

100% Renewable and Carbon Neutral Smart Energy Systems: The Danish Target of a 70% decrease in CO2 emission by 2030

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Renewable Energy Systems

A Smart Energy Systems Approach to the **Choice and Modeling of 100% Renewable Solutions**





The long-term Objective of Danish Energy Policy



EUROPEAN

2019 New Government and agreement: 70% reductions in Greenhouse gases by 2030

Climate Law and Action plan:

- 1. Energy savings in among others public buildings
- 2. National Strategy for Sustainable buildings
- 3. Strategy for electrification of transport, industry and society in general
- 4. More funds for green research and demonstration projects
- 5. Assessment of Danish and North Sea countries mutual expansion of offshore wind
- 6. Investigation of energy island of 10 GW wind before 2030
- 7. Support afforestation (new forest)
- 8. Climate adoption via coordination of coastal protection



AALBORG UNIVERSITY DENMARK



Politisk forstkåte mellow Socialdonokratiet, Radikale Venstor, SF og Enbedsästen: Retfærdig retning for Danmark

olketingsvalget 2019 har givet Danmark en historisk mulighed for at sætte en ny politisk retning.

Vi skal gå forrær i kampen mod klimakrisen. Dannark skal narkant hæve ambitonerne for klima, miljo og natur og pånge sig det äntennätonale lederskab for den gronne omstilling. Folleringet kan båre det gronneste padament i verden, det ikke kan gor noget, men som gor det, det skal til for at leve op til Pasi-aftalen.

Vi skal stytke voces velfærd igen. Så Dannark bliver verden: bedste land at være bam i, så der bliver mere tid ti omsog i undflædstørsenet, og så alle kan se fæm til en tryg og værdig alderdom. Velfærd giver lige milligheder og fråder til forskullighed.

Vi skul bekempe den nigende ulighed. Så vi igen begruder at stytke den samfundsmodel, der har givr Dammak til et af de met tillsfråde og sygge hande i verden. Hvedsen fattigdens eller grådighed hosse hjemme i vore hand, og vi han miligheten for at tag er opgen med begre dels.

Vi skal tage et opgør med centraliseringen af Danmark. Så der er udväling, muligheder, arbeidspladser op vaffæd i hele kudet. Det har en værd i sig selv, æ beskninger tærffer tær på den, det vedrorer. Danmark er fo life ut stors forskale.

Vi skul satte på uddannelse. Så voret unge kan udfolde og udfordte sig så meget, som de kan – og så hrver ny generation går en bedre fremtid i mode end den fornige. I et velfærdssamfund som det danke skal det ikke være ens baggnud, det afgor, hvilke muligheder man har i livet.

Vi skal fremme integrationen. Så vi kan leve sammen, selvom vi er forshellige. Med respekt for hinanden og de demokantiske spilleregjer vi bygger vores samfund på. I Daanaak er alle frie og ligeværdige.

Vi skal lofte et ansvar for verden. Så Danmack er et hand, der hjølper mennesker i nod. Som står vagt om de internationale konventioner, klivit avhøjder for RNV verdesambl og engageet indgår i forplågende internationale Editestabet. Danmark isla tvære et besat had, frore ot invers 47 osse indryn til avtesta for verden.

Vi trot på, at polatik betydse noget. At vi kan lose de reelle problemse i tredet for at fore symbolpolatik. Si vi summet han sætte en ny og progenstør stening for Damank. Forventingsørne et store. Bås at han indifise på en gang, og forsthutseningen es, at det fore en anvandig donomik politik, ett attere opde anamerikke fore ednerevikler for ednerevikler. Vi har en nult mulighed for at gå i gang med at stelloser de håb, vælgense har til et nyt politisk færtal

Det er på den baggeund, at partier, med et flettal af mandater i Polketinget, har peget på Mette Predenkoen (5) som kongelig undersoger med henblik på at danne en regeting, der skal sikre en ny politisk retning for Danmark.

Som frombsening for tilbrevien af en idea repering er Sonatdemokrate, Rakhiel Versen, IF og Enheldnisten enige om inv plotick forsider-i, en en medlene, at en ny repering er fordjært et at rege en akke instattere, de under ser it brevis en opfolsk ening for Jonana, Instatteren kal konstaret i blevi trejensperioden og genze i et bredt samstelene med Polketigert ovrige parier. En ny repering vil enbrides repektere als gedande folg.

Side 1







Energi System Analyse Model



Energy PLAN

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A Holistic Smart Energy Systems Approach **IDAs Klimasvar** - Transport- og energiløsninger 2030 DA Executive Summary IDA's Energy Vision 2050 m strategy for 100% renewable Denmar A onewa/ SMART ENERGY SYSTEMS A (AP)AALBORG UNIVERSITY









IDAs Climate Response: Looks Beyond 2030

Denmark should fulfill its objective of a 70 percent CO2reduction in 2030 in a way, so it fits well into a full decarbonization by 2045

Therefore:

- We should prioritize technologies before 2030 which paves the way for the next steps beyond 2030.
- On our way towards 2030 we should begin the innovation of those technologies we will need after 2030 even if they cannot play a bit role before 2030.













IDAs Climate Response: In a European context

Denmark should fulfill its objective of renewable energy and CO2reductions in a way, so it fits well into a context in which the rest of Europe - and the world - will do the same.

Therefore:

- Denmark should include the Danish share of *international aviation and shipping* even though it is not included yet in the UN way of calculating the Danish CO2 emissions.
- Denmark should not exceed our share of *sustainable use of biomass* in the world.
- Denmark should make our contribution in terms of *flexibility and reserve capacity* to integrate wind and solar into the *European electricity supply*.































	Investments	Annual cost
IDAs Climate Response	Billion EUR	Million EUR/year
Building renovation	16,5	715
Wind power	10,4	556
Electric vehicles	9,8	919
Individual heat pumps	9,4	682
Industry (electrification and energ	4,8	343
District heating and 4GDH	4,0	196
Photo Voltaic	2,8	125
Biogas plants	2,4	163
Nye gas power plant capacity	2,1	120
Largescale heat pumps in DH	1,2	67
Electrolysis and Hydrogen storage	1,0	67
Geothermal	1,1	59
Wave power	0,6	40
Gasification, hydrogenation and el	0,7	42
Electric Vehicles infrastructure	0,6	300
Intelligent flexible eldemands	0,5	31
Solar thermal, excess heat and the	0,5	23
Distrcit cooling	0,2	12
Expansion of the natural gas grid	0,2	12
Sum	68,7	4471





CO2 emissions in the UN accounting...











Sector integration

The IDA Climate Response focus on synergies and flexibility as a result of sector integration including the following investments in energy conversion and storage capacity:

- Largescale thermal storage capacity of 112 GWH
- Utilization of existing Natural Gas Storage capacity of 40 GWh
- Additional electrolysis capacity equivalent to a 50% utilization
- Use of seasonal over capacity on heat pumps and large-scale electric boiler equivalent to 700 MW
- Intelligent charging of Electric Vehicle Batteries of 14 GWh
- Flexible intelligent eldemand equivalent to approx. 2.5 TWh/year





Bi	oma	SS

Tabel 11. Udfordringer ved biomasseforbrug i Danmark og globalt

	Biomasseforbrug pr. person
I dag i DK (166 PJ)	29 GJ/capita
Seneste forskning for EU (8500 PJ) (Hamelin et al., 2019)	17 GJ/capita
EU 2050 scenarioer (A Clean Planet for all)	14 - 21 GJ/capita
IDA 100 pct. VE i 2050 (200 PJ – Dansk andel)	32 GJ/capita
Energistyrelsens scenarioer fra 2014	35 – 45 GJ/capita

IDAs Climate Response reduces biomass consumptions from 29 to 26 GJ/capita.

IDAs Climate Response focus on:

- Denmark to reduce the use of biomass
- Denmark to use sustainable biomass with low CO2 emissions
- Denmark to prepare for a long term target of not exceeding the Danish share of sustainable biomass use in the World.





Renewable Energy in 2030

IDAs Climate Response need the following Renewable Energy:

- Solar thermal in district heating of 6-7 PJ.
- Solar thermal in individual houses of 8-9 PJ.
- 500 MW geothermal heat for district heating of 13-14 PJ.
- Photo Voltaic on large building roofs expand from bow1.000 MW to 5.000 MW i 2030.
- Onshore wind power expand from approx. 4.200 MW at least 4.800 i 2030.
- Offshore wind power expands from approx. 2.000 MW to 6.630 i 2030.
- Wave power contributes with 132 MW (with wind power as an alternative)





Smart Energy Europe



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