IDAs Klimasvar 2045

Sådan bliver vi klimaneutrale

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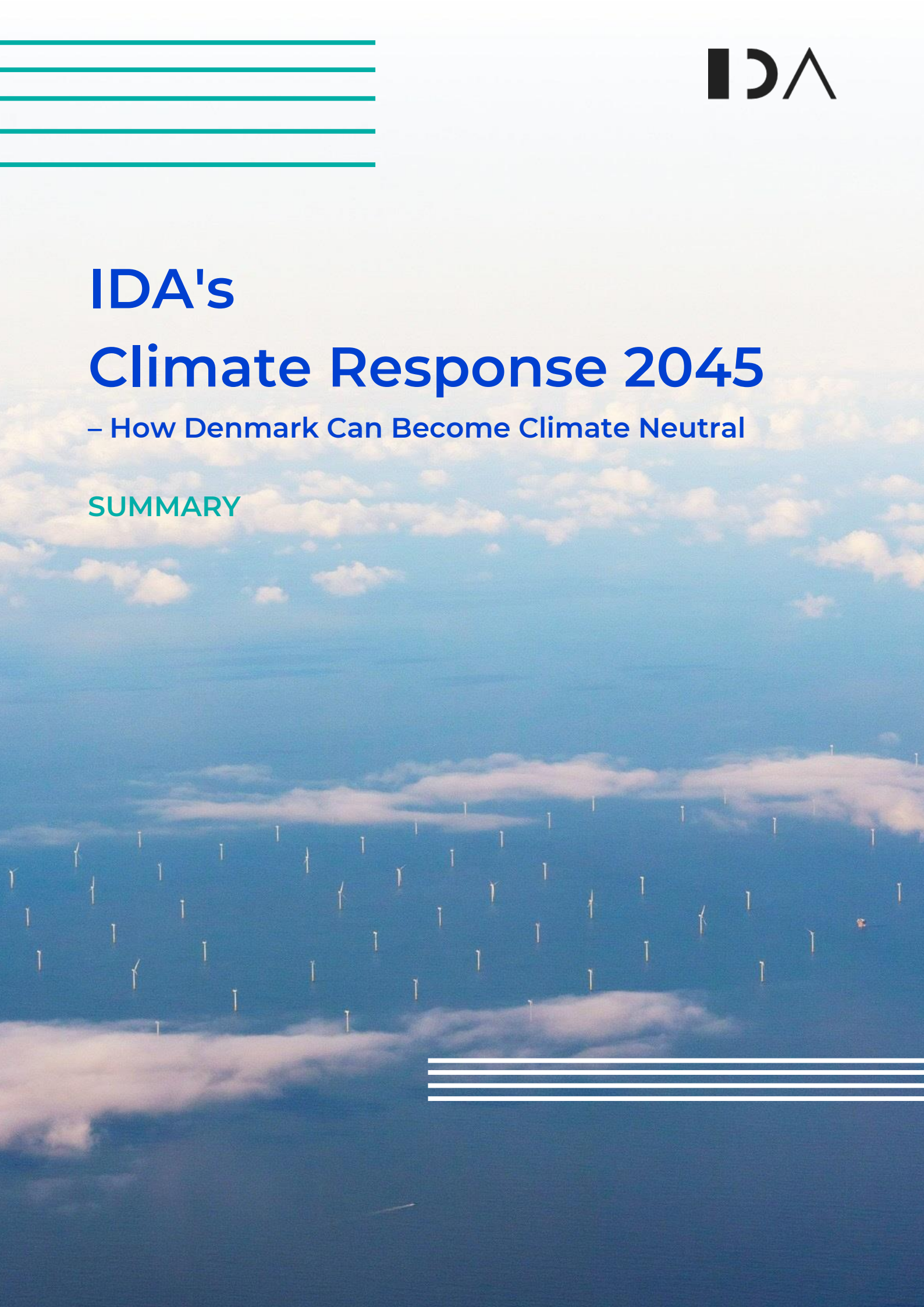
IDA's Climate Response 2045

– How Denmark Can Become Climate Neutral

SUMMARY



The goal: a climate-neutral Denmark

For the past year, we have been living in a time of COVID-19, and the pandemic continues to affect all aspects of our daily lives. As a society, we have proven that we can handle major challenges when the world demands it, and in IDA believe we must apply that same resourcefulness to the solution of other challenges. First on the list is the climate. The political focus in the last year or two has been on the first target of the Danish Climate Act. The goal of a 70% reduction in greenhouse gas emissions by 2030. There is still some way to go before Denmark reach that goal. But 2030 is only 9 years away, so we need at the same time to be working on the second Climate Act goal of a climate-neutral Denmark. The Danish Society of Engineers, IDA, in collaboration with the Sustainable Energy Planning Research Group in the Department of Planning at Aalborg University, has therefore worked out a scenario for climate neutrality in Denmark by 2045.

IDA's Climate Response does not cover all sectors. We have restricted ourselves to energy and transport. This means that we have defined a context in which the other sectors will also contribute to meeting the overall objective. In addition to energy and transport, those sectors include industrial processes, agricultural land use and others such as waste disposal and sewage treatment.

Danish emissions were 75.7 Mt in 1990; a 70% reduction thus means bringing this down to 22.7 Mt in 2030. IDA assumes that there will also be reductions in the other sectors up to 2030. Concretely, it is assumed that the other sectors will reduce emissions from an (expected) 17 Mt in 2020 to 11.7 Mt in 2030. **Energy and transport emissions will be reduced from 30 Mt in 2020 to approx. 11 Mt in 2030 and zero in 2045.**

IDA's Climate Response is our vision of how Denmark can achieve its goal of a 70% reduction in climate gases by 2030 and become climate neutral by 2045 in the field of energy and transport. IDA's Climate Response has been published in two rounds: first in May 2020, and in June 2021 with concrete modelling and analysis of the year 2045. All together the IDA's Climate Response has the following conclusions.

This is the route to a 70% reduction by 2030 and climate neutrality by 2045 in the most cost-effective way in the transport and energy sector:

- ⇨ We must continue to focus on energy efficiency improvements in industry and buildings. Keeping energy consumption down will make the conversion to sustainable energy less resource intensive. The goal for heat savings should be a 12% reduction by 2030 and a 30% reduction by 2045 as against the present.

- ⇨ We must plan on the basis that there will be a pronounced rise in electricity consumption because energy use will be switched from fossil fuels to electricity and because new demands will arise from, for example, hydrogen and electrofuel production.

⇨ Much more wind power will be required. Wind power must be expanded from approx. 6 GW in 2020 to at least 11 GW in 2030 and 19 GW in 2045.

⇨ Solar photovoltaic (PV) must be expanded, using big industrial roofs, from 1 GW to 5 GW in 2030 and 10 GW in 2045.

⇒ Power-2-X, and the direct need for hydrogen in transport, will mean making room for big electrolysis plants: 1200 MW of electrolysis by 2030 and 4800 MW by 2045.

⇒ Surplus heat from industry and data centres must be used in the district heating system. The same goes for surplus heat from electrolysis and Power-2-X production, e.g., electrofuels. District heating must be expanded with geothermal energy, large heat pumps and solar heating.

⇒ Oil and gas boilers must be phased out before 2030 and replaced with district heating and individual heat pumps. District heating must be expanded to supply 63% of heating needs, primarily in natural gas areas.

⇨ Carbon capture from various point sources such as waste incineration will come to play an important part even before 2030. Priority must be given to carbon capture for use in electrofuels (CCU), which is the circular solution. Only in the longer term should priority be given to storage (CCS), which will compensate for emissions that cannot be eliminated in other ways.

⇨ Denmark must reduce its dependence on the burning of biomass. But biomass must not be phased out; it must be developed. IDA's Climate Response 2045 proposes the use of a combination of conversion technologies such as biogas, thermal gasification, pyrolysis and HTL.

⇨ Buses, cars, vans, and trains must become electric. There is only room for 1.5 million petrol and diesel cars in 2030, and none in 2045. On the other hand, there will probably be more than 3 million electric cars on the roads in 2045.

⇨ 5% of lorries should be battery powered or plug-in hybrids, and 5% should be running directly on electricity by 2030. This must rise to 35% of lorries on battery power and 400 km of e-roads in Denmark by 2045.

IDA's Climate Response points the way to meeting the Danish climate goals

IDA's Climate Response sets out a concrete vision of how, in purely technical terms, Denmark can meet the objective of a 70% CO_2 reduction by 2030 and climate neutrality by 2045 in a socioeconomically sound way. IDA's Climate Response prioritises Denmark's use of green conversion to stimulate industrial development and create jobs. IDA's Climate Response also highlights how we can prepare ourselves technologically for the period after 2030.

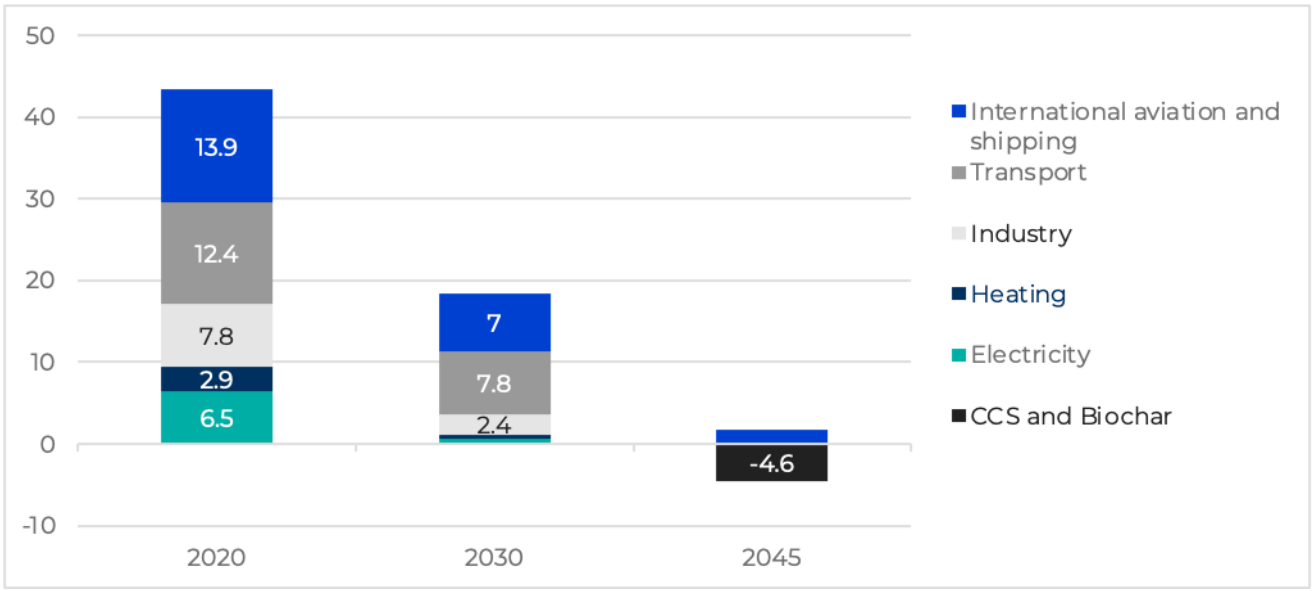
CCS may become necessary also in Denmark, but, for the field of transport and energy, IDA believes that it is necessary to focus on CCU.
In the other sectors, it may become necessary before and/or after 2030 to make use of CCS (carbon capture and storage) to become completely carbon neutral. To enable other sectors to use CCS technology, IDA's Climate Response 2045 focuses exclusively on CCU (carbon capture and utilisation) in the energy and transport sector, where the captured CO_2 will be utilised (CCU) in the form of Power-2-X for production of sustainable energy fuels, particularly for air transport and heavy goods transport.

Moreover, IDA's Climate Response 2045 includes the development and utilisation of sustainable biomass resources in such a way as to create the potential for carbon sinks in the form of biochar and, potentially, CCS.

IDA's proposal for 2045 takes account of the Danish share of international sea and air transport. When these contributions are included, actual CO_2 emissions in both 2020 and 2030 are higher than the figures we normally provide for UN estimates. In IDA's Climate Response, the estimate goes up from 47 to 61 Mt/year for 2020 and from just under 23 to just under 29 Mt/year for 2030. **IDA's Climate Response 2045 is a vision of how climate neutrality can be achieved, including the Danish share of international sea and air transport.**

If the contribution of international air and sea transport is included, the figures go up as shown in the graph. This shows how IDA's Climate Response 2045 will reduce CO_2 emissions from the energy sector to zero except for the contribution of aircraft contrails. However, this is offset by the potential of biochar and CCS to compensate for it and to contribute to compensating for the other sectors.

CO2 emissions by sector, including the share of international air and sea transport (Mt/year)



Green conversion requires investment but provides operating advantages.
IDA's Climate Response requires about 500-600 billion Danish kroner of investments in the next 10 years to 2030, and about a further 600 billion kroner in the period 2030-2045. The most significant investments are listed in the table.

As a starting point, construction costs, lifetimes and operation and maintenance are based on the Technology Catalogue published by the Danish Energy Agency and Energinet. In the cost estimate, they are converted to an annual outlay assuming a socioeconomic discount rate of 3%. Where the costs are not available in the Technology Catalogue, or where other costs are more relevant, this is indicated under the individual section. For fuel prices and handling costs, the Danish Energy Agency's latest 2030 pricing projection has been used.

Major investments, 2020-2030 and 2030-2045

	2020-2030		2030-2045	
	Investment need	Annual depreciation and interest in 2030	Investment need	Annual depreciation and interest in 2045
	Billion DKK	*Million DKK/year*	*Billion DKK*	*Million DKK/year*
Building renovation	124	5,360	185	7,986
Offshore and onshore wind turbines	78	4,173	102	5,150
E-vehicles (incl. e-roads)	73	6,896	52	4,947
Individual heat pumps	70	5,114	7	946
Industry (savings and electrification)	36	2,570	28	2,079
District heating expansion and 4G district heating	30	1,467	7	462
Solar photovoltaic (PV)	21	937	22	969
Biogas plants	18	1,223	12	857
New gas-fired power stations	16	897	1	18
Charging points, electricity grid and ITS	14	825	25	1,463
Large heat pumps	9	499	28	1,594
Electrolysis and hydrogen storage	8	501	78	3,531
Geothermal energy	8	440	8	410
Wave power	5	303	5	303
Gasification, pyrolysis and electrofuels	5	316	25	1,579
Smart, flexible electricity requirement	3	235	1	93
Solar heating, surplus heat, and heat storage	3	176	2	97
District cooling	2	89	0	0
Gas grid (2030) and hydrogen grid (2045)	2	89	10	390
Total	**525**	**32,110**	**598**	**32,874**

Compared with the baselines, this means that the socioeconomic cost of interest and depreciation will increase by about DKK 32 billion per year in 2030 and by about DKK 33 billion per year in 2045. On the other hand, approximately the same sum will be saved on fuel, and hence on the operating costs of the Danish energy system, in both scenarios.

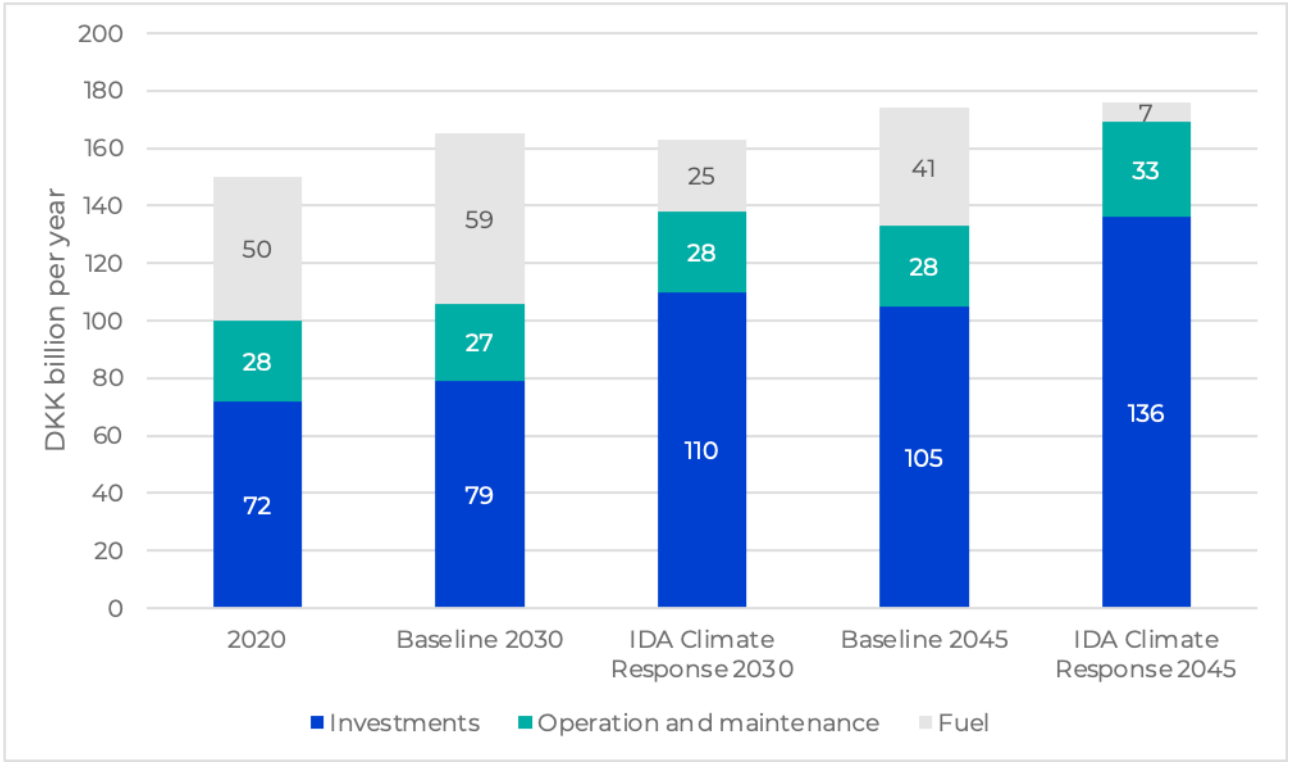
The restructuring of the costs is shown in the figure below. As can be seen, fuel costs will be replaced with investment costs. The total cost goes up slightly as against 2020, but this is because energy requirements are also expected to increase between now and 2030. Compared with such a 2030 baseline situation, the total cost does not increase if fuel prices

develop in line with the Danish Energy Agency's latest expectations. However, this comparison is highly dependent on which fuel prices are assumed.

The conclusion is therefore that, if the restructuring is carried out the right way from a technical point of view, it will have no significant socioeconomic cost. However, it will have major fiscal consequences, necessitating a tax and duty restructuring. The 2045 costs in the figure are calculated on the same assumptions as those for 2030.

IDA's Climate Response includes all technological changes and investments all the way from today's energy system in 2020 to the implementation of the 70% objective in 2030 and full climate neutrality in 2045. We do this to enable assessment of all costs, and all consequences relating to CO_2 reduction and employment, of the entire transformation of Denmark's energy system, including those that have already been decided politically and are therefore included in the Danish Energy Agency's projection.

Socioeconomic costs 2020, 2030 and 2045



Note: where figures do not tally 100% with Table 1, this is due to the table including only the most significant investments.

Less dependence on import of wood pellets

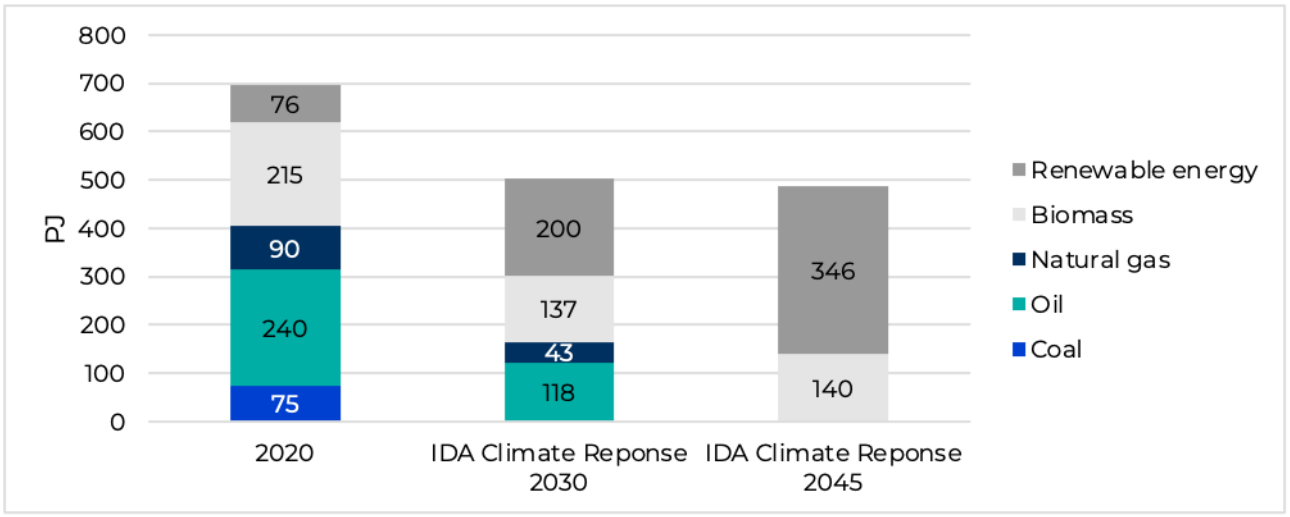
With IDA's Climate Response, consumption of fossil fuels will be reduced through efficiency improvements and replacement with sustainable energy. At the same time, the burning of biomass will also be reduced. In per capita terms, biomass consumption will be cut from approx. 29 GJ/head in 2020 to approx. 24 GJ/head in 2030. IDA's Climate Response 2045

proposes the use of a combination of conversion technologies such as biogas, thermal gasification, pyrolysis and HTL. In 2045, the entire energy supply will be based on biomass and other sustainable forms of energy. Nett biomass consumption will be kept at about 23 GJ/capita in 2045.

IDA's Climate Response can be implemented with or without energy islands
In the summer of 2020, a political majority in Denmark reached an agreement on the establishment of to energy islands. The islands will form the basis for the expansion of Danish offshore energy.
IDA's Climate Response entails an expansion of offshore wind from about 2 GW at present to 6-7 GW in 2030 and about 14 GW in 2045. This will be supplemented by a pronounced investment in Power-2-X. IDA's Climate Response takes account of outlay on wind turbines and Power-2-X plants, including the landing of power, but does not include any additional costs of the planned energy islands.

IDA's Climate Response can therefore be implemented with or without energy islands. A key consideration in the development of the Danish energy islands is the integration of their output into the overall energy system to maximise the opportunities for flexibility and the utilisation of heat from production of hydrogen etc.

Fuels and sustainable energy sources (wind, solar and biomass) in IDA's Climate Response 2045 compared with 2020 and IDA's Climate Response 2030



Regarding **energy efficiency**, with IDA's Climate Response, Denmark will be able to fulfil its obligations under the EU's Energy Efficiency Directive. Regarding **sector coupling**, IDA's Climate Response will ensure cost-effective use of different storage options, flexibility, and adjustment, thus reducing imbalances in energy supply to a minimum.

IDA's Climate Response results from a research collaboration between IDA, The Danish society of engineers and the Sustainable Energy Planning Research Group, Department of Planning, Aalborg University. IDA's Climate Response is written by the report authors, who also carried out all the analyses.

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Read the full report here in Danish: IDAs_klimasvar_2045_ver_02062021.pdf (aau.dk)