Is it economically a good idea to build nuclear power plants in Denmark?

Example of analyses that can be performed with PMS

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Strategirummet

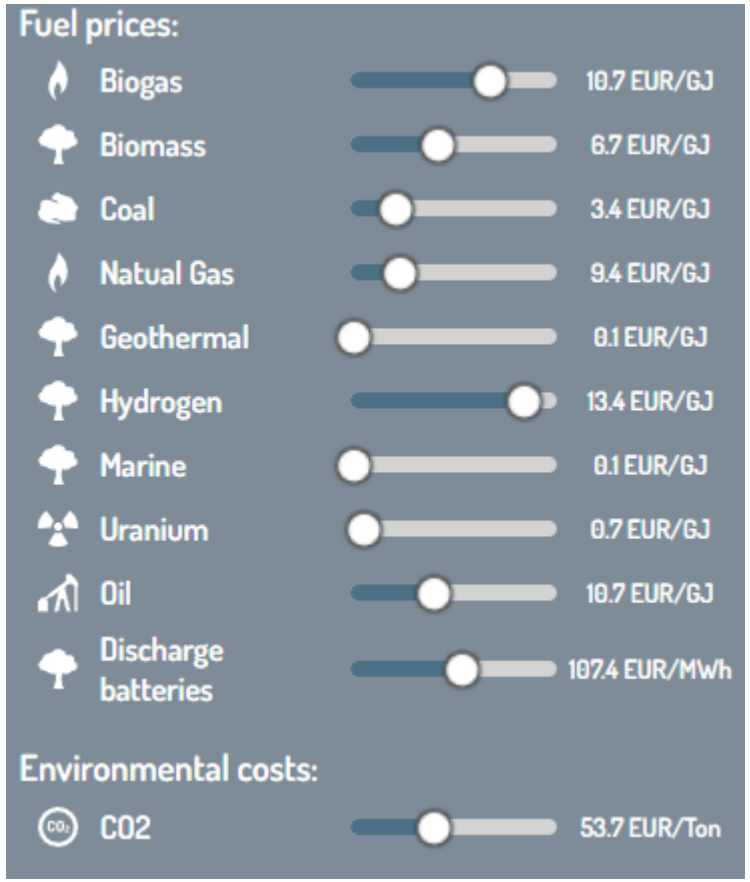
Purpose

- You will see how Power Market Simulator (PMS) can be used to create a preliminary project regarding building new nuclear power plants
- The analysis will show the socio-economic and corporate economics of placing of nuclear power plant in Denmark
- This type of preliminary project will improve the ability to define the actual project, involving analysis companies that have advanced energy system models

The Preliminary Project

- Insert a nuclear power plant in DK1 and calculate revenues for the plant as well as societal benefits and costs
- PMS-scenario is used for the analysis
- Data input comes from the general database to the PMS

Data for fuel prices and CO_2-quota prices



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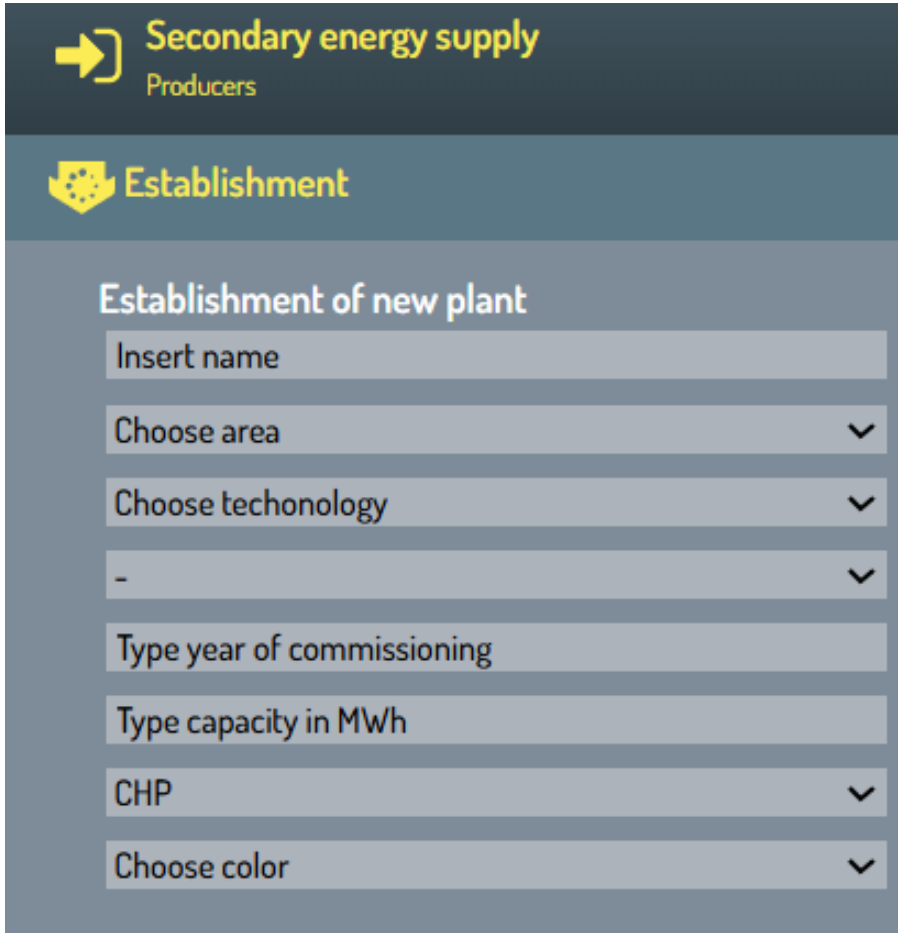
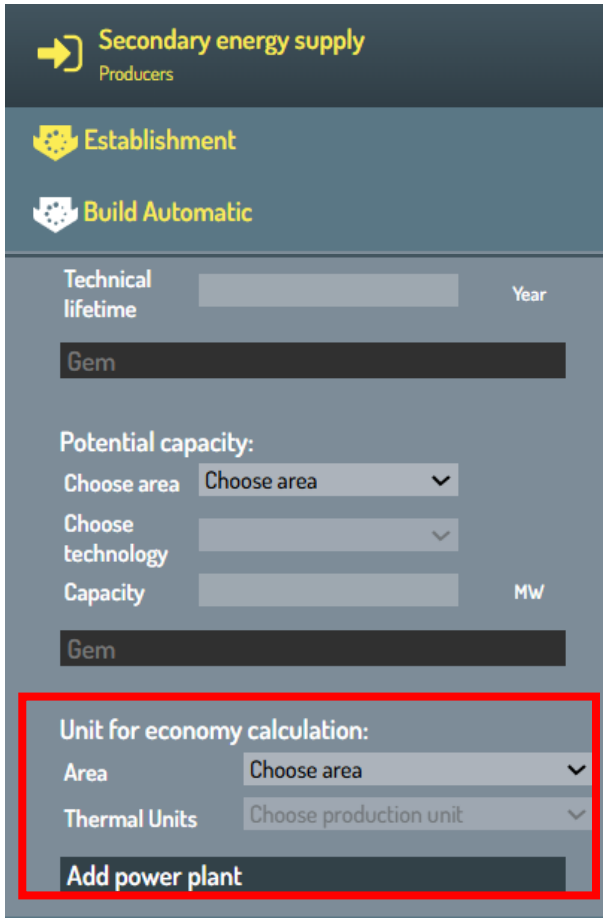
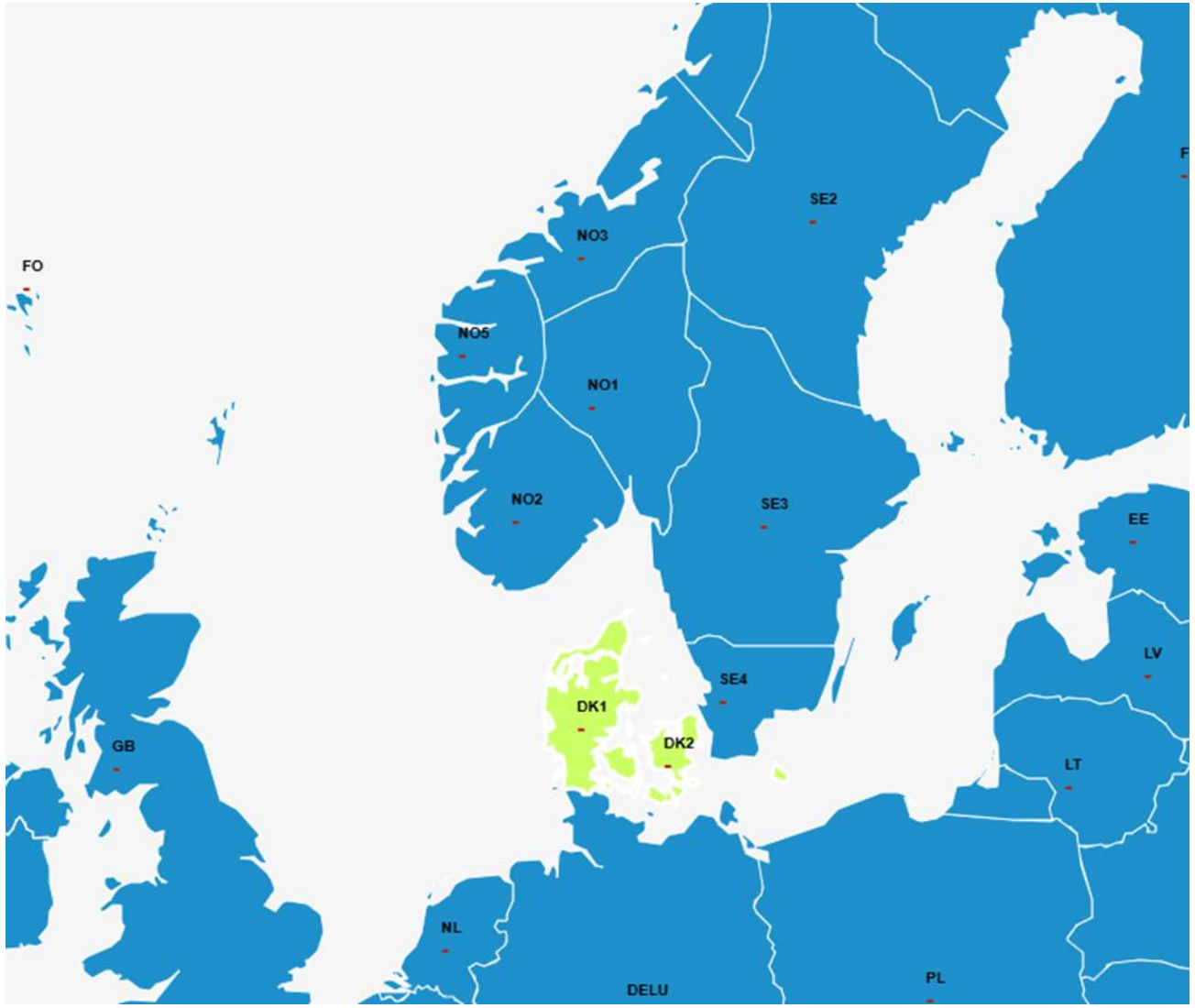
The nuclear power plant is built here



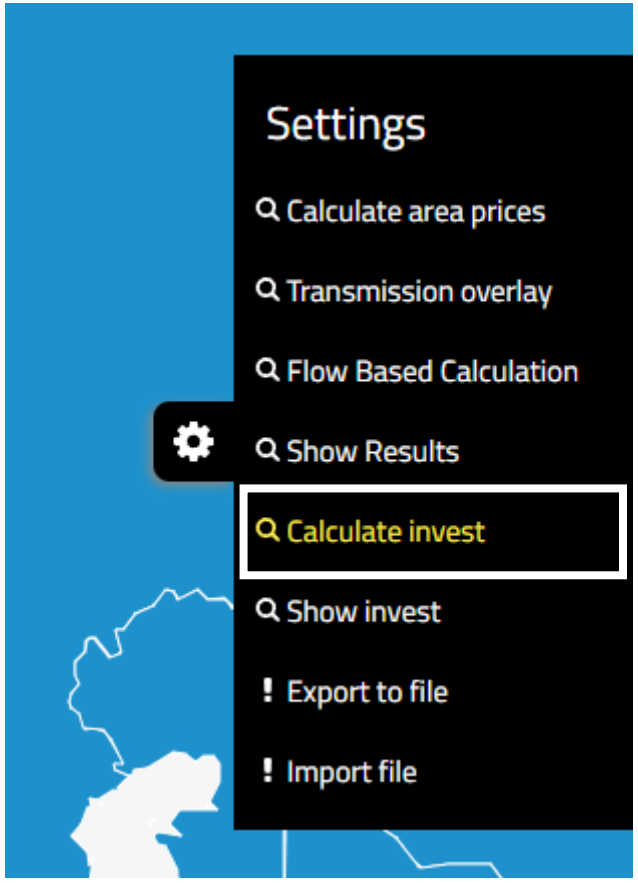
The nuclear power plant we will calculate contribution margins for is inserted here



The areas included in the calculation are shown here



The scenario calculation starts here



Calculation assumptions

- We analyze the period 2025 – 3050
- We insert the following PtX-plants according to “Analyseforudsætninger til Energinet”
  - 2030: 5.000 MW i DK1 og 2.000 MW i DK2
  - 2035: 3.000 MW i DK1
  - 2040: 2.000 MW i DK1
  - 2045: 3.000 MW i DK1
  - 2050: 2.000 MW i DK1
- Expansion with on-shore wind is limited to 2,500 MW in DK1 and 1,500 MW in DK2. No Hydro Power can be built in Denmark
- Short term marginal cost for a nuclear power plant: 18.5 euros per MWh
- The PtX plants buys electricity when the market price is below 40 euros per MWh
- The model only builds power generation plants
- Existing and planned flexible consumption plants are included in the calculation

We need more debate

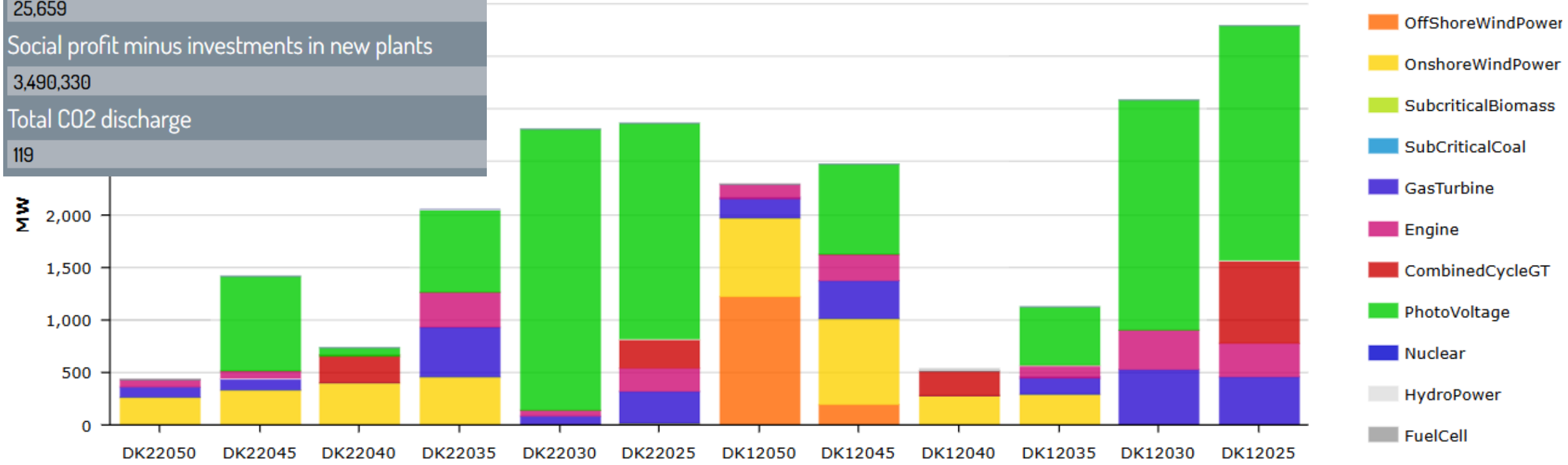
- There will certainly be some who believe that other input data should be used for the model, and that this will change the conclusion of the analysis
- That is correct, the analysis could be improved by many others participating with their ideas for the future
- This fits well with the purpose of Power Market Simulator, which is to create a commonly available modeling tool that can be used to increase the debate about how we develop the energy system of the future.

Total production costs
31,713
Total production surplus
59,350
Total consumption surplus
3,456,588
Total transmission surplus
51
Total societal surplus
3,515,989
Interest and payback of investments in new plants
25,659
Social profit minus investments in new plants
3,490,330
Total C02 discharge
119

The calculation does not include transmission connections abroad

The table shows the societal costs and benefits for Denmark for the entire period. Economical values are in mill. Euros. CO_2 discharge is in mill tons

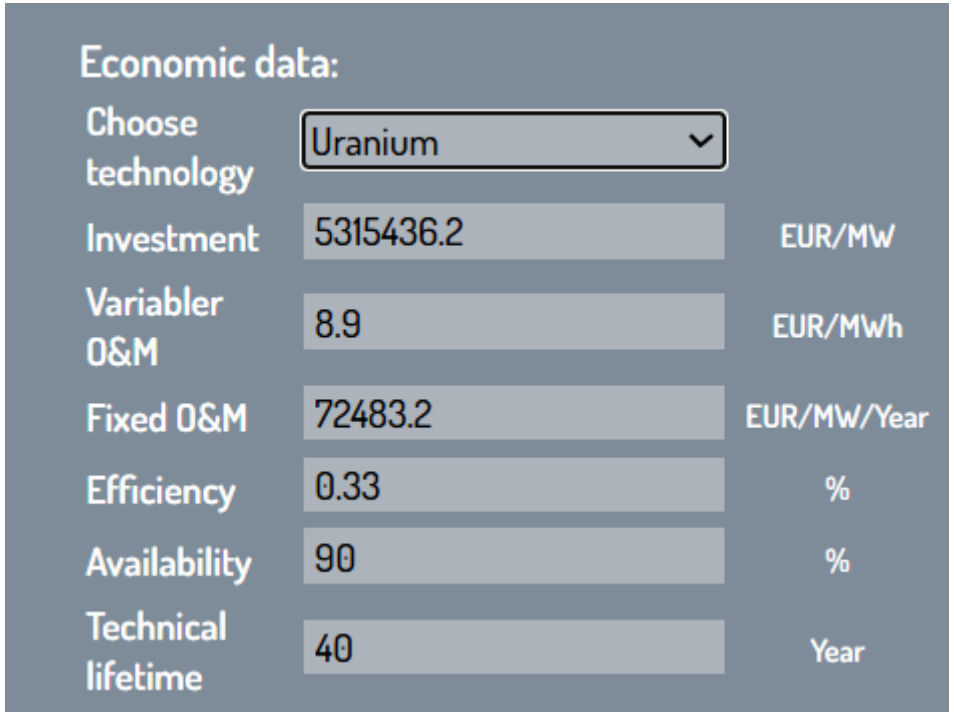
The figure shows what is being expanded with



What can be deduced from the analysis?

- The investment model invests in controllable plants until there is enough capacity to cover demand at all hours of the year
- The figure shows that in 2025, investments will be made in gas turbines, engines and combined cycle plants to provide sufficient capacity
- The calculation therefore shows that Denmark is not self-sufficient in power
- Significant amounts of investment are being made in solar cells
- Investments will be made in onshore wind power when the existing turbines are phased out

Assumptions regarding nuclear power plants

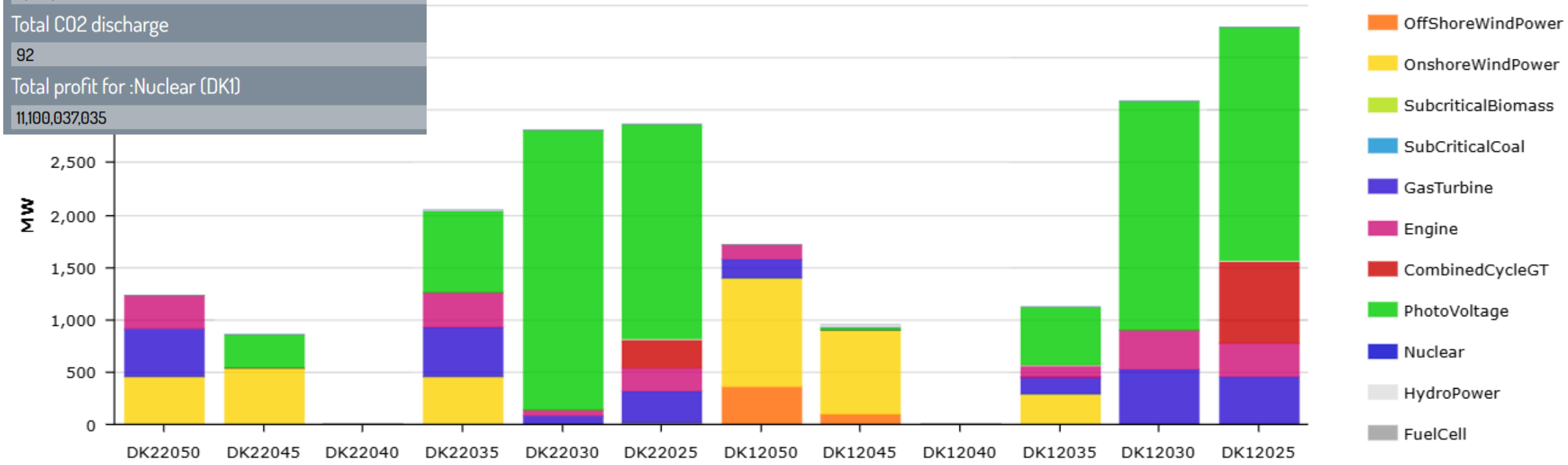


Can be easily changed by the user

Total production costs
27,777
Total production surplus
59,901
Total consumption surplus
3,461,221
Total transmission surplus
31
Total societal surplus
3,521,153
Interest and payback of investments in new plants
23,351
Social profit minus investments in new plants
3,497,802
Total CO2 discharge
92
Total profit for :Nuclear (DK1)
11,100,037,035

We are now making a new calculation where we build 1,000 MW of nuclear power in DK1 in 2040

Restrictions:
Without any other nuclear power than the plant we install ourselves

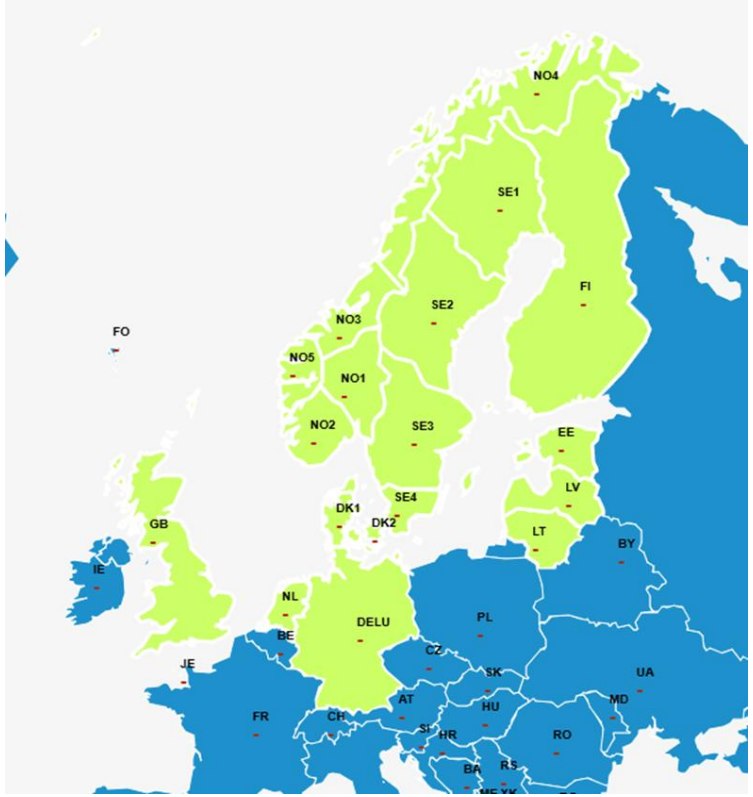


What can be deduced from the analysis?

- Comparing the two figures regarding capacity expansion shows that the nuclear power plant replaces around 500 MW of expansion with CCGT and On-Shore Wind in 2040
- Comparing the two tables shows that production costs fall when nuclear power is expanded and the social surplus increases (this does not include the costs of interest and repayment of the investment in the nuclear power plant and the plant's fixed operating costs)
- The nuclear power plant generates earnings of approximately 11 billion euros over a 10-year period. The profit per year and per MW is therefore 1.1 mill euros. Assuming that the fixed operating costs of the plant are 0.1 million euros per MW per year, there are 1 million euros per year for interest and depreciation
- With an internal rate of return of 7%, this profit can finance an investment of approximately 12 million euros/MW
- There is great uncertainty about what it costs to establish nuclear power plants, but the 12 million euros per MW is above the upper limit of the various assumptions
- The analysis therefore shows that it is economically good business to invest in nuclear power plants in Denmark

Sensitivity analysis regarding the contribution margin for the nuclear power plant in the situation where Denmark is part of a larger market area

The calculation area is increased to the following

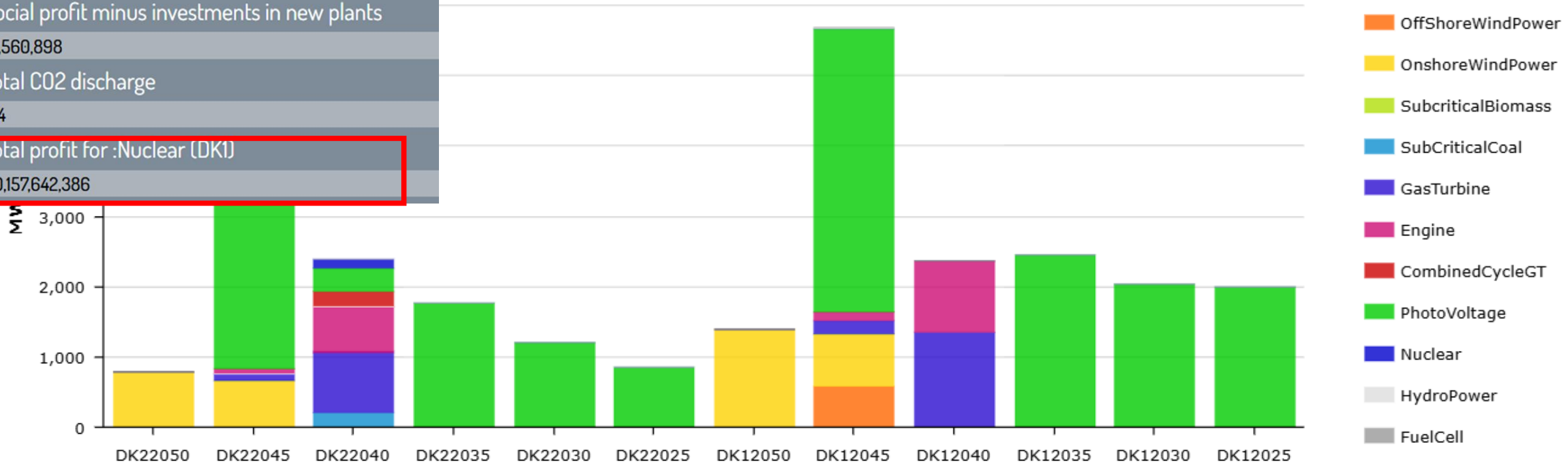


1,000 MW of nuclear power in DK1 in 2040

Total production costs	11,270
Total production surplus	56,255
Total consumption surplus	3,500,419
Total transmission surplus	22,922
Total societal surplus	3,579,595
Interest and payback of investments in new plants	18,697
Social profit minus investments in new plants	3,560,898
Total CO2 discharge	24
Total profit for :Nuclear (DK1)	10,157,642,386

Restrictions in Denmark:
Without any other nuclear power than the plant we install ourselves
With max 2.500 MW on-shore wind i DK1
With max 1.500 MW on-shore wind i DK2

No restrictions in the other contries



What can be deduced from the analysis?

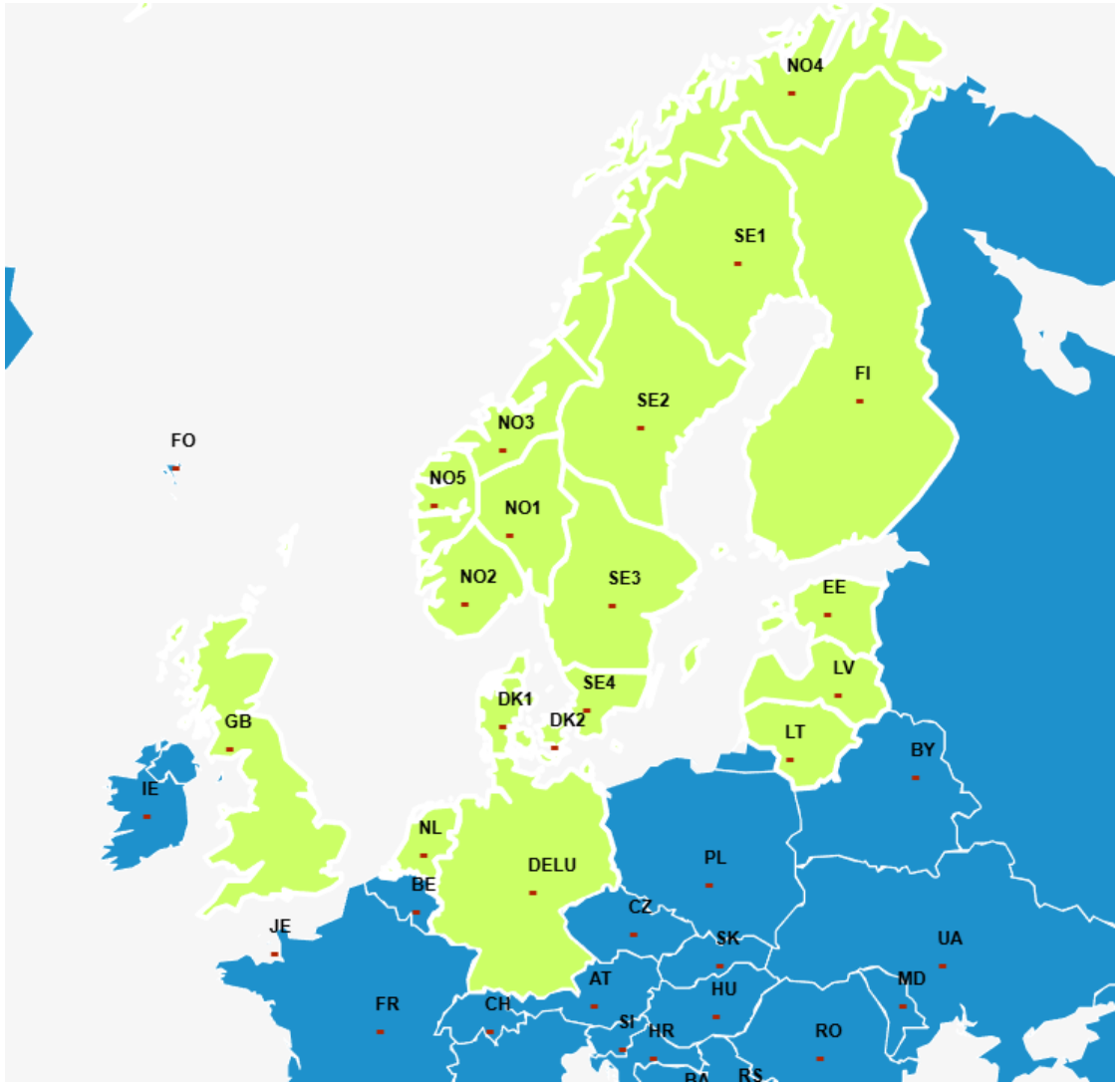
- The figure shows that investments are made in much fewer power plants until 2040, when we utilize electricity connections abroad
- After 2040, there will be capacity problems in Germany which will increase electricity prices, and therefore more plants will be established in Denmark
- When comparing the nuclear power plant's earnings with and without the inclusion of surrounding price areas, earnings fall slightly when calculated on the larger system

What is the earnings at the Danish nuclear power plant compared to the earnings at the Finnish nuclear power plant Olkiluoto 3 in the period 2040 - 2050?

To investigate whether it is more attractive to establish nuclear power in Denmark than in Finland, we examine the contribution margin for a Danish nuclear power plant of 1,600 MW with the contribution margin for Olkiluoto 3 in the period 2040 – 2050.

The calculations are made without the additional PtX plants in Denmark.

Calculation area



Total earnings at the Danish plant in the period 2040 - 2050

Except for the profit value which is in euros, all other economic values are in million euros. CO_2-dischart is in mill. tons

Total production costs	12,477
Total production surplus	53,633
Total consumption surplus	3,503,273
Total transmission surplus	23,940
Total societal surplus	3,580,846
Interest and payback of investments in new plants	14,917
Social profit minus investments in new plants	3,565,930
Total CO2 discharge	24
Total profit for :Nuclear1600 (DK1)	15,348,781,171

Results are for the total calculation area

Total earnings at the Danish plant in the period 2040 - 2050

Total earnings at Olkiuoto plant in the period 2025 - 2050

Results are for the total calculation area

Except for the profit value which is in euros, all other economic values are in million euros. CO_2-dischart is in mill. tons

Overview over investment for for FI
Total production costs
15,994
Total production surplus
94,277
Total consumption surplus
8,190,767
Total transmission surplus
115
Total societal surplus
8,285,160
Interest and payback of investments in new plants
11,222
Social profit minus investments in new plants
8,273,938
Total CO2 discharge
39
Total profit for :Olkiluoto-3 (FI)
9,814,991,248

The calculation is with the same restrictions as the calculation with 1,600 MW of nuclear power in Denmark - but without the plant

Total earnings at Olkiuoto plant in the period 2025 - 2050

To calculate the earnings for Olkiuoto plant for the period 2040 - 2050, we need to extract additional data from the PMS model. We have done this, and the result shows the following

	Profit
2025 - 2030	320
2030 - 2035	547
2035 - 2040	1.781
2040 - 2045	3.245
2045 - 2050	3.853
2040 - 2050	7.099

Prices are in mill. euros

What can be deduced from the analysis?

- The nuclear power plant located in Denmark has a higher income than the Olkiuoto plant in the period 2040 – 2050
- This is because the price level in DK1 is higher than the price level in Finland. Denmark will in most cases be linked to the German prices
- It is therefore more attractive to establish nuclear power plants in Denmark than in Finland