate neutrality, which Costa Rica wants to achieve by 2021[1]. In addition, the correlation between the national climate targets and simultaneous sustainable development is very important in this index (alignment of the NDCs with the SDGs). In this category the country also scores very well and it serves as a good example for a just energy transition.

In the study published by the IRENA Coalition for Action (2019) on the global mapping of 100% renewable energy targets, Denmark was the only country that defined a target for all sectors. In 2012, Denmark decided with the energy agreement to convert the entire energy system to renewable energies by 2050. In 2018 the agreement was extended with new milestones for 2030 and it was decided that Denmark will by then reach 100% renewable energy in net electricity consumption and 55% renewable energy in net energy consumption. In the 2018 Agreement, new budget plans and political measures for the period after 2020 were formulated. For example, new offshore wind farms will be built, grant pools for energy savings in industry and buildings will be set up, reserves will be created for the further expansion of renewable energies, tax breaks in the heating sector will facilitate its modernisation, and subsidies for green mobility or energy and climate-related research will be provided. Furthermore, countries that formulated 100% renewable target for the electricity sector only are Austria, Cape Verde, Costa Rica, Fiji, Iceland, Solomon Islands, Sweden and Tuvalu. All other coutries have either not specified their targets or have no targets at all (cf. ibid.).

In the ranking of CAN Europe (2018) which checks where EU countries stand on fighting climate change, the only country that achieved a rating in the category "good" was Sweden and countries in the category "moderate" are Portugal, France, the Netherland and Luxembourg. These countries perform better in this ranking because they recognize that the EU's climate and energy policies must be in line with the Paris Agreement and they call for more climate ambition, especially with regard to EU energy goals. Sweden achieves the highest score in

[1] Although Costa Rica originally set itself this goal, its president presented a climate policy package in February 2019 that did not meet this target. In December 2019 they submitted its long term strategy to the UN which confirms a net zero emissions target for 2050 only (M. Darby & Gerretsen, 2020).

the criteria "Overall performance on climate and energy indicators" (70%), "Progress on implementation [of] 2020 targets" (50%) and "Domestic targets additional to the EU targets" (70%). In the criterion "Support for higher ambition in EU 2030 climate and energy legislation", Sweden has the highest percentage (89%) with Luxembourg. In the criterion "Support for more ambitious EU overall targets and strategies for 2030 or 2050" Sweden has the highest percentage (83%) together with Luxembourg and France.

In the assessment on the Draft National Energy and Climate Plans done by ECF (2019) only Spain exceeds more than 50% of the available points. Countries that achieved more than 40% are France (46.9%), Greece (44,2%) and Sweden (42.8%). What defines the pioneers according to this study is not only that their 2030 targets are in line with the Net Zero GHG emissions target by 2050, but also that they use the EU targets as a minimum standard for national climate ambitions. Furthermore, these pioneers are those who formulate credible policies, measures and involve stakeholders in the transition process. Spain achieves the highest score in the criterion "target adequacy" and performs particularly well in the indicators "2030 non-ETS GHG targets" and "2030 renewable energy target". Sweden is in third place in this criterion and thus far ahead. Spain achieves the second highest score after Greece for the criterion "Policy detail" and does particularly well for the indicators "Policies and measures for achieving non-ETS GHG targets", "Policies and measures for achieving RES targets" and "Policies and measures for achieving EE targets". France is in third place in this criterion behind Greece and Spain (ECF, 2019).

The European Environment Agency tracked the progress towards Europe’s climate and energy targets for 2020 and 2030. Member States that are on track towards their 2020 climate and energy targets in all three categories GHG emissions (2017), final energy consumption (2017) and the share of renewables in gross final energy consumption (2017-18) are the United Kingdom, Finland, Denmark, Latvia, Czechia, Romania, Portugal, Spain, Italy, Croatia and Greece. The countries that are on track towards their projected progress of their 2030 climate targets are Portugal (26,2 percentage points of the gab to 2030 Effort Sharing target), Greece (9,1) and Sweden (0,1) (EEA, 2019).

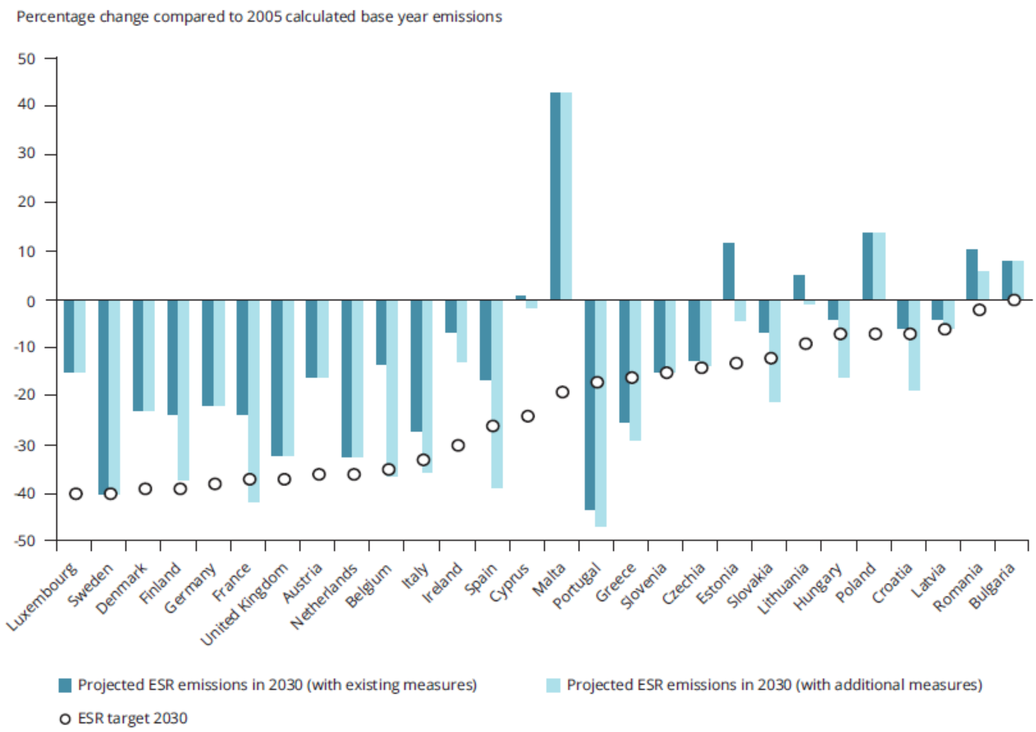


Figure 12: Projected progress of Member States towards their 2030 Effort Sharing targets (EEA, 2019)

Carbon Market Watch and Transport & Environment in their "EU Climate Leader Board" were assessing where countries stand on the Effort Sharing Regulation. They placed Sweden as the only country in the category "Good" with a score of 67 out of 100 points. Germany (54/100) and France (53/100) as the only two countries achieved the grading "Moderate" ranking place second and third. While all three countries achieve 21 of 35 possible points for the "Starting point" criterion (from which the emission reduction targets are applied), Sweden achieves the full score of 35 for the "Ambition level" criterion (if its compatible with the Paris Agreement objectives).

As already described in Chapter 3.3, all studies refer to national energy and climate targets, especially those for 2030. It goes without saying that those countries that score very well in this criterion are not yet pioneers of energy transition. This is specially the case if they have set targets that are too low from the beginning, do not even achieve them in the end, or are not compatible with the Paris Agreement.

Nevertheless, the comparison of the studies should give a rough picture of which countries are on a better path and where those trailing behind can take a lead.

The following table lists the different studies and adds up how often which countries are mentioned in the top positions. The study by the the European

Environment Agency has two different assessments which is why they are counted separately. In this table, however, only the countries that have been mentioned more than twice are listed.

Countries	Burck et al. (CCPI)	CAN EU	ECF	EEA1	EEA2	Hirsch et al.	IRENA	T&F, CMW	WEF (ETI)	Total
Sweden	x	x	x		x		x	x	x	**7**
Denmark	x			x			x		x	**4**
France		x	x					x	x	**4**
Finland	x			x					x	**3**
United Kingdom	x			x					x	**3**
Greece			x	x	x					**3**
Portugal		x		x	x					**3**
Costa Rica						x	x			**2**
Norway	x								x	**2**
Austria							x		x	**2**
Spain			x	x						**2**
Netherlands		x							x	**2**
Iceland							x		x	**2**
Luxembourg	x	x								**2**

Table 2: High performing countries in the rankings

Sweden stands out as a country that scores very well in the studies. The only study in which Sweden is not represented in the top ranks is the one by Hirsch et al. However, this is only due to the fact that there the regional focus was different. Also Sweden is not not on track to reach its 2020 target because its 2017 final energy consumption was above a linear indicative trajectory between the 2005 level and the 2020 target (even though this could be now different due to reduced energy consumption during the first month of the COVID-19 pandemic, but which is not considered here).

In the studies by Burck et al., CAN Europe, CMW/ T&E and WEF, Sweden ranks highest, in the study by ECF Schweden ranks fourth and in the study by EEA Schweden is among the 3 countries that can achieve its 2030 target. The IRENA Coalition for Action has no ranking, but also here Sweden is among the few countries that have more comprehensive 100% renewable energy targets. Sweden is not represented as a pioneer in the EU countries comparison with regard to achieving the 2020 target assessed by EEA though.

According to the WEF, Switzerland and Norway are also pioneers in the energy transition. However, since both countries are not EU member states, they do not appear in the CAN, T&E/CMW and ECF studies. EEA has its own assessment for individual European non-EU member states such as Norway and Switzerland, but these are not included in the ranking and direct comparison between EU member states.

5 The case of Sweden

Using Sweden as an example country, this chapter analyses the literature to explore the reasons why Sweden is considered a leader in energy transition. This will then be compared with the findings from the eight case studies. The aim of this approach is to find out to what extent energy and climate policies were decisive for Sweden's leading role. Before that, Sweden's energy sector will be presented, as well as the country's climate and energy targets and its implemented policies that are focusing on energy transition.

5.1 Sweden's energy sector

The total amount of energy supply in Sweden in 2016 accounts for 564 TWh, while the energy is always in balance and energy input equals used energy (losses are included). Used energy is divided into the industrial sector using 142 TWh, the residential-and service sector using 146 TWh, and the transport sector using 87 TWh in 2016 (Swedish Energy Agency, 2018). Figure 13 below shows that the vast majority of fossil fuels are used in the transport sector.

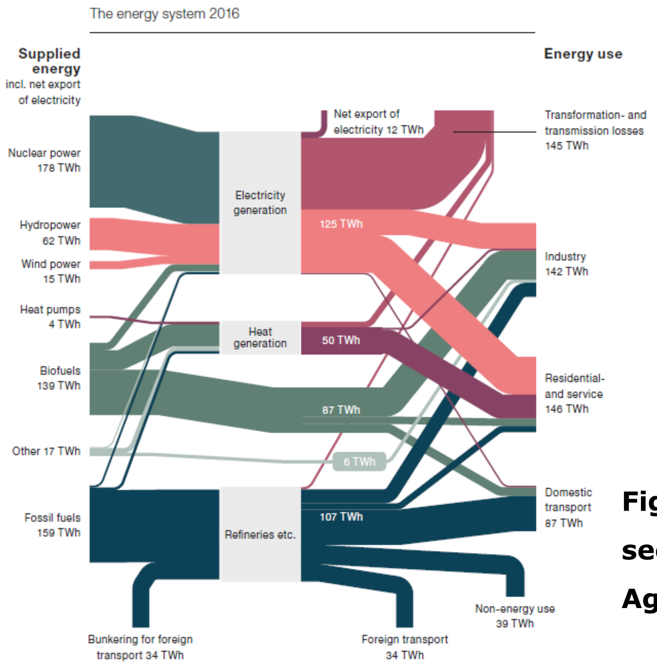


Figure 13: Sweden's energy sector 2016 (Swedish Energy Agency, 2018)

In particular, rising oil prices as a result of the 1973 oil crisis have initiated the market development of energy policy and have strongly influenced Sweden's current energy mix. While primary energy consumption has been increasing since the 1970s, the share of fossil fuels has been declining and has been reduced mostly in industry and buildings. Hydropower production increased in the 1970s but has remained stable since then. Biomass consumption has increased by 188% since 1990, mainly in district heating and electricity production. The residential and commercial sector is now almost CO_2-free, which has been made possible mainly by district heating in combination with electric heating. Thus, the increase in biomass consumption and nuclear power generation have been the main factors contributing to a reduction in oil consumption in Sweden (Millot et al., 2020). In 2018, over 50% of used energy in Sweden derives from renewable energy sources whereas hydropower, mostly used for electricity production, and bioenergy for heating are the top renewable sources (Swedish Institute, 2020). As shown in figure 13, biofuels in particular have increased over the last 30 years and crude oil and petroleum products have decreased over the same period. Solar cells have also been increasingly installed in recent years and the number of grid-connected solar systems grow by 52% between 2016 and 2017, bringing the total installed capacity with 15300 systems to 231 MW by the end of 2017 (Swedish Energy Agency, 2018). The extent to which nuclear energy should be part of the Swedish energy mix and how it will be used in the future in the decarbonisation of the country has been a bone of contention for years and has divided the political parties. As of 2020, three nuclear power plants and a total of eight nuclear reactors are in operation (Swedish Institute, 2020). The energy produced from it accounts for over a quarter of the total energy supply in percent.

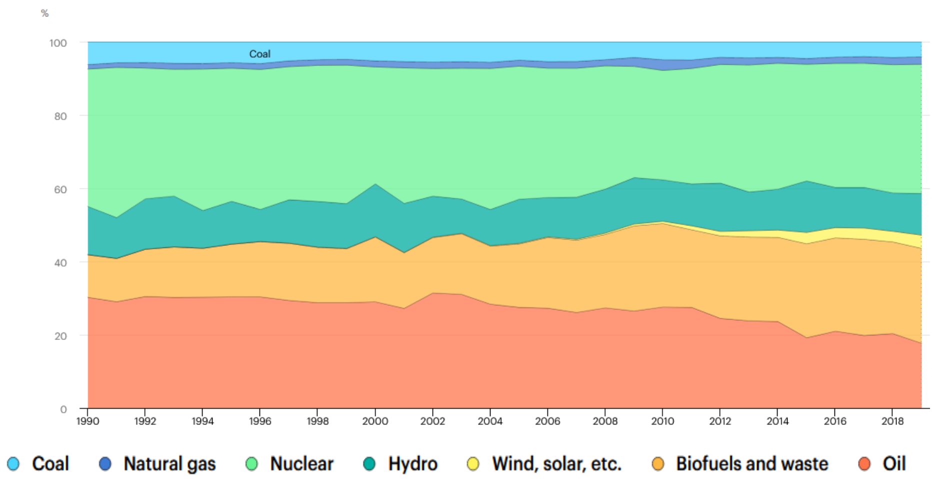


Figure 14: Total energy supply by source in % in Sweden (IEA, n.d.-a)

Total CO_2 emissions decreased from 52 $MtCO_2$ in 1990 to 32.5 $MtCO_2$ in 2019 (IEA, n.d.-a). The same is valid for GHG emissions in general. If Land Use, Land-Use Change and Forestry (LULUCF) are not included in the calculation, then Sweden records a decline of 25% in GHG emissions to a total of 54 $MtCO_2eq$ between 1990 and 2016 (IEA, 2019a).

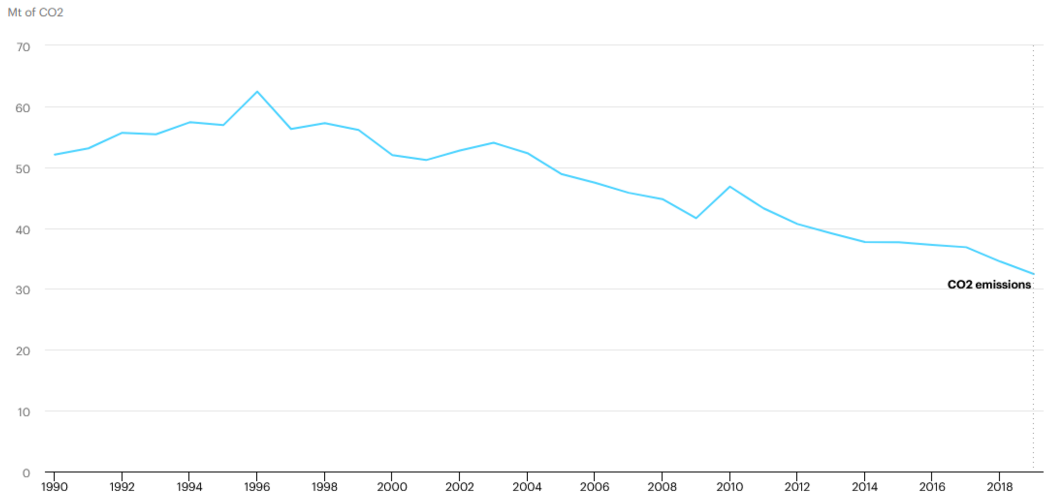


Figure 15: Total CO2 emissions, Sweden 1990-2019 (IEA, n.d.-a)

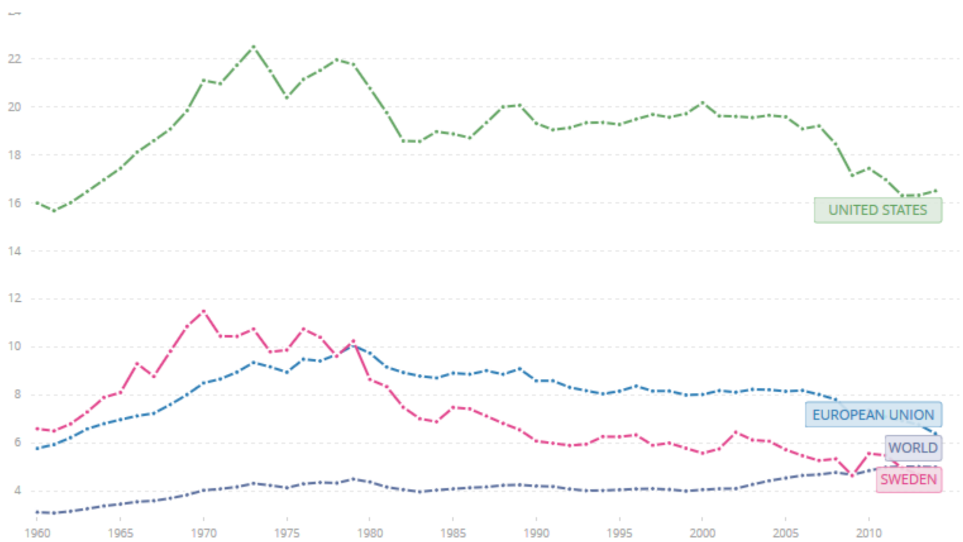


Figure 16: CO2 emissions (metric tons per capita) – EU, US, World, Sweden (Carbon Dioxide Information Analysis Center et al., n.d.)

In 2019 the average person in Sweden used 3.2 tons of CO_2 according to the International Energy Agency, which is the lowest value compared to other EU countries (IEA, n.d.-a). However, as already described in Chapter 3.1., the comparison of national CO_2 emissions often takes into account production-based emissions that are emitted within national borders. This does not take into account emissions produced by production in another country, which are then imported through trading. Although Sweden's production-based emissions are low, taking the consumption-based emissions as a basis, it is clear that they are higher in Sweden and that Sweden is one of the largest net importers of CO2 emissions. This can be seen in figure 17, which raises the question to what extent Sweden has simply outsourced its emissions, a concept commonly referred to as “carbon leakage”.

There are some studies that deal with this issue, but they come to different conclusions. Some, such as Aichele and Felbermayr (2014); Davis and Caldeira (2010); as well as Su and Thomson (2016) argue that production-related emissions are not due to decoupling. Other studies, argue that countries that are net importers of emissions do not necessarily have to contribute to an emissions shift, as a study has shown, using Sweden as a case study. In this study it is argued that “Sweden exports continue to contribute to avoiding more emissions abroad than what is caused by Swedish imports even if this effect is decling and migh switch sign in the near future. […] This can be interpreted as Sweden supplying heavy products to the world that are elsewhere produced with worse carbon efficiency” (Jiborn et al., 2018, p. 32). Nevertheless, Sweden is increasingly shifting its carbon-intensive production to countries that produce less energy efficiently, a trend that is of concern. In this respect, the authors suggest that policy instruments such as carbon taxes, cap-and-trade systems or border tax adjustments take this relative carbon efficiency into account (cf. ibid.). However, it is important to note in this context Sweden's energy-intensive companies have benefited massively from their pollution. This is because under the EU ETS rules, industrial companies that are deemed to be exposed to the risk of carbon leakage receive pollution permits. Various Swedish companies have been able to generate over €700 million over the period 2008-2014, paid for by European taxpayers and enabling less climate-friendly investments (Carbon Market Watch, 2016).

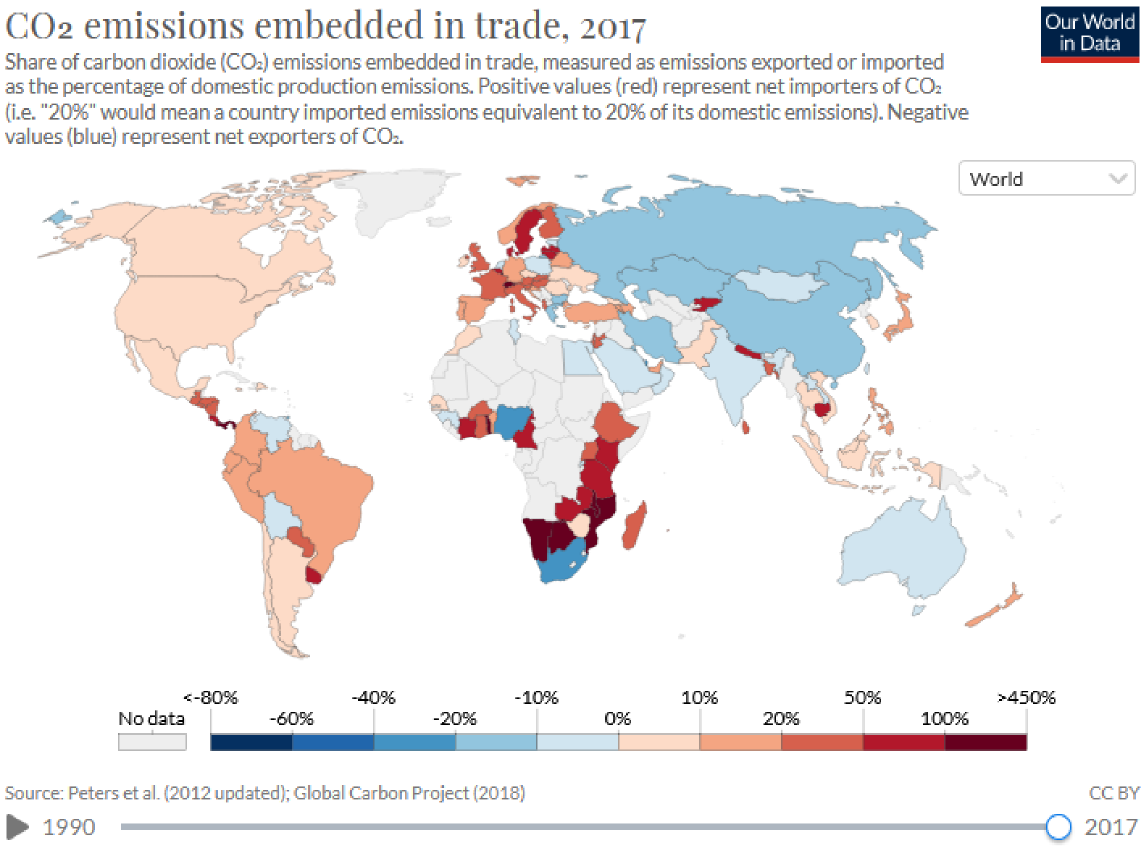


Figure 17: CO2 emissions embedded in trade, 2017 (Ritchie, 2019)

5.2 Sweden's climate and energy targets

Early on, Sweden set itself the goal of reducing its dependence on oil and since 1975 it has pursued a policy that secures "energy supply through an increase of domestic and preferably renewable sources of energy sources" (Nilsson et al., 2004, p. 72). To achieve this, the fuel mix should be changed and energy efficiency increased. In all sectors (apart from the transport sector) nuclear energy provided an alternative to oil in Sweden and 12 reactors were built between 1973 and 1985. As there was repeated political opposition, there has been a referendum in 1980 and a decision to phase out nuclear energy by 2010, even though this referendum was revised in 1997. Due to concerns about climate change, sustainable development was first recognised as a guiding principle of Swedish energy policy in 1991 and the development of a sustainable, secure and competitive energy system was set as a political goal. When Sweden became a member of the European Union in 1995 this led to a reform of the electricity market in 1996 (ibid.).

The 1997 Energy Act confirmed the policy guidelines of 1991 and established them in the 1998 "Energy Policy Program". This program set the overall objective to compensate the loss of 3 TWh of nuclear electricity production due to the closure of the Barsebäck 2 nuclear power plant by using electricity from renewable energy sources instead and by a reduction in electricity consumption. However, an assessment of this programme has shown that distortions of competition and obstacles to technological development occur when only individual technologies or energy sources are supported. Therefore, in 2002, the Parliament adopted a new Energy Act and introduced a new mechanism, namely a trading system of electricity certificates, whereby renewable energy sources compete on equal terms (more on this in the next sub-chapter). The Parliament has also set a target of increasing electricity consumption from renewable resources by 10 TWh between 2002 and 2010, and of increasing wind energy to 10 TWh by 2015 (Wang, 2006).

However, the renewable energy targets up to 2002 were vaguely formulated and focused only on a "substantial increase" in renewable energies. It is therefore not easy to determine whether the policies until then were successful or not and are difficult to assess (Nilsson et al., 2004)

The energy and climate policy of many EU member states is determined and guided by EU guidelines. Sweden's measures are also guided by this. On the basis of the EU burden sharing agreement and the EU Renewable Energy Directive, Sweden must achieve a 49% share of renewable energy by 2020, while Sweden raised this target to at least 50% of total energy consumption (Swedish Energy Agency, 2015).

Since the Emissions Trading System (ETS) is a cap-and-trade system, there are no national sub-targets and the target is identical for Sweden as for the EU, meaning a reduction of 43% by 2030 compared to the value of 2005. In the non-ETS sectors, however, which are regulated by the Effort Sharing Decision (ESD) and the Effort Sharing Regulation (ESR), Sweden has a reduction target of 17% by 2020 and 40% by 2030, compared to the values from 2005 (IEA, 2019a). However, in September 2020, the European Commission proposed to raise the 2030 target to 55% and will present detailed legislative proposals by June 2021 to implement and achieve this new target. As this target is also implemented through the EU Emissions Trading Scheme, the national emission reduction targets under the ESR and the land use, land use change and forestry Regulation, the sub-targets would then also change so that all sectors contribute to the overall 55% target (European Commission, 2020).

Sweden's climate policy framework which has been adopted in 2017 consists of three pillars, namely its national climate targets, the Climate Act, and the climate policy council. The target to achieve net zero GHG emissions by 2045 is set five years earlier than the EU roadmap target and is complemented by 2030 and 2040 sub-targets (63% and 75% reduction for non-ETS emissions compared to 1990 levels). Transport sector emissions are supposed to decrease by 70% by 2030 with 2010 as the starting year.

In January 2018 the Climate Act entered into force which obligates every government to execute a climate policy in line with the climate goals, present a yearly climate report and carry out a climate policy action plan with a detailed goal orientated roadmap. This process is monitored and supported by the Climate Policy Council, which acts politically autonomously and is the third pillar of the climate policy framework (Swedish Environmental Protection Agency, 2019).

Furthermore, the so called Energy Agreement from June 2016 defined the target of 100% renewable electricity production by 2040, which then has been included in the final Energy Bill that the parliament adopted in June 2018 (IRENA Coalition for Action, 2019). In addition, the goal has been set to make energy consumption 50% more efficient by 2030 (vs. 2005). This agreement does not provide for the termination or prohibition of the use of nuclear energy and the agreement was abandoned in December 2019 (Ministry of Infrastucture Sweden, 2020).

Target	Target year	Base year
Sweden must cut its net greenhouse gas emissions to zero and then achieve negative emissions. A maximum of 15% of emission reductions should come from additional measures.	2045	1990
75% reduction in emissions from sectors outside the European Union's Emission Trading System (EU ETS). A maximum of 2% from additional measures.	2040	1990
63% reduction in emissions from sectors outside the EU ETS. A maximum of 8% from additional measures.	2030	1990
70% reduction in emissions in the transport sector	2030	2010
40% reduction in emissions from sectors outside the EU ETS. A maximum of 13% from additional measures[4]	2020	1990
50% of final consumption of energy to be covered by renewable sources	2020	
100% renewable electricity generation (this is a target not a deadline for nuclear energy)	2040	
50% improvement in energy efficiency	2030	2005

Table 3: Important objectives, policies and measures in Sweden's Integrated National Energy and Climate Plan (Ministry of Infrastucture Sweden, 2020)

As required by the European Commission, Sweden submitted its National Energy and Climate Plan, as well as its Long-term Strategy by the end of 2019 and beginning of 2020.

5.3 Sweden's policy instruments for energy transition

Until carbon taxes and subsidies were introduced in 1991, Swedish energy policy focused mainly on technological R&D and less on fostering markets for new energy technologies and systems. The first energy research programme from 1975 to 1978 started with the investigation of all kinds of technologies in the fields of renewable energy and end-use efficiency. Wind energy and biomass turned out to be important energy sources for Sweden at an early stage and were therefore also important components of all subsequent energy research programmes (Nilsson et al., 2004).

In 1977, the country adopted a law to establish energy planning for municipalities in conjunction with energy advice centres for households. This policy instrument has played an important role in the implementation of public policies at local level and has shaped the institutional organisation of the country (Millot et al., 2020).

Sweden introduced the carbon tax in 1991 at a rate equivalent to 23€ per tonne of fossil CO_2 emitted. Since then, this rate has increased gradually to the equivalent of 110€ and is levied on heating and motor fuels. However, it does not measure actual emissions, but only the carbon content of the fuel, as this is proportional to CO_2 emissions. In contrast, sustainable biofuels are not taxed, as they do not cause a net increase in carbon in the atmosphere. Industries that are not covered by the EU ETS are regulated under separate tax rates, which have been adjusted and increased steadily. Notwithstanding, these have been subject to the same general tariff since 2018. In addition to the carbon tax, there has been an energy tax for key fuels since the 1920s (Government of Sweden, 2020).

In 2003, Sweden introduced a quota system for renewable energies which is combined with certificate trading, the major policy measure in increasing the share of renewables in Sweden. This was then extended in 2012 by establishing a common market together with Norway, where producers receive a certificate for each MWh of electricity produced from renewable energy. These certificates must then be purchased by electricity suppliers, certain electricity consumers and energy-intensive companies, in due proportion to their electricity sales and consumption, which is the quota. The quota obligations are set by the Norwegian and Swedish governments and all renewable energy production technologies can be used. The number of certificates is therefore predetermined, but the market then determines the price and the projects implemented (Energy Facts Norway, 2019; Vågerö, 2019).

In order to accelerate the process to climate neutrality, the Fossil Free Sweden initiative began in 2015 by the Swedish Government in order to enable various interest groups, such as companies, municipalities, organizations or other actors, to sign the declaration on a climate-neutral Sweden and to draw up concrete meassures to reduce emissions within their businesses or associations (Fossilfritt Sverige, n.d.).

Futhermore, the Climate Change Laws of the World database which collects national-level climate change legislation and policies worldwide lists three important policies for Sweden. Next to the Swedish Climate Policy Framework, they name the Regulation on State Subsidies for Solar Panels and the Action Plan for a fossil-fuel independent vehicle fleet. The first aims to facilitate the installations of all types of solar/ PV installation for private individuals, companies and municipalities through financial support. The second includes an action plan for the implementation of measures to enable "a fossil fuel independent vehicle fleet by 2030" (Climate Change Laws of the World database et al., n.d.).

As an example of financial support, one can mention the sum of 80 million US dollars that has been made available by the Swedish government for Solar's rebates for 2019 with the aim of covering the costs of purchasing PV systems and thus increasing the installation and growth of solar systems. The total amount allocated for solar rebate programs by the Swedish energy agency Energimyndigheten is $323 million for the period 2009 to 2019. The installed systems can then in turn participate in the Norwegian and Swedish electricity certification program (Bellini, 2019).

5.4 Sweden's leadership role

Policy assessment and success factors

Among IEA member countries, Sweden has the second-lowest CO_2 emssions per capita, as well as per GDP and is "leading the way towards a low-carbon economy” according to IEA (n.d.-b). A study carried out by Gogan et al. (2017) highlights that together with Norway, France, Finland and Switzerland, Sweden has not only a very low carbon intensity, but also outperforms the other countries when it comes to the fastest decarbonization rate per capita. They argue that nations “with high levels of hydro-electric power and strong nuclear energy programmes are cutting emissions much faster than those advancing 100% renwable policies” (cf. ibid.: p.3).

Millot et al. (2020) on the other hand highlight the increase in biomass consumption as a reason for emissions reduction. They name two factors that incluenced its development: on the one hand, the competitiveness of biomass has been promoted by the introduction of the carbon tax in 1991 and is identified by the government as a key factor in reducing CO2 emissions alongside energy taxes; on the other hand, there has been a high level of confidence in innovation in the renewable energy sector. As a result, many programmes have been promoted since the 1970s and industry and government have worked closely together to promote energy independence.

As figure 12 above shows, the transport sector in particular poses a challenge for Sweden, as it is precisely in this sector that most emissions are produced. Andersson (2019) has analysed the introduction of carbon taxes on transport fuels and examined their efficiency. He argues that it has had the greatest effect in the transport sector, and that about 90 percent of the revenue from the carbon tax is now coming from this sector. He comes to the conclusion that “consumers respond more strongly to changes to the carbon tax rate than equivalent market-driven gasoline price changes. The estimated carbon tax elasticity of demand for gasoline is three times larger than the price elasticity”. He was able to empirically prove that the carbon tax can significantly reduce carbon dioxide emissions. He calculated that the carbon tax, together with the VAT on fuels, could achieve an average annual reduction of almost 11 per cent in CO_2 emissions in the transport sector, and the carbon tax alone could achieve 6 per cent. In addition, the Swedish Energy Agency (EPA) have found in an analysis that the carbon tax not only has an impact on the transport sector, but also reduces emissions in the heating sector (cf. ibid.: p.27).

The concern over raising fuel prices with a carbon tax, which are already regarded as excessive, is there will be strong opposition, especially from the population living in more rural areas. Given the very ambitious targets in the

transport sector, it is interesting to see how Sweden intends to achieve them. According to Schieve, as long as no alternatives are available, further decarbonisation cannot be implemented politically. However, sustainable biofuels and, in the long term, electrification are possible options (Schieve 2019).
Air traffic is also problematic. According to a study, emissions from car use in Sweden are the same as the greenhouse gas emitted by Swedish citizens from flying, which amounted to 10 million tonnes of CO_2eq in 2017, a 47% increase since 1990. Per capita, Sweden's average annual CO_2eq is 1.1 tonnes, which is five times higher than the average global per capita emissions from flying, which is approximately 0.2 tonnes per capita (Kamb & Larsson, 2019). However, in Sweden kerosene remains tax-exempt even though Sweden has publicly spoken out in favour of a kerosene tax (Schulz, 2019).
Another study investigates the effectiveness of energy and carbon taxes using an economic approach and how that led to the drastic reduction of CO_2 emissions. This study also concluded that the CO_2 tax has had a significant impact on CO_2 emissions, specifically in the case of petrol. In other sectors, however, it was not the CO_2 tax alone but always in combination with energy taxes that led to a reduction in emissions. The study thus confirms that CO_2 taxes in combination with energy taxes are a viable policy instrument. However, the authors also emphasize that the development of nuclear and hydroelectric power, as well as the price of oil and net electricity imports from other countries have also contributed to the reduction of CO_2 emissions (Shmelev & Speck, 2018).
Sweden and Norway, both countries that have long been trying to take a leading role in environmental matters, have taken very different paths and a study shows that the policy instruments used have been very decisive in determining "which renewable energy sources have been developed, when and how". The common market for green certificates helped to encourage investment in the more advantageous system for each individual country, which was bioenergy and wind in Sweden, after Sweden had not the opportunity anymore to build more hydroelectric power plants (Ydersbond, 2014). Although the quota system was extended to 2045, the market price has fallen so drastically in recent years that the system has become superfluous. Sweden and Norway have set an overall target of 46.4 TWh of renewable electricity by 2030. However, more electricity is being generated and the target will be reached as early as 2021, so the price of a certificate would be zero. This illustrates that wind power is already so cheap

today that its development flourishes without this support mechanism (IRENA, 2020; IRENA Coalition for Action, 2019).

Compared to monetary mechanisms such as feed-in tariffs, which are used in around 93% of cases in the European Union, the quantity based quota system scores worse in analyses, both in terms of quantity and speed of expansion, as well as in the category of cost-effectiveness, making feed-in tariff systems a more efficient way to promote the expansion of renewable electricity. In practice, quota and tendering models have been found to interfere with the achievement of targets, market diversity and also with the security for investors (IG Windkraft, 2015).

Due to the quota system, the expansion of renewable energies has actually been slower in comparison to other European countries. In Germany, for example, by 2013 it has increased nine times as fast as in Sweden and the amount of wind energy generated exceeded that of Sweden by a factor of twelve. Smaller municipal utilities and energy cooperatives are also heavily disadvantaged by the quota system, in contrast to the large energy suppliers, which can take on the risks of the quota model due to their larger capital resources. This in turn leads to a less decentralized and technically diversified development of the renewable energy system (Zimmermann, 2013).

A number of international energy crises have also led to a change of direction in Swedish policy towards the development of renewable energy. Research and development, as well as fuel conversion programmes, were particularly stimulated by the oil crisis in the 1970s (Ydersbond, 2014).

Nilsson et al. (2004) argue that it was policy instruments to stimulate demand for biomass and wind power that brought about fuel switching and new investment. Non-discriminatory subsidies for wind power, and carbon taxes were particularly important in encouraging biomass conversion. The cost reductions for wind energy also show that low costs lead to higher cumulative production. Guidelines to remove barriers through simpler licensing procedures, regulation and standardisation are also important. Research and development efforts complemented by policy paved the way for decarbonisation of the energy sector. For example, Sweden had much higher overall per capita spending on energy research and development than other IEA countries, with a very strong focus on energy efficiency and renewable energy.

Another very positive trend towards an energy system based on renewables is the fact that Sweden closed its last coal-fired power plant in April 2020. This act took place two years earlier than planned and in the same week as Austria's closure of its last coal-fired power plant. This makes Sweden the third European country to eliminate coal from its grid for electricity production. Belgium was the first EU country to phase out coal in 2016 (Rosane, 2020).

Xylia (2016) investigated how energy efficiency is being addressed in Swedish energy and climate policy frameworks and describes existing gaps. In her view, energy efficiency is often placed behind emission reduction or renewable energy targets and is not given equal priority. The performance of energy efficiency in Sweden is strongly in need of improvement compared to other energy and climate objectives, even if it is in line with the average performance of the EU. The problem is that compared to the emission reduction targets in EU ETS and non-ETS sectors, there are no sector-specific distinctions and the target for energy efficiency is set at national level. Effective action and ambitious results are therefore difficult to achieve due to this policy gap and the overall complexity of the policy framework for energy efficiency. For example, the target for energy efficiency is expressed in energy intensity, but future achievements are measured in absolute reductions in final energy consumption and policy instruments are mainly focused on energy savings.

Overall, Sweden's commitment to energy and climate policy is mainly due to its membership of the European Union and its ambitious legislation. Membership has also given Sweden a stronger position in international negotiations (Xylia, 2016; Ydersbond, 2014).

A study by Sarasini examined the role Sweden plays as a pioneer country in climate change mitigation and identified two factors that limit this role. On the one hand, there is a risk of "leakage", which refers to the fear among political decision-makers that excessively strict climate regulations could lead to energy-intensive sectors simply relocating their production to locations where less stringent standards have to be met. This would therefore damage Sweden's global competitiveness. Another constraint calls into question Sweden's long-term leadership in renewable technologies, as the leadership role can only be maintained if Sweden is able to export climate-friendly technological innovations. The disagreement among policy makers about the future of nuclear power plays a significant role in this context, as further investment in nuclear power would make investments in renewable energy more difficult. Nontheless, the author believes that pioneers benefit from long-term climate policy regulations, which can boost investment in renewable technologies, especially in the energy sector. Sweden has succeeded in creating jobs and improving prosperity, as well as industrial competitiveness (Sarasini, 2009).

The importance of policies aimed at limiting fossil fuel supply in order to achieve mitigation targets has already been discussed in more detail in Chapter 2. Governments are in a position to influence the supply significantly by divesting from pension funds, investment funds or multilateral financial institutions and stop the further promotion of fossil fuel subsidies, as Sweden has already done (Lazarus & van Asselt, 2018). However, the Swedish government is not very transparent in publishing the concrete financial support of public financing, which makes it difficult to trace where fossil fuel subsidies or environmentally harmful subsidies are granted and to assess the progress in that regard (Gencsu & Zerzawy, 2017). A study that identified a total of 11 fossil fuel subsidies in Sweden emphasises that these are mostly exceptions to the CO_2 tax (e.g. CO_2 tax breaks for some industrial plants outside the EU ETS) and notes positively that these exceptions have been significantly minimised in recent years. Furthermore, Vattenfall, a Swedish energy company and one of Europe's largest electricity producers, reduced its share of coal production by more than half between 2014 and 2016 and has reduced its funding for coal-fired power. Instead, however, Vattenfall has expanded its gas-fired power generation by 10% between 2014 and 2016. The same applies to the Swedish Export Credit Corporation (Aktiebolaget Svensk Exportkredit) and the National Export Credits Guarantee Board (Exportkreditnämnden), which have also expanded their financing for natural gas in recent years. There is criticism that numerous tax concessions are granted for the consumption of fossil fuels in the transport, industrial and agricultural sectors. For example, over EUR 1 billion a year is allocated to the transport sector in the form of subsidies, 80% of which went to diesel subsidies. However, the Swedish government is also not very transparent in publishing the concrete financial support of public financing, which makes it difficult to trace where fossil fuel subsidies or environmentally harmful subsidies are granted (Gencsu & Zerzawy, 2017).

Regarding divestment, there has been some progress. For instance, there are five pension funds in the Swedish national income pension system (the AP

Funds). Första AP-fonden (AP1) is one of them that has decided in December 2019 to divest from fossil fuels and "to develop measurable targets and a roadmap towards achieving a carbon neutral portfolio by 2050" (Första AP-fonden, 2020). Also the Fourth Swedish National Pension Fund (Fjärde AP-fonden AP4) by selling more than 20 thermal coal companies (using a threshold of 20% of revenues) and Sjunde AP-fonden (AP7) by implementing a climate policy of "active engagement including pursuing shareholder resolution to enact change" were taking similar steps to reduce climate risk (Institute for Energy Economics & Financial Analysis, 2020).

To sum up, public policy has been very important in the energy transition, even if it was not originally designed to address environmental concerns or to reduce CO2 emissions, but only to reduce oil dependency and promote energy independence. The shift to bioenergy proved to be very effective in establishing a low-carbon energy mix. An important instrument for promoting it was the carbon tax, especially in the construction and energy sectors, although it could not trigger a complete energy transition in the transport sector. The welfare system and its institutional arrangements also set the course for the transformation of the Swedish energy system in the 1980s with the combination of welfare and competition policy. The culture of consensus and dialogue plays an important role in the success of Swedish climate policy, which is supported by long-term visions (Millot et al., 2020).

Sweden's performance according to the rankings

In addition to the assessment of the policies implemented in Sweden, a summary of why Sweden has been identified as a pioneer in the rankings of the eight case studies will be given here.

Sweden has the highest carbon tax worldwide (Burck, Hagen, et al., 2019a) and CO_2 pricing has proven to be an advantageous instrument for making renewable energies competitive. It was the main instrument to drive the energy transition and facilitated that the non-ETS sectors were regulated too (IRENA Coalition for Action, 2019). It incentiviced the education of energy consumption, as well as the improvement in energy efficiency and an increased usage of renewable energy alternatives.

According to the CCPI, Sweden has the lowest CO_2 emissions per capita (consumption based only) compared to the other countries considered in the studies and also performs best in regard of its well-below-2°C compatibility and in the "GHG emissions" category in generell (Burck, Hagen, et al., 2019a).

In the ETI, Sweden scores the highest on environmental sustainability which they define with the indicators PM2.5, Energy intensity, CO_2 per capita and CO_2 intensity (World Economic Forum, 2018).

This low-carbon power generation mix, and especially the high share of renewable energy is mentioned positively, especially in the studies by the Climate Action Network Europe (CAN Europe, 2018), as well as in the ranking of the Climate Change Performance Index. This rates rates Sweden "very high" due to its high share of renewable energies and classified Sweden’s “high” performance concerning their below two degree compatibility (Burck, Hagen, et al., 2019a).

Overall, Sweden's climate policy framework is considered to be very strong compared to other countries. In particular, the effective institutional and regulatory, legally binding framework, which should provide the achievement of net greenhouse gas emissions of zero by 2045, as well as the political will support the transition in the country effectively. Additionally, the annual climate report ensures cross-party commitment and stability even across political cycles, thus promoting the implementation of reforms (Burck, Hagen, et al., 2019a; World Economic Forum, 2018).

The European Environment Agency (EEA, 2019) comes to the conclusion that Sweden is on track towards its 2020 target regarding GHG emissions (2017) and its share of renewables in gross final energy consumption (2017-2018). To the same conclusion comes CAN Europe (2018) in its analysis, concluding that Sweden is not only on the right track to achieve its domestic climate and energy targets for 2020, but also has set their domestic targets higher than required by the EU.

In 2017, Sweden was able to overachieve its 2017 Effort Sharing GHG emission reduction target by more than 10 percentage points, together with 7 other Member States, namely Croatia, Greece, Hungary, Portugal, Romania, Slovakia, and Slovenia. The same is valid for Sweden’s 2020 Renewable Energy Directive target, which is for Sweden 49% and thus the highest of all EU member states. It exceeded its target already in 2017, together with 11 other member States. As two extraordinary examples, Sweden and Finland also stand out as two countries that have significantly increased their share of renewable energy in the transport sector. By increasing the use of hydro treated vegetable oil (HVO) as a renewable diesel fuel, Sweden has succeeded in increasing the share of renewable energies in transport by 13.5 percentage points (2016 to 2017). In addition to the existing carbon tax, biofuels have been tax-free since 2007. This stable bioenergy policy has made this development possible, although some changes had to be made in 2018 as a result of EU regulations limiting state tax exemptions for biofuels based on food crops (EEA, 2019).

Under the Effort Sharing Decision various flexibility mechanisms exist to facilitate that the annual targets can be reached. One of them is the Annual Emission Allocation (AEA) which can be used if Member States overachieve their targets. They can transfer them to another Member State that would otherwise not reach its target or bank the surplus for another year. Sweden, the only country to do so, cancelled its annual surpluses for the period 2013 to 2017 which adds up to 31 million AEAs and shows leadership by encouraging other EU countries to do so too (EEA, 2019; European Commission, 2019).

Together with Greece and Portugal, Sweden is one of the three countries that will likely remain below the ESR emission targets for 2030 with the measures currently in place (EEA, 2019).

In general, Sweden is committed to close certain loopholes in the EU law. For example, it does not intend to use the ETS surplus loophole and advocates that underperformance should not be rewarded through this mechanism and should be avoided (CMW & T&E, 2017).

The European Climate Foundation (2019) highlights that the EU targets should rather be acknowledged as minimum thresholds for national climate ambition. They name Sweden, together with Luxembourg and Spain as three countries that set their targets above the compliance level on the GHG emissions not covered by the ETS. Sweden and Luxembourg with absolute targets of -50% GHG emission cuts are leading there, even though they are still not managing to align their 2030 target with the goal of net zero emissions by 2050. The same applies for a 2030 economy-wide GHG reduction target. Sweden with a GHG reduction target of -63% compared to the 1990 level has set the highest target so far. Within the 'Moderate ambition' range, Sweden is also one of the seven (out of 28 Member States) that goes beyond the minimum level that is required for the target of renewable energy in gross final energy consumption. In order to reach the net-zero goal by 2050 at the latest, many intermediate steps will be necessary before then. All decisions must therefore be taken in coherence with the objectives of the Paris Convention. The few EU countries that make this connection between their short-term requirements and their long-term visions are France, Denmark, Latvia and Sweden. According to the information in its draft NECF, Sweden expects to achieve both its 2030 RES target as well as its efficiency target with policies already in place and existing measures. In addition, the ECF has identified Sweden's ambitions in relation to the implementation of various policies and measures in general. Across the dimensions of energy efficiency, renewables and GHG emissions Sweden’s draft plan provides “a good level of detail on existing and planned policies” (cf. p.70).

The IRENA Coalition for Action (2019), that mapped 100% renewable energy targets, globally names Sweden as one of the few countries that has adopted such a target for the electricity sector.

Sweden is also a strong advocator of ambitious climate action at EU level (Burck, Hagen, et al., 2019a) and a leader when it comes to realizing that EU climate policy must be in line with the Paris Agreement. Together with Portugal, France, the Netherlands and Luxembourg, Sweden is leading the debate on future EU energy targets and is committed to more ambitious measures. For instance, Sweden calls for targets to reduce emissions by 55% by 2030 and net zero emissions by 2050 the latest (CAN Europe, 2018).

Importantly, Burck et al. (2019) highlight is the fact that Sweden is one of the strongest financial donors to the Green Climate Fund.

Overall, the comparison of the rankings has shown that they define Sweden as a pioneer, mainly because of its ambitious targets and the achievement of those targets. The precise policies that have been used to achieve these targets have not been well explored and the studies do not provide a clear picture of the exact success factors. Only in the rankings by Burck et al (2019) and the IRENA Coalition for Action (2019) have the CO_2 tax been mentioned as an important instrument. Apart from that, the generally strong climate and energy framework, which is legally binding, was only mentioned.

Nevertheless, one point of criticism that is consistently reflected in several studies is that Sweden still has far too high levels of energy use per capita and therefore, cannot demonstrate the necessary savings in final energy consumption and progress towards achieving the energy efficiency targets (year 2017). This reflects the general trend in the EU and even greater ambitions in that regard are required to ensure that the 2030 targets will be met (EEA, 2019).

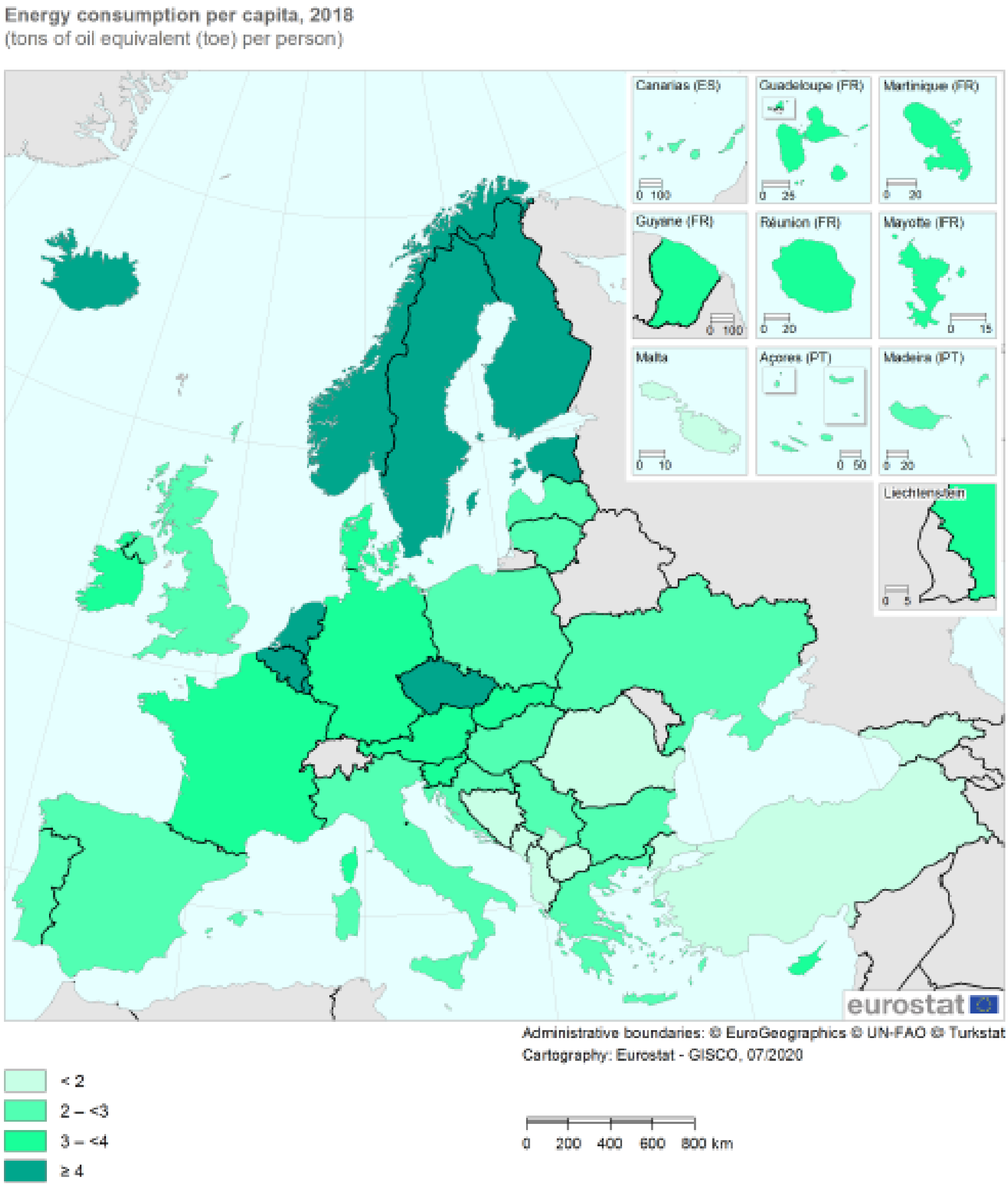


Figure 18: Energy consumption per capita, 2020 (Eurostat, 2020)

5.5 Outlook

<u>Carbon budgets</u>

As ambitious as Swedish climate policy may seem in comparison to other countries, it is still far from meeting the objectives of the Paris agreement. This is the conclusion reached by Anderson et al. (2020), who in a study attributed certain carbon budgets to Sweden, taking into account equity and following the principle of "common but differentiated responsibilities and respective capabilities" and, in contrast to many other studies, did not include negative emissions technologies (NETs). On the one hand, they calculate a stricter budget, which allows Sweden 280 $MtCO_2$ emissions and a weaker one, which allows 370 $MtCO_2$ emissions. They also argue that a Paris-compliant carbon budget for industrialised countries would require a complete decarbonisation of energy already by 2035-2040. From these calculated budgets, annual emission reduction rates were then derived from the year 2020 onwards. This result was compared to the Swedish reduction agenda and it becomes clear that the annual CO_2 reduction rate of 5% under the Swedish pathway is well below the 12% (referred to as DD2 in figure 19) that would be at least necessary to stay below the weaker carbon budget of 370 $MtCO_2$ emissions. If even a country like Sweden has such large deficits in its current emission reduction measures, the picture for the rest of the EU countries would be even more disastrous.

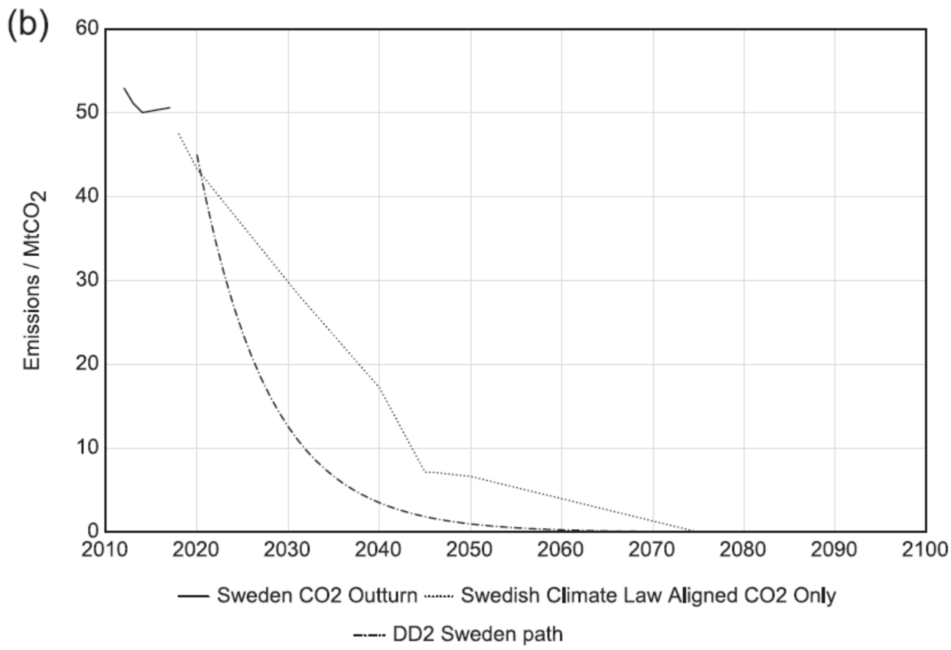


Figure 19: CO2 emissions implicit in Swedish current policy vs. Paris-compliant pathway (Anderson et al., 2020)

Carbon leakage

As described in chapter 5.1., some sectors receive free allocation of emissions certificates under the ETS system to counteract carbon leakage, which means that a large part of the emissions are not priced. Now, under the Green New

Deal, a carbon border adjustment mechanism has been proposed by the European Commission, which would imply that all CO_2 emissions, including some from imported goods, will be priced at the EU ETS certificate price. Some industries, such as the steel and aluminium production industries, will have to bear significantly higher carbon costs and thus would drastically reduce more carbon emissions (Zimmer, 2020). However, in order to avoid further problems with this mechanism, it is important to consider how it should be properly implemented. For example, it should be questioned on which basis which sectors are covered, or how emissions are to be measured and verified (Tsafos, 2020). It also remains unclear to what extent this mechanism will be implemented at all. Despite great popularity, e.g. by more than 3000 respected American economists, it is also strongly criticised, especially by some trading partners who might oppose its introduction. It is also not clear to what extent this system is compatible with existing obligations under the World Trade Organisation (Wolff & Bruegel, 2019).

Energy efficiency

CAN Europe (2018) assumes that Sweden's climate target for 2030 is severely threatened by the high per capita energy consumption and especially by the high emissions in the transport sector. In order to counteract this, more incentives for investment in energy-saving measures would need to be created. Burck et al. (2019) criticise the lack of energy consumption targets and incentives for energy efficiency and emphasise that Sweden also scores poorly in the energy consumption category because it lacks a 2030 target that is "well-below 2°C compatible". In their opinion, by then Swedish emissions should already reach net zero emissions "to put the country on a well-below 2°C pathway".

Transport

In connection with the draft NECFs of the EU member states, it is also criticised that not a single country in the EU has drawn up a cost-effectiveness calculation for the various measures proposed to decarbonise the transport sector, making it difficult to achieve the reduction target of 70% by 2030 (vs. 2010). This is the result of a study by the think tank Farm Europe, which questions the effectiveness of the draft NECFs. Most EU countries, including Sweden, do not rely heavily on electrification, but nevertheless no country has calculated how much the transition to electric cars will cost and the electrification infrastructure is also only being developed very slowly. They write: "It is of utmost importance that society has a clear understanding of what to expect for the future and that citizens support chosen policy tools in order to achieve climate targets. Discussion today focus on 'ambitions' rather than on good governance" (Michalopoulos, 2019, p. 5).

Biomass and biofuel

In Sweden a high proportion of the energy system is based on biofuels as about 55% of the land area in Sweden is forested, with a further increase expected in the future. According to the Swedish government and the Swedish Bioenergy Trade Association Svebio, biofuels are climate neutral, whereas critics argue that this argument has led to under-reporting of emissions (World Energy Data, 2019).

A study commissioned by Transport and Environment and Birdlife Europe has analysed 13 studies that formulate pathways for decarbonising the economy and look at the extent to which bioenergy plays a role in these scenarios. The result is that all studies take into account the growth of bioenergy until 2050. However, the problem is that there are no uniform sustainability criteria for biomass for transport and energy. The increase in the use of biomass to generate energy will lead to an increased demand for agricultural land. This land, which is actually used for the production of food and feed, will therefore lead to direct and indirect land use changes. In addition, agricultural land would also expand into natural areas rich in carbon stocks, which means that life-cycle emissions from biofuels are sometimes higher than those from fossil fuels. The study thus criticises the use of biomass for energy production and argues that Europe should instead use renewable energy sources from wind and sun (Transport and Environment & BirdLife Europe, 2020).

In its draft NECP Sweden declared to use biomass to levels that would need to be checked with sustainability standards (ECF, 2019). In an open letter, 70 NGOs and 30 scientists have called on the Swedish Parliament, the government and the Swedish Forestry Agency to stop forestry in all forests with a high nature conservation value. The main concern was the systematic clearing of natural forests for allegedly sustainable timber production and the acquisition of bioenergy in the name of the climate crisis by the Swedish forestry industry. It is criticised that instead of preserving biodiversity and reducing greenhouse gases, forest management is being intensified and that this habitat destruction has led to more than 1800 living species now on the red list (Klein et al., 2020).

Hydropower

A similar problem exists for the generation of electricity by hydropower, which accounts for about half of the electricity generated. Here, the need to guarantee energy security contrasts with the concern to simultaneously preserve and improve the goods and services of the ecosystem. Critics argue that, on the one hand, the legal framework is outdated and, on the other hand, the various regulations, guidelines and laws of these two interests are in conflict with each other, with the interests of energy security outweighing those of environmental quality (Lindström & Ruud, 2017).

Nuclear power

Renewable energy, nuclear power and fossil fuels with carbon capture and storage (CCS) are commonly referred to as low-carbon energy supply options, but the opinions if nuclear power should be an essential part of the energy transition differ greatly.

The International Atomic Energy Agency (IAEA) published several papers related to the role of nuclear power as the solution to phase out oil, coal and gas to mitigate emissions. They argue that approximately 68 gigatonnes of CO_2 emissions have been avoided between 1970 and 2015 through the use of nuclear energy, considering that fossil fuels would have emitted this amount of electricity otherwise. Nevertheless, they emphasise that low-carbon energy sources do not compete with each other and therefore, if one technology would drop out, it would be replaced by fossil fuels, but not by the other low-carbon energy sources instead. They therefore argue that other renewable energy sources alone would not be able to replace fossil fuels to achieve the Paris climate targets and therefore low carbon technologies, including nuclear energy, must be expanded (IAEA, 2018).

Gogan et al. (2017) see great potential in nuclear energy because it enables the fastest possible decarbonization, highlighting that the fast decarbonisation rate per capita in Sweden was due to the use of nuclear power.

Verbruggen & Yurchenko (2017, p. 163) on the other hand argue that it should not be "considered a sustainable, responsible option for the low carbon transition". Nuclear waste poses significant risks and places a permanent and irreversible burden on ecosystems, which by its nature cannot be sustainable. They also speak of an "unresolvable stalemate" in connection with the fact that subsidizing nuclear power hinders and delays the further expansion of renewable energies.

The positions on the extent to which nuclear energy should play a role in the implementation of a sustainable energy system transformation vary widely in Swedish politics. One group is in favour of its use and regards nuclear energy as a complement to the expansion of renewables, while the other group sees nuclear energy as a competitor to them. The example of Sweden clearly shows that, even though all major political camps share the opinion that a sustainable energy transition towards renewable energies must take place and that Sweden should also be an active player at the international level with a lead role, there are still very different ideas on how exactly the transition to a more sustainable energy system should look like. This example demonstrates that energy system transformation depends very much on political ideologies and deep social structures and is not just a political process (Edberg & Tarasova, 2016).

A study that has examined various hypothetical development paths in Sweden for the conversion to completely renewable energies without nuclear power, focused on exploring its ecological and economic costs comes to the conclusion "that a large installed capacity of renewable sources focused on a substantial increase in wind and solar photovoltaic, cannot replace nuclear generation if the current electricity costs and greenhouse-gas emissions are to be maintained […] and is neither economically viable nor environmentally friendly" (Hong et al., 2018, p. 63).

Regulatory loopholes

In order to enable Member States to comply with their national guidelines under the Effort Sharing Regulation and to achieve their objectives in a "fair and cost-efficient" way, so-called flexible mechanisms have been implemented (European Commission, 2016). However, the European Climate Foundation (2019) criticises that these regulatory loopholes would tempt countries not to take serious measures such as reducingtheir emissions outside the ETS system in a sustainable manner. In the draft NECPs, not a single country has agreed to refrain from using these mechanisms. Sweden in this context has explicitly announced that net removals from LULUCF will play an important role.

Notwithstanding, Sweden has not indicated in the draft NECP how it intends to account for the LULUCF sector (EEA, 2019).

6 Discussion

6.1 Interpretation and implications

The analysis of the rankings has shown that they all show only very fragmented illustrations of the progress of energy transition in the individual countries. The only studies directly related to energy transition are those by the World Economic Forum and by Hirsch et al (Friedrich-Ebert-Stiftung). Both studies, however, only give the current situation of the countries with regard to their ability to initiate the energy transition and the energy landscape, as in the case of the Energy Transition Index, or the current situation with regard to the just transition of the energy system, as in the case of the Just Transition Index. Leadership in connection with political development and actual decarbonisation in recent years is not presented. This is only included in the Climate Change Performance Index (CCPI), which reflects the trend of recent years and takes into account the current status, as well as the projected performance towards the countries' 2030 targets. In addition, the CCPI also assesses the countries' performance in relation to the Paris Agreement and their 2°C compatibility, which is rather neglected in the other studies.

However, since this study also aims to map the political component and identify European pioneers, rankings were selected to assess political performance. This was done in the rankings primarily on the basis of climate targets and the potential to achieve them, although the development of recent years was rather ignored. It is therefore clear that all studies and their rankings do not directly reflect leadership in energy transition. Nevertheless, together they were able to give a picture of which countries are doing better, and Sweden clearly comes out on top as the leader.

The question now arises is; how far Sweden is also meeting the criteria of a leader in energy transition that have been presented in the conceptual framework?

Sweden started to change its energy mix as early as the 1970s, even if this was not originally done for climate protection reasons but only to achieve energy independence. Nevertheless, this early development gives Sweden an advantage today and continues to shape the current energy mix. Back then, the country strongly favoured biomass and nuclear energy, which, in addition to the already high share of hydropower, contributed to an overall lower carbon energy production and a decrease in production-based CO_2 emissions. However, the consumption-based emissions that include trading show that Sweden is one of the largest net importers of CO_2 emissions, which is why it is often argued that Sweden has simply outsourced its production and thus its emissions to other countries. This has also been confirmed by some studies, but it cannot be seen as the only reason for the decrease in emissions. Furthermore, this problem could be addressed in the future through the carbon border adjustment mechanism under the EU Green New Deal.

Even though Sweden stands out in a positive way due to its high share of renewable energies, it is held back by its high final energy consumption, which is explained by the fact that energy efficiency is not given as much attention in climate and energy policy as emission reduction and renewable energies. Furthermore, the low carbon intensity is also the result of the high share of nuclear energy in Sweden's energy mix. It is not clear to what extent this really contributes to a sustainable energy transition. A topic that is highly controversial in the swedish political discourse.

The two challenges that a leader in energy transition must adress (based on Meijerink and Stiller 2011), have been overcome by Sweden, at least theoretically:

1. The Swedish government has been able to influence the political process to such an extent that policies supporting energy transition have been accepted and implemented: The political framework in Sweden is widely regarded as one of the strongest in the studies and the Climate Act now forces every government to pursue policies that are in line with the climate and energy goals.
2. The Swedish government has improved the link between different policy-making levels, sectors and actors: The initiative *Fossil Free Sweden* was founded to communicate and promote the climate goal of a climate-neutral Sweden, to integrate different stakeholders in the process and facilitate exchange of knowledge.

The success factors presented in the second chapter for the implementation of energy transition also largely apply to Sweden. Sweden is politically stable and there are no geopolitical conflicts prevailing. The political will to transform the energy system has existed since the 1970s and, above all, the results of the case studies show that Sweden has made strong commitments and has ambitious positions at international level. The climate and energy targets in particular are very ambitious by European standards, although more specific targets are needed for individual sectors and not only for the electricity sector. Energy efficiency targets should also be more sector-specific. The implementation of the politically independent Climate Policy Council and the Fossil Free Sweden Initiative should ensure that different stakeholders can contribute their expertise to the implementation of a Net-Zero Pathway and participate in the transformation process. With regard to renewable energy policies, Sweden has shown that no specific policy has been decisive for emission reduction by itself, although the CO_2 tax stands out positively and contributed significantly to the decarbonisation of the heating and building sectors. For the transport sector it was useful and also contributed to emission declines, but did not result in a full decarbonisation of the sector.

Sweden's quota system has not been found to be as effective as feed-in tariffs in other countries, but nevertheless this and the joint emissions trading market between Sweden and Norway have led to an expansion of renewable energy, with a focus on biomass and wind energy in Sweden. Sweden has also spent a lot of money on energy research and development and has provided the renewable energy sector with substantial financial resources, for example the 80 million US dollars for Solar Rebates. As the strongest donor to the Green Climate Fund, Sweden is also the country that is most committed to supporting other vulnerable countries that have fewer financial resources for energy system transformation.

Even though Sweden has succeeded in achieving a relative decoupling of economic growth from per capita resource consumption, energy consumption is still very high, which is why the integration of sufficiency policy into Sweden's energy efficiency policy should be sought.

In summary, it can be said that while Sweden has proven to be a pioneer of energy transition, it is still far from taking the necessary measures to achieve net-zero emissions by 2035-2040 as suggested by Anderson et al. This result also paints an even more pessimistic picture for all other EU countries that are pursuing even less ambitious decarbonisation pathways.

6.2 Limitations

It is beyond the scope of this study to include all relevant aspects. Those that could have been included, but would require further reasearch will be explored in the following sub-chapters.

Power structures, political orientation and corporate interests

In the conceptual part, a quotation from Edberg and Tarasova (2016) was used, which argued that it is important to analyse which ideological ideas are represented by political decision-makers in relation to energy transition and social development, so that the complexity of energy transition can be better understood from a socio-political perspective.
This aspect is not been further explored in the studies examined and thus in this thesis, but it is one that should not go unmentioned. For example, a study by Schaller and Alexander (2019) comes to the conclusion that half of all votes against resolutions on climate and energy in the European Parliament come from the spectrum of right-wing populist parties, where two out of three right-wing populist MPs regularly vote against climate and energy policy measures. Furthermore, seven of the 21 right-wing populist parties analysed deny anthropogenic climate change, which is problematic for the progress of the energy transition in view of the so-called "swing to the right" that is currently emerging in the EU.
Certain companies are also trying to prevent the implementation of stricter climate and energy guidelines in the EU. For example, since 2010, the five largest oil and gas companies in the world (BP, Chevron, ExxonMobil, Shell and Total), as well as their lobbyists have spent more than 251 million euros on lobbying in the EU to delay, weaken and sabotage climate protection measures. But this harmful influence of the fossil fuel industry does not only occur in Brussels (e.g. also at the UN climate conference or at national level) and is not only limited to political decision makers. Hundreds of millions are being spent through advertising, press trips or the financing of climate-related events to delay climate action (Corporate Europe Observatory et al., 2019).

Eurocentrism

Although some of the selected studies covered a broader regional framework, the focus of this work was European. Due to the limited scope, it was unfortunately not possible to work on a larger geographical context within the framework of this thesis. Countries are subject to different structural, economic, social and institutional conditions, as well as different starting points, which makes a direct comparison not always appropriate. For this reason, countries with similar characteristics should rather be compared, which in the case of this thesis with European countries. Nevertheless, research on leadership in energy transition is of utmost importance in an international context. This includes, for example, funding more studies that take into account the realities of countries of the Global South or what role the relationship between countries of the Global North and Global South plays in the context of energy transition, for example in the extraction of raw materials for the production of renewable energies. Wood & Baker (2020, p.vii) critizise that "while we may applaud countries like Costa Rica or Sweden for their ambition to become 'fossil free' nationals, the challenge for countries like Angola or Indonesia will be much greater.[…] These international, national, and subnational equity and fairness dimensions underscore the necessity of a *just* transition, and more broadly the need to view energy transitions through the lens of energy justice".

International unregulated sectors

This thesis is mainly focusing on national climate action. Nevertheless, certain sectors are not included in national climate policies and are also underrepresented in the discourse of international negotiations. Emissions from the shipping and aviation sector cannot be attributed to individual countries and are thus not properly regulated under the Paris Agreement. Both sectors are growing rapidly and the resulting emissions are growing with them. The CO_2 emissions of the international aviation industry are expected to account for 22% of global emissions by 2050 (Stay Grounded, 2019) and those of international freight transport are expected to increase by at least 50% by 2050 and, according to EU estimates, account for one-fifth of global emissions, if no drastic interventions are being made (Green, 2018). These sectors should therefore be considered in the energy transition, and here, too, leadership is needed from states to ensure that stricter international regulations are being introduced.

Role of business, civil society and individuals in energy transition

Especially the Fridays for Future movement started by Greta Thunberg in Sweden has shown that civil society has been a key factor in calling for stricter laws, programs, guidelines and strategies on climate change. A greater number of corporations are accepting their responsibility and declaring that they want to operate climate-neutrally by 2050 at the latest and want to reorganise their management in a climate-friendly way. For example, since the founding of the "We Mean Business Coalition" in September 2019, almost 2000 companies have already committed themselves to this (We Mean Business Coalition, n.d.). This is an important step in the right direction, especially in connection with the fact that since 1988 more than 70% of global greenhouse gas emissions have been caused by just 100 companies according to the Carbon Majors Report (Griffin, 2017). According to Pedro Faria this "pinpoints how a relatively small set of fossil fuel producers may hold the key to systemic change on carbon emissions" (Riley, 2017).

<u>COVID-19</u>

The COVID-19 pandemic, which began in December 2019, and its consequences for the energy transition were not considered in this work because they were still too uncertain at the time of writing. However, this topic is highly relevant and many studies are currently being published on how economies can recover from this health and economic crisis without causing more damage to the climate. It is argued that the current situation represents a "once-in-a-generation opportuny to boost clean energy technology progrees" for countries (IEA, 2020, p. 48) and that so-called "green recovery plans" are needed to reduce CO_2 emissions while boosting the economy. The lockdown has led to a significant reduction in global emissions in many countries, but as economic activity picks up, emissions will increase again. Even if the lockdown were to remain in place for the most part until the end of 2021, temperatures are estimated to be only 0.01°C lower in 2030 than expected before the pandemic (Gabbatiss, 2020).

7 Conclusion

This thesis has looked to define leadership in energy transition and thus answered the research question "What is leadership in energy transition from a normative perspective? How are leaders defined?". So far, there is neither a uniform definition for energy transition nor a standardised method to measure the progress of energy transition in a country. Thus, it has been difficult to identify leadership in energy transition and to identify individual countries as pioneers. This thesis consequently defined it in the following way: Leadership in energy transition can be demonstrated when countries can prove that they can reduce and ultimately minimise their CO_2 emissions to a neutral level by expanding renewable energies and increasing energy efficiency, while at the same time reducing energy need and consumption.

The results show that for the assessment of countries most studies chose indicators that focus on targets for the expansion of renewable energies and the increase of energy efficiency. Even though, the "important energy transformation indicators" defined by the IEA are included in the rankings to some extent, the only study that included them directly is the one by the World Economic Forum within its Energy Transition Index. These indicators have a strong technical component, but per capita energy consumption from a socio-political perspective is rarely mentioned in the studies.

Who are the leaders in energy transition in the European Union? What country is standing out in its performance to transform the energy sector? This research question was answered with the analysis of eight case studies and their nine different rankings. All studies examined agree that countries generally perform very poorly and are not yet doing enough to accelerate energy transition and slow down climate change. In the rankings, Denmark and France have been in the higher positions 4 out of 9 times, while the one country that is clearly standing out positively is Sweden with 7 out of 9 mentions and also mostly with the best scoring of all countries. More than 50% of the energy used in Sweden comes from renewables and Sweden has very low per capita CO_2 emissions (consumption based). Sweden also has a low carbon intensity and the fastest decarbonisation rate per capita in Europe.

The research question “What factors helped countries to achieve a pioneering role? What role do climate and energy policies play in that regard?” was first answered in chapter 2.3., and then compared with the case study of Sweden. In general, good governance and strong institutions, a strong political will for energy transition, robust policy frameworks and targets, the expansion of renewable energies, the increase of energy efficiency, as well as financial flows into energy transition can be considered as reasons for leadership in energy transition. These reasons were also decisive for Sweden's success. The Swedish case study found that the CO_2 tax in combination with other instruments was very successful in reducing emissions.

This tax is the highest CO_2 tax in the world, was introduced early and made renewable energy competitive in Sweden. It guaranteed that the non-ETS sector was also regulated and in combination with energy taxes, the CO_2 tax was able to drastically reduce CO_2 emissions. In a global comparison, Sweden is a pioneer regarding CO_2 taxes and other countries should follow suit. Of the OECD and BRIICS countries, for example, most CO_2 emissions are for free and 90% of those that have a price cost less than 30 Euros per ton of CO_2, a price that is set far too low. Introducing carbon pricing would be a cost-effective way of channelling investment into low-carbon infrastructure technologies (OECD, 2017).

Sweden has also benefited from its long-term political climate regulations, which has boosted investment in the renewable energy sector. Therefore, it has created jobs and improved industrial competitiveness and prosperity and could serve as a role model for other countries.

Nevertheless, this work has also shown that neither the efforts of Sweden nor of any other country are sufficient to cope with the catastrophic effects of the climate crisis. Even if Sweden may appear to be in the forefront compared to other countries, the mitigation efforts are "less than half of what is the absolute minimum necessary to deliver on the Paris Agreement" (Anderson et al., 2020, p. 16). To achieve this, Sweden would need to demonstrate annual mitigation rates of at least 12%, which is well above its proposed 5% mitigation rate.

This thesis has also made clear that there is eventually still the possibility to keep the warming below 1.5°C. But the window of opportunity is getting smaller and smaller and the next few years, when drastic countermeasures will have to be taken, are crucial to achieve this goal.

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