# *HIA – Module 2*

Read the instructions and each question carefully and write your answer in the respective green box. **Remember to always cite your sources to the information you provide, both in your text and in the reference list!** You'll find a reference box after each answer box. Please use the Harvard referencing style.

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For this assignment you are supposed to analyze the energy system of a country of your choice from the list of the IEA: Countries & Regions - IEA. You can choose your home country or any other country you are interested in. Follow the instructions below and please read all questions before starting. There are even "country reports" from IEA about most of the countries, where you can find more detailed information (You will find them further down on the page of your country). Make sure you can find that report for your country to get the best out of the assignment. Please stick to the same country throughout the assignment.

1. Describe the energy system of your country of choice thoroughly. In your description answer also the following questions: What are the energy sources? What sources are used to produce
electricity? What are the overall shares of renewable energy and fossil energy sources? What sectors are the biggest energy consumers? Note that question 2 below is about the emissions of the energy system. Write 800 (+/- 20%) words.

**Answer:**

Let us start with an overview of the energy production and consumption in Sweden. Then I will focus on electricity supply and demand. Finally, it's important to touch upon the differences between the four bidding zones in Sweden, which differ greatly both in the distribution of electricity sources and in end-user prices.

**Energy**

In 2023, two dominant energy sources were nuclear (36.8% or 527 PJ) and biofuels and waste (35.3% or 509 PJ). Other two major sources were hydro (16.5% or 239 PJ) and geothermal, solar, wind etc. (10.9% or 158 PJ) (IEA, 2024b).

Total final electricity consumption in 2022 was 1249 PJ. 40% of the usage is attributed to industry, 38% to buildings and 22% to transport (IEA, 2024a, p. 18).

Sweden is the European leader in renewable energy consumption in nearly every metric analysed by Eurostat (2024). In 2023, 66.4% gross final energy consumption came from renewables, already meeting the EU's 2030 target of 42.5%. The share of renewable energy used by transport was 33.6%, making Sweden the only country in Europe already meeting the 2030 target of 29%. In

yet another sector – heating and cooling – Sweden also led the EU ranking with the renewable energy share of 67.1%.
Fossil fuels account for just 24% of total energy supply, which is the lowest share among IEA member countries, and much lower than IEA average of 78% according to data from 2022, (IEA, 2024a, p. 32). Out of the 24%, 20% comes from oil (mainly used in transport sector), 3% from coal and 1% natural gas (both used mainly in industry). Sweden doesn't have any crude oil production, therefore this resource is mainly imported from Norway.

**Electricity**

In 2023, the electricity production of Sweden was dominated by hydro (40%, or 66336 GWh), nuclear (29% or 48289 GWh) and wind (20.5% or 34074 GWh) (IEA, 2024b). 63% of electricity generation in Sweden is controlled by 3 largest producers: Vattenfall, Fortum and Uniper (IEA, 2024a, p. 31).

In 2022, Sweden was the largest net exporter of electricity in Europe (Holmberg and Tangerås, 2022, p. 21), having exported 33 TWh (or 19% of total electricity output) (IEA, 2024a, p.30); and the second largest total exporter (without substracting imports) after Germany (IEA, 2024b). In 2023, that number increased to 35 TWh (17.2% of net electricity produce) (IEA, 2024a, p.31). For comparison, the yearly export capacity is 95 TWh (Holmberg and Tangerås, 2022, p.12).

Electricity demand of Sweden has been stable at around 140 TWh since 1990 (IEA, 2024a, p. 30). Electricity final consumption in 2022 was split: 37.1% in industry sector, 33.1% for residential use, 3.3% in transport sector, 25.2% in commercial and public services, and remaining 1.3% in agriculture and forestry.

As reported by Eurostat (2024), 87.5% of gross final electricity consumption in Sweden was sourced from renewables in 2023, marking the second highest score in EU after Austria.

The biggest change in the electricity production in the last 20 years have been growing investments in wind and solar power. Wind power capacity doubled from 2015 to 2022. At the same time, nuclear capacity dropped by 29% between 2016 and 2022 due to decommisioning of nuclear reactors (IEA, 2024a, p. 30-31).

**Regional differences between bidding zones**

Sweden’s electricity market is divided into four bidding zones: SE1, SE2, SE3, SE4 (respectively from north to south). The transmission capacities between them are, going from north to south: 3300 MW, 7300 MW, 5600 MW (Holmberg and Tangerås, 2022, p. 12).

All nuclear power production is located in SE3 (elområde Stockholm), and it accounts for the majority of production in that region. In SE1 (elområde Luleå) and SE2 (elområde Sundsvall), most electricity is produced from hydro with the second biggest source being wind power. Finally, in SE4 (elområde Malmö),

wind accounts for the majority of production, followed by wind, thermal and solar (IEA, 2024a, p. 48).

Electricity prices differ a lot between bidding zones, especially during high demand hours during the day. At the moment of writing this paragraph (4th of February 2025, 16:30), 1 kWh costed: 7 öre in SE1 and SE2, 39 öre in SE3 and 190 öre in SE4 (Spotprices.eu, 2024 based on data from ENTSO-E, 2024).

Changes in electricity prices between bidding zones are a symptom of congestion in the transmission grid. If the network capacity is too low to handle the flows from north to south at high enough rate (this situation is called a bottleneck), the price goes up in the zone with electricity deficit (Holmberg and Tangerås, 2022). The current imports and exports between bidding zones in Sweden and neighboring countries can be viewed live at the website Kontrollrummet (Svenska Kraftnät, 2024). At the time of writing this (as well as most of the time, at least since the energy crisis of 2022), SE1 and SE2 have energy surplus while SE3 and SE4 have energy deficits.

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2. Try to find information about the emissions of the energy system of your country. Be aware of the difference between the energy and electrical system of your country. There are many sources that misuse these words and share with that misleading information. You are asked here to find your own sources and reference accordingly. Write ca. 500 (+/- 20%) words.

**Answer:** Total energy-related emissions in 2022 were 32 Mt CO2, with the following split: transport 43%, industry 28%, buildings 18% and 11% other uses (IEA, 2024a, p.18). Per-capita emissions of Sweden are 3.1t CO2/year, which is the 3rd lowest among IEA countries and a result of long downwards trend (-47% since 2000) (IEA, 2024b).

Sweden had nearly no fugitive emissions in 2022 (IEA, 2024c).

A note on working with different sources: while I haven't found much confusion between energy and electricity, it was difficult to find more sources (beyond IEA) which would focus on energy-related emissions. For instance, Panorama Sverige (Naturvårdsverket, Klimatpolitiska rådet and Energimyndigheten, 2025), considers Energy a separate category of emissions, distinct from Transport, Industry etc. By contrast, IEA calculated energy-related CO2 emissions as electricity and heat used in each sector.

**Fossil fuels distribution**

Oil accounts for 76.1% of total CO2 emissions from fuel combustion, coal for 19.1% and natural gas for the remaining 4.7%.

**Electricity**

99% of electricity generated in Sweden is low-emissions, mostly coming from renewables and nuclear; only 1% of production is from fossil fuels (IEA, 2024a, p. 6).

**Electricity and District Heating**

Emissions from electricity and DH account for 9% of Sweden's CO2-equivalent emissions, or 3.8 Mt in 2023 (Naturvårdsverket, 2024b). Fossil fuels share in this number keeps decreasing year after year and it was 0.49 Mt in 2023, compared to 4.66 Mt in 1990. On the other hand, burning of waste has been on the rise with emissions equal to 3.03 Mt in 2023, which was the second highest year after 2022's 3.11 Mt. This is explained by increased presence of fossil plastic, which in fact is responsible for 90% emissions from waste burning.

Further division into subsectors looks as follows (Naturvårdsverket, 2024b): cogeneration 73% of emissions, district heating 26%, separate electricity production 1%, flue gas treatment 0.01%.

**Interior transport***

GHG emissions from the interior transport in Sweden total to 13.86 Mt of CO2 equivalent in 2023. They are dominated by personal cars (8.27 Mt in 2023) and heavy cargo cars (2.8 Mt in 2023) (Naturvårdsverket, 2024a).

**International flights and sea travel**

In 2023, international sea travels were responsible for 5.43 Mt of CO2-equivalent emissions. It's worth noting that this number has been consistently decreasing since the 2020 pandemic, when it reached all time high of 8.31 Mt

(Naturvårdsverket, 2024d). The emissions from flights in 2023 were 2.14 Mt of CO2-equivalent.

**Industry**

Industry is responsible for a third of Sweden's total territorial emissions. Around 60% of this share is attributed to fuel use (Naturvårdsverket, 2024c). While most of energy use is sourced from electricity and biofuels, in 2018 (latest data available at Naturvårdsverket, 2024c) petroleum products, coal and blast furnace gas were still used to obtain 23 TWh of energy.

* Note: the page I used for this section (Naturvårdsverket, 2024a) is concerned with emissions in general, not only energy related. I decided to still present this data since overwhelming majority of transport emissions come from fuels.

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3. Do a quick search about your country's plans to decarbonize its energy system as a whole or just the electricity system if information is difficult to find. Answer at least the following questions in your text:

- What are the country's strategies?
- Have they already achieved decarbonization? How?
- Do you think their plans are ambitious enough?

Keep also in mind to use valuable and reliable sources and **do not only** base your answers on newspaper articles. Look out for official governmental documents or NGO reports. Write ca. 500 (+/- 20%) words.

**Answer:**

Sweden has adopted a legally binding 2045 net zero emissions target, five years earlier than the EU target (IEA, 2024a, p. 4).

**Nuclear or renewables?**

While Swedish nuclear capacity has been in decline (decreased by 29% since 2016) due to decommissioned reactors, investments are planned for new power plants (IEA, 2024a, p. 31).

In 2023, the Swedish government passed a budget amendment updating the 2040 target from 100% renewable electricity to 100% fossil-free electricity (Sveriges Riksdag, 2023a). This is a less restrictive formulation, since it allows also nuclear power to be part of the solution.

Later that year, the government approved legislative amendments allowing for building three new reactors (Sveriges Riksdag, 2023b).

**The Industrial Leap**

The Industrial Leap, or Industriklivet, is a program led by the Swedish Energy Agency (202?) and is a part of the Next Generation EU (European Union, Directorate-General for Communication, 2025) initiative. Initiated in 2018, the program has so far resulted in supporting 167 projects around industry transition with 5.7bn SEK in funding. The sectors which received the biggest funding are iron and steel industry, refinary and chemical industry, and mining and mineral industry (Swedish Energy Agency, 202?).

**Fossil Free Sweden (Fossilfritt Sverige)**

Fossil Free Sweden is an initiative of the Swedish government from 2015 (pre-dating the Paris climate conference) to lead a sustainable industry transition in Sweden. It involves 22 business sectors, which have produced roadmaps for sustainability targets within a framework proposed by FFS. The project has been coordinated since 2016 by Svante Axelsson.

Example goals defined by Fossilfritt Sverige include: 50% more efficient use of energy by 2030 compared to 2005 (Fossilfritt Sverige, 202?a), decreasing CO2 emissions from transport by 70% by 2030 compared to 2010 (Fossilfritt Sverige, 202?b), fossil free domestic and outwards flights by 2045 (Fossilfritt Sverige, 202?c).

In December 2024, the government announced the decision to continue and expand the Fossilfritt Sverige initiative (Regeringskansliet, 2024).

**Decarbonizing Transport**

The government's publication from December 2023 (Regeringens skrivelse 2023/24:59, p. 139) presents the goal of completely decarbonizing transport no later than by 2045. The document claims that since the technology - electrification - is already developed, decarbonization of transport is in principle easier than that of land use or industry. Sweden has the highest ratio of EVs among newly sold cars in EU (for a few years that was a government bonus for low-emission cars, but it was phased out in February 2023) (IEA, 2024a, p. 27).

One of the proposals in that publication are (9.2.1.) bonus payments for scrapping of personal vehicles with combustion engines (Regeringens skrivelse 2023/24:59, p. 143). This proposition faced some criticism, pointing that:
1) it may increase the demand for new cars, thus increasing indirect emissions related to vehicle production and scrapping,
2) it is expensive to implement and will harm the second-hand car market.

Other decisions include:
- subsidizing introduction of heavy cargo cars (*lastbilar*) for companies, municipalities and regions (9.2.2.)
- lower the drivers license requirements for heavy cargo cars with electric engines (9.2.3.)
- annotating new vehicles on the market with energy efficiency and lifecycle emissions (9.2.5.)

**Do I think the plans are ambitious enough?**

It's hard to judge Sweden's decarbonization plans since it is already leading in EU by many metrics, making it difficult to point to other countries for inspiration.

Obviously decarbonizing transport will be a big challenge, especially ferry and plane transport, where the electrification is not ready yet to support long journeys.

Regarding the transition of car transport to EVs, I think that improving the transmission grid between bidding zones and increasing its capacity will play a very important role. This will make the electricity prices in SE3 and SE4 (where most people in Sweden live) lower and more predictable, thus incentivizing drivers to switch to electric cars.

**Further reading**

Panorama Sverige (Naturvårdsverket, Klimatpolitiska rådet and Energimyndigheten, 2025) is a nice browser for ongoing SET initiatives in the country.

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| **AI Declaration:** | I have not used generative AI. |