

Climate impact of four closed reactors

The announced decisions by Vattenfall and Eon about premature closure of four reactors at the Swedish nuclear power plants Ringhals and Oskarshamn will result in an increased use of electricity generated from fossil fuels in neighbouring countries. Here the climate impact is calculated from a few simple assumptions, and the results are compared with other emissions.

Initial conditions

The four reactors to be closed prematurely are given in Table 1 together with their electricity generation at full power, followed by the average yearly availability (load factor) since the first year of commercial operation. Data are obtained from the IAEA PRIS database and the pages for Swedish reactors [1].

Some definitions:

- A year has $365 \cdot 24$ hours = 8760 hours.
- **Load factor** is the percentage of electricity generated compared with if the reactor would run at full power the entire year. From the tables in PRIS the cumulative values are used, giving the average value for each reactor since the first date of commercial operation. For individual years the load factor may vary between zero and more than 90 percent.
- **Operating time** is the capacity factor multiplied with the number of hours in a year.
- **Electricity generation** gives the average amount of electricity per year, defined as the electrical power multiplied with the operating time, and is given here both in Tera-Watt-hours (TWh) and kilo-Watt-hours (kWh).

Reactor	Power (MW _{el})	Power (kW _{el})	Load factor (%)	Operating time (hours)	Electricity gen. (TWh _{el})	Electricity gen. (kWh _{el})
Ringhals 1	878	878 000	67,2	5887	5,2	5 168 500 000
Ringhals 2	807	807 000	67,4	5904	4,8	4 764 700 000
Oskarshamn 1	473	473 000	60,4	5291	2,5	2 502 700 000
Oskarshamn 2	638	638 000	73,3	6421	4,1	4 096 600 000

Table 1. Electrical power, cumulative load factor and yearly electricity generation for the four reactors to be closed down.

Climate impact

According to the ISO-certified life cycle analysis (LCA) by Vattenfall [2] their reactors have a climate impact of about 5 grammes of CO₂-equivalents per kWh electricity. The entire life cycle with mining, fuel production, construction, operation, decommissioning and final storage of used fuel is included. For the reactors owned by Uniper (ex Eon) and Fortum at Oskarshamn the same values are used as in the Vattenfall LCA.

Export of Swedish surplus electricity contributes to push fossil fuels out of the market in the countries neighbouring Sweden. In the Vattenfall LCA coal has a climate impact of 781 g CO₂-eq/kWh_{el} and is given for coal based central heating plants that give both electricity and heat. Electricity-only coal plants have emissions up to 1000 g CO₂-eq/kWh_{el}. When there is plenty of electricity from renewables it is power plants with black coal that reduce their production. The dirtier brown coal continue to run as base load, as clearly seen in weekly data at the German web page Energy Charts [3].

Continued use of Swedish nuclear power that pushes out coal power from Germany, Denmark, Finland, Poland and the Baltic states will reduce the climate impact with $781 \cdot 5 = 776$ g CO₂-eq/kWh_{el}. Table 2 gives the resulting climate emissions, given in tonnes of CO₂-eq, for the different reactors, followed by the equivalent amount from coal power, and finally the reduced climate impact per reactor that is kept running. As the table shows the four reactors save between two and four million tonnes each for every year of continued use. The total result is 12 million tonnes in reduced climate impact.

Reactor	Power (MW _{el})	Electricity generation (kWh _{el})	Nuclear power (tonnes CO ₂ -eq)	Coal power (tonnes CO ₂ -eq)	Saved CO ₂ (tonnes CO ₂ -eq)
Ringhals 1	878	5 168 500 000	25 843	4 036 600	4 010 800
Ringhals 2	807	4 764 700 000	23 824	3 721 200	3 697 400
Oskarshamn 1	473	2 502 700 000	12 513	1 954 600	1 942 100
Oskarshamn 2	638	4 096 600 000	20 483	3 199 500	3 179 000
Total	2796	16 532 500 000	82 663	12 911 900	12 829 300

Table 2. Yearly electricity generation from Table 1, calculated climate impact for the four reactors, climate impact from the equivalent amount of electricity from coal power, and the total reduced climate impact if the reactors continue to run.

Comparisons

The results are difficult to evaluate without anything to compare with, therefore a few examples are given:

- The total Swedish climate emissions in 2014 was 54 million tonnes, out of which 17.8 million tonnes come from domestic transports, 8.2 million tonnes from international transports (boats and flights) to and from Sweden, and 2.2 million tonnes from electricity generation [4].
- If the four reactors run five more years it corresponds to a reduced climate impact equivalent to the total emissions in Sweden during one year.
- The total global emissions in 2014 were 35 500 million tonnes [5].
- In 2013 the Swedish government sold, under harsh criticism, a surplus of 1.3 million emission allowances accumulated during the years 2008-2013, corresponding to 1.3 million tonnes of CO₂-equivalents [6].

Comments

The Vattenfall LCA has very low emissions for nuclear power. The study is ISO-certified in the EPD-system and should be considered as credible [7]. If we instead use the median value given by the UN climate panel, IPCC [8] with 16 g for nuclear power och 1001 g for coal power, the reduced climate impact is 5.0 Mton CO₂-eq/year for Ringhals 1 och 16.2 Mton for all four reactors. If we instead, conservatively, assume the highest value for nuclear power (220 g) and the lowest value for coal power (781 g) the result is 2.9 Mton for Ringhals 1 and 9.3 Mton for all four reactors. The conclusion in these calculations are in line with the results in a scientific article that was published in 2015 [9]. In the calculations above no limitations in transmission capacity between Sweden and the neighbouring countries have been taken into account.

Sweden is since a few years net exporter of electricity, to a large extent due to the surplus electricity given by the fast increase in wind power. The export of electricity pushes fossil fuels out of the market, primarily coal, in neighbouring countries. Premature closure of Swedish reactors will reduce the amount of low emission electricity exported to the neighbouring countries. That is bad business for the climate.

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References

- [1] [IAEA Power Reactor Information System, Sweden](#).
- [2] [Vattenfall, Life Cycle Assessment – Vattenfall's electricity generation in the Nordic countries](#).
- [3] [Fraunhofer ISE, Energy Charts](#), (click in the box "all sources").
- [4] Swedish Environmental Protection Agency, [Nationella utsläpp och upptag av växthusgaser](#) (in Swedish).
- [5] [BP Statistical Review of World Energy, June 2015](#).
- [6] [Supermiljöbloggen, Koldioxidbråk i Riksdagen, 16 januari 2014](#) (in Swedish).
- [7] [The International EPD System](#).
- [8] The IPCC-rapport, [Annex II, page 982](#), 2011.
- [9] Staffan Qvist och Barry Brook, Environmental and health impacts of a policy to phase out nuclear power in Sweden, [Energy Policy 84 \(2015\), 1-10](#).