NTNU | Norwegian University of Science and Technology

Bør kjernekraft være en del av framtidens ikke-fossile energi i Norge?

Folkets Hus, 10. September 2024

Martin Hjelmeland, PhD. | Institutt for elektrisk energi, NTNU

martin.hjelmeland@ntnu.no

The Nuclear's Energy role in a Renewable Energy System (NERES) project

Financing:	Strategic project (NTNU)
Period:	March 2023 – Dec 2025
Homepage:	https://www.ntnu.edu/iel/neres
Project lead:	Magnus Korpås

Martin Hjelmeland
Postdoc

Jonas K. Nøland
Assoc. Prof.

Magnus Korpås
Professor

Recent news

European push for nuclear

The European Industrial Alliance on Small Modular Reactors (SMRs) aims to facilitate and accelerate the development, demonstration, and deployment of SMRs in Europe by the early 2030s.

Kadri Simson, EU's Commissioner for Energy:

*"SMRs can contribute on our decarbonisation pathway to **complement renewables**, and provide baseload energy production for **deep electrification**, reliable source of **heat for industries and urban districts**, as well as for **low-carbon hydrogen production**."*

Statement, February 9th, 2024

Ursula von der Leyen, President of the European Commission:

*"When we speak about our energy, we **have to produce our own energy**, more renewables, **more nuclear**, more efficiency."*

Statement, August 30th, 2024

North-American push for nuclear

Jennifer Granholm – US Secretary of Energy:

"We are determined to build a world class nuclear industry in the United States and we're putting our money where our mouth is."

"*2 down, 198 to go.*"

Statement, June 2nd, 2024

OPGs Darlington hosting 4x BWRX-300:

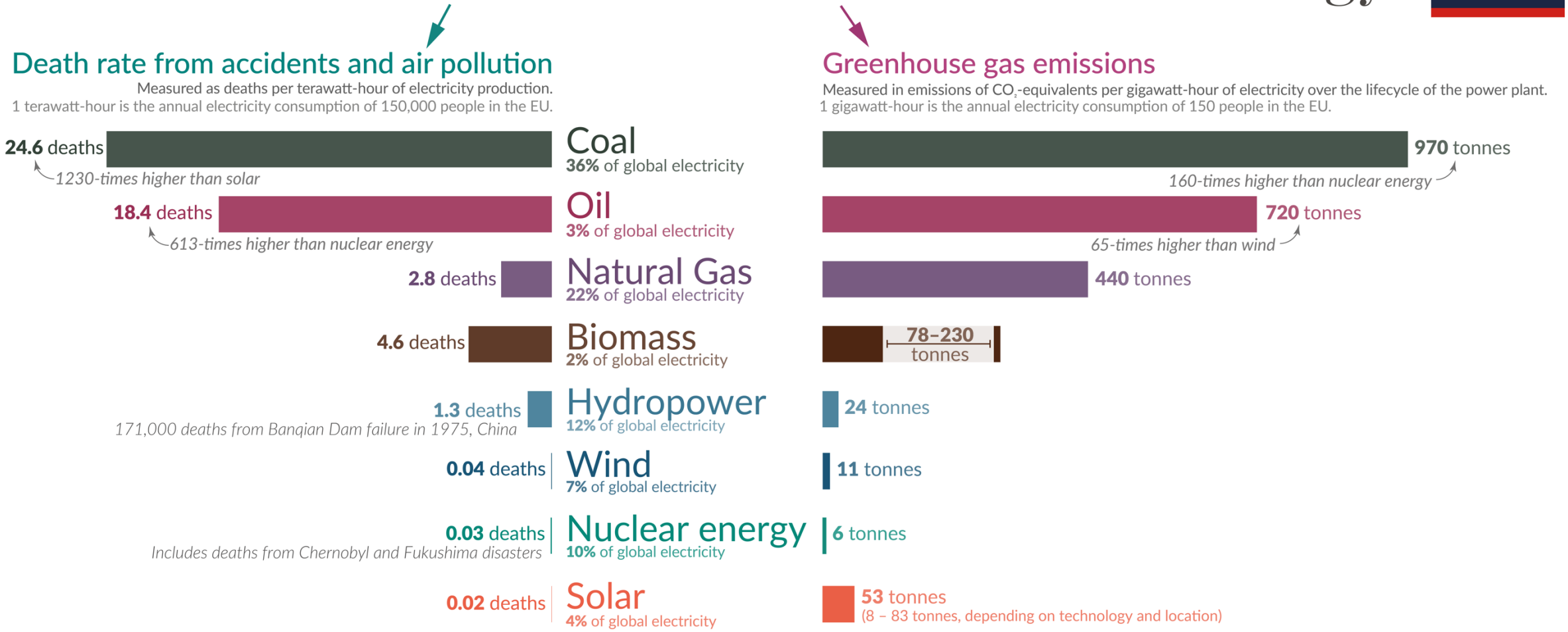
Goal: Complete construction of first SMR by end of 2028, commercially available by end of 2029.

At COP28 more than 20 countries signs nuclear energy declaration

Nuclear energy & sustainability

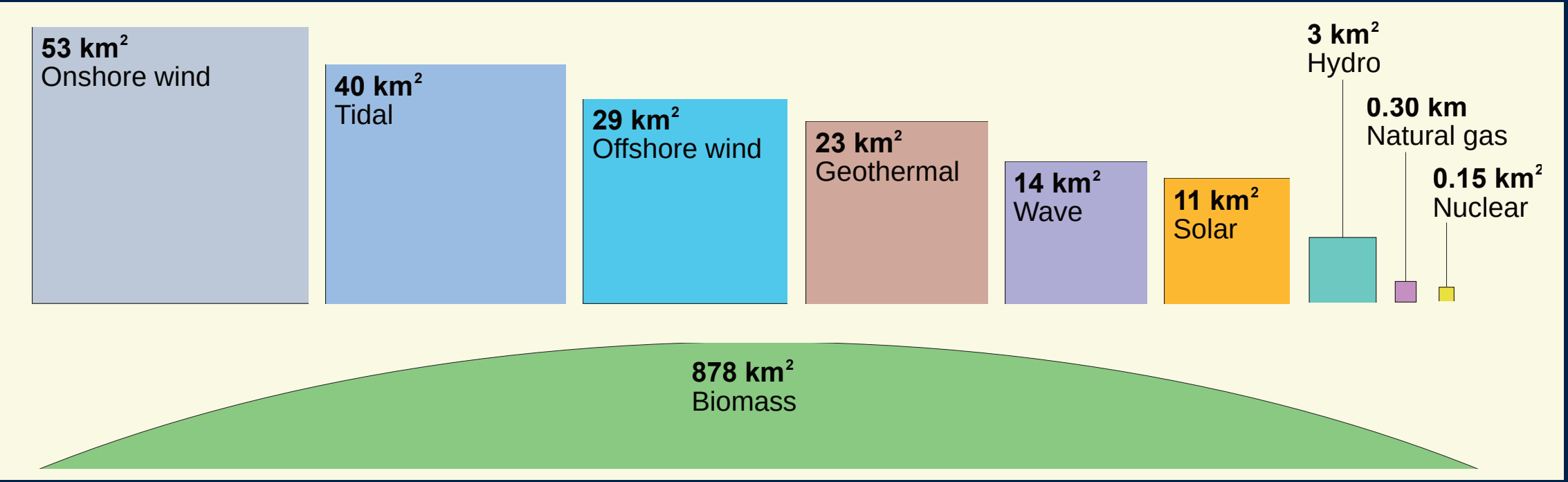
What are the safest and cleanest sources of energy?

Our World in Data



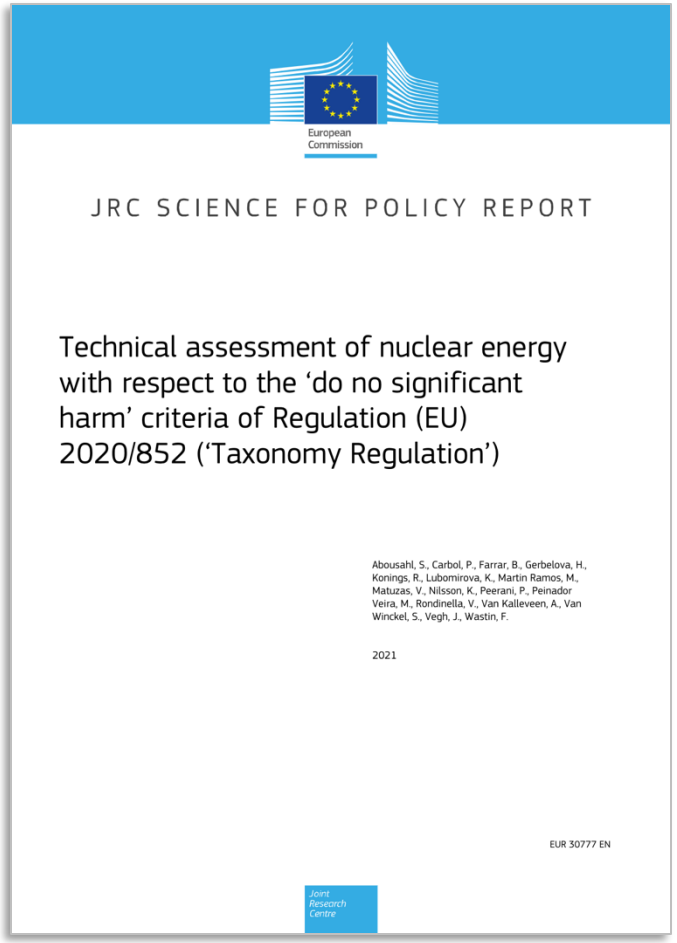
Death rates from fossil fuels and biomass are based on state-of-the art plants with pollution controls in Europe, and are based on older models of the impacts of air pollution on health.
This means these death rates are likely to be very conservative. For further discussion, see our article: OurWorldinData.org/safest-sources-of-energy. Electricity shares are given for 2021.
Data sources: Markandya & Wilkinson (2007); UNSCEAR (2008; 2018); Sovacool et al. (2016); IPCC AR5 (2014); UNECE (2022); Ember Energy (2021).

Land use



Source: (Nøland, J. K., Auxepaules, J., Rousset, A., Perney, B., & Falletti, G. (2022). Spatial energy density of large-scale electricity generation from power sources worldwide. *Scientific Reports 2022 12:1*, *12*(1), 1–26.)

Nuclear energy recognized as sustainable by JRC and UNECE



Safest energy source

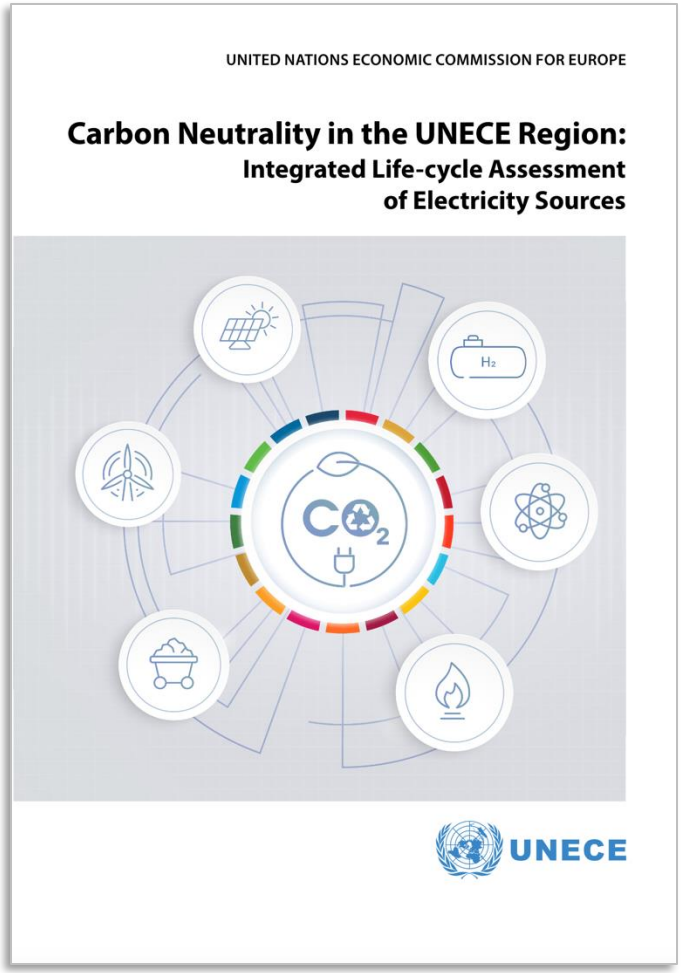
Lowest land use

Lowest material use

Lowest CO2 emissions

As sustainable, or more sustainable than alternatives

Nuclear waste can be safely handled



Lowest negative impact on resource use (minerals & metals)

Lowest negative impact on human health (including cancer)

Lowest negative impact on ecosystems (climate, nature & environment)

Source: (EC Joint Research Centre. (2021). Technical assessment of nuclear energy with respect to the "do no significant harm" criteria of Regulation (EU) 2020/852 ('Taxonomy Regulation')
(United Nations Economi Comission for Europe (UNECE). (2022). Carbon Neutrality in the UNECE Region: Integrated Life-cycle Assessment of Electricity Sources.)

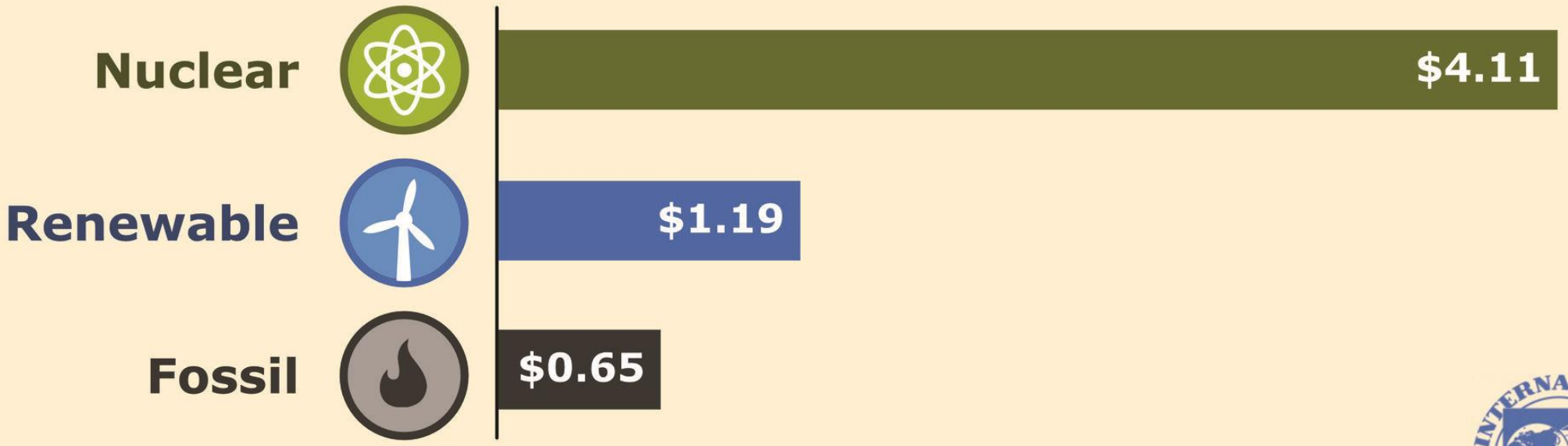
No energy source is perfect

Risk, **benefits** and **alternatives**

Source: (risk-engineering.org, “Risk perception”)

More than just electricity

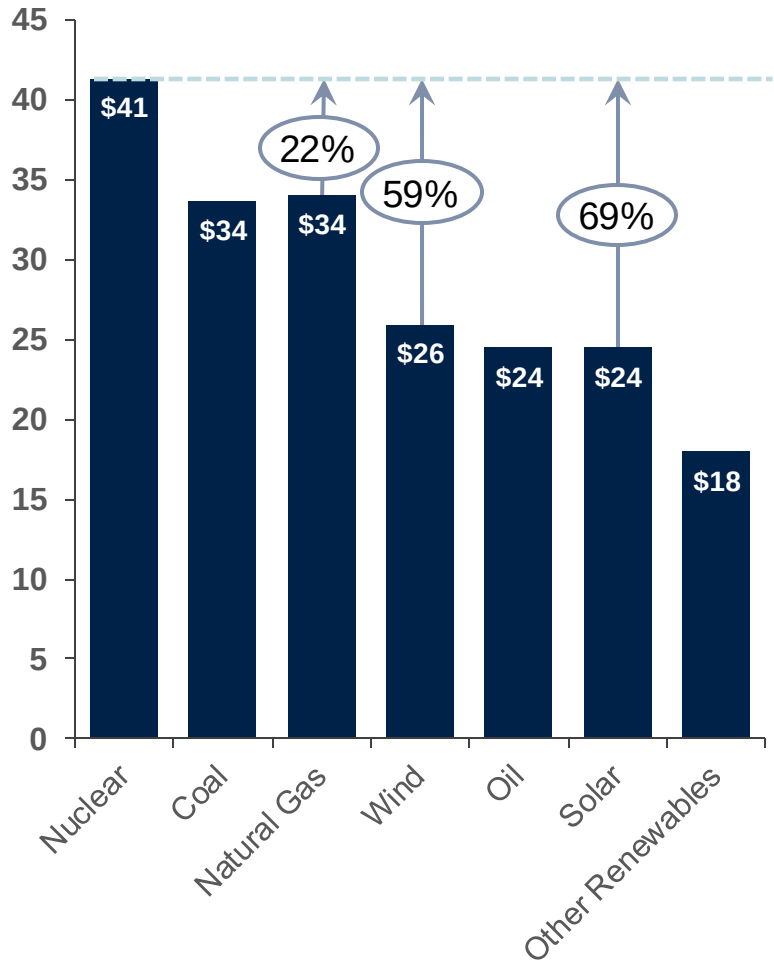
Verdiskaping (BNP) fra investeringer i energiproduksjon



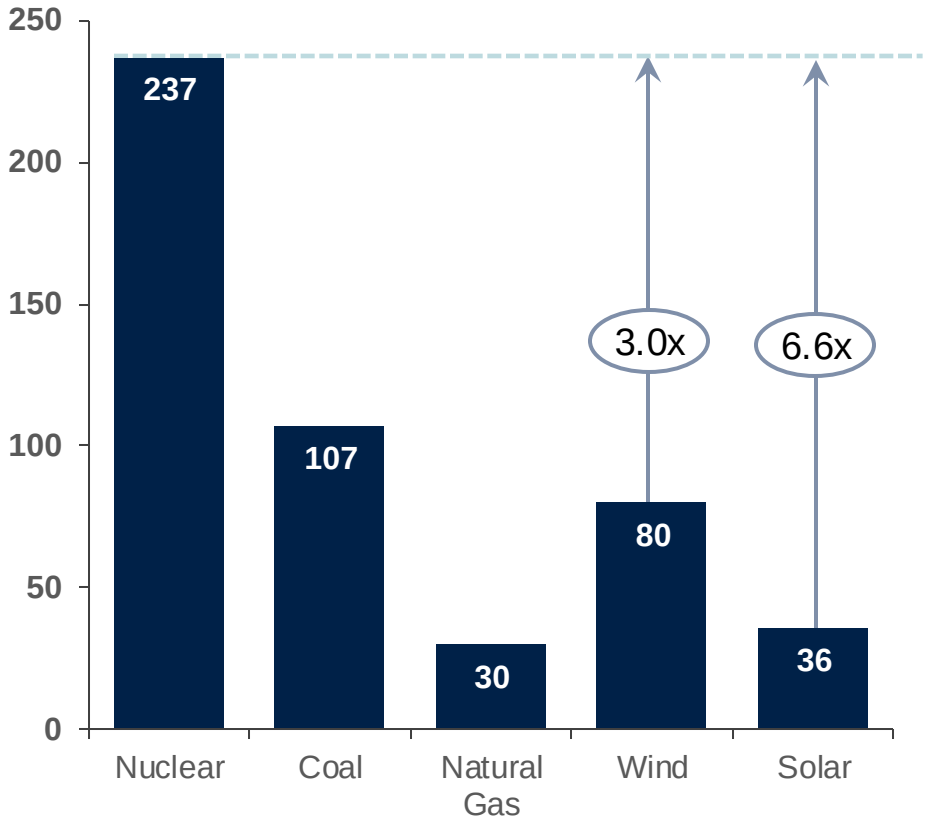
Nicoletta Batini, Mario Di Serio, Matteo Fragetta, Giovanni Melina & Anthony Waldron, "*Building back better: How big are green spending multipliers?*", Ecological Economics **193** (2022) 107305; see Tables 2 and 4 (pp. 8–9).

Nuclear energy provides the highest paying jobs and the highest share of permanent local jobs in the US.

Median hourly wages by energy sub-sector
[USD]



Permanent jobs on site equivalent to a 1 GWe coal plant
[#]



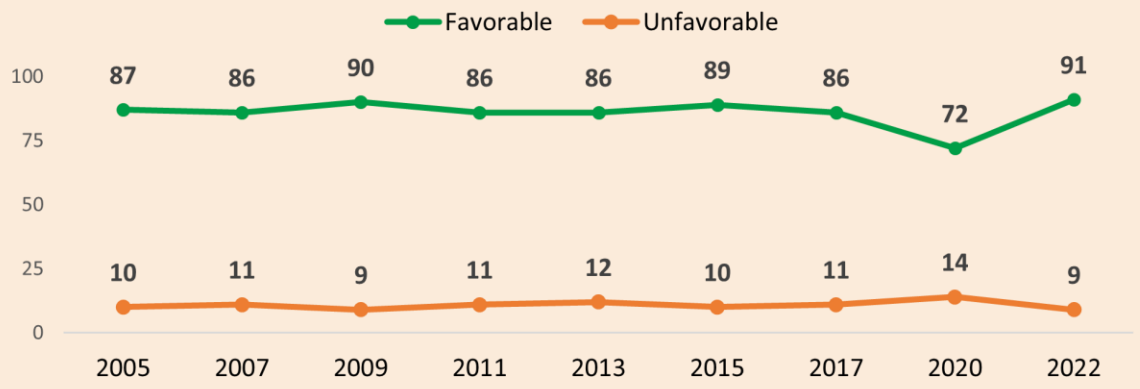
Source: (USEER. (2020). Wages, Benefits, and Change A Supplemental Report to the Annual U.S. Energy and Employment Report.)
(ScottMadden Inc. (2021). Gone with the Steam How new nuclear power plants can re-energize communities when coal plants close.)

Hva sier de som bor nært eksisterende kjernekraftverk?

Bakgrunn

- 910 besvarelser innen 16 km radius fra kjernekraftverk
- Besvarelser fra 52 av 54 amerikanske kraftverk
- Husholdninger med arbeidere på kraftverket ble ekskludert

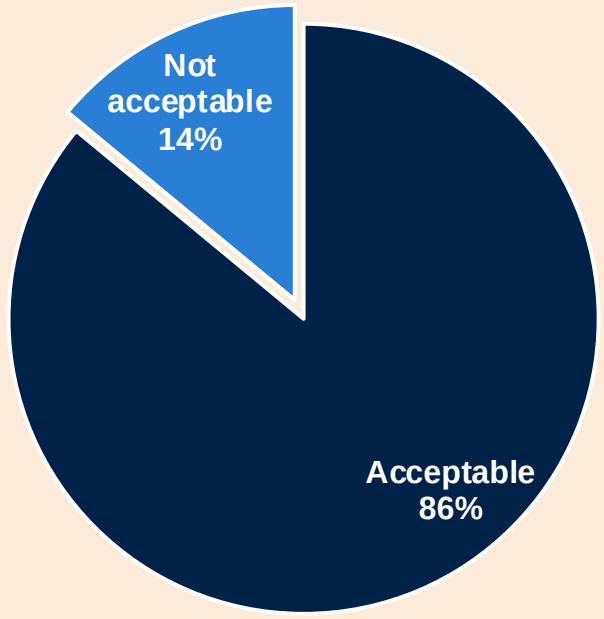
Thinking of the nuclear power plant closest to where you live, would you describe your general impression of this plant and the way it has operated recently as very favorable, somewhat favorable, somewhat unfavorable, or very unfavorable? (%)



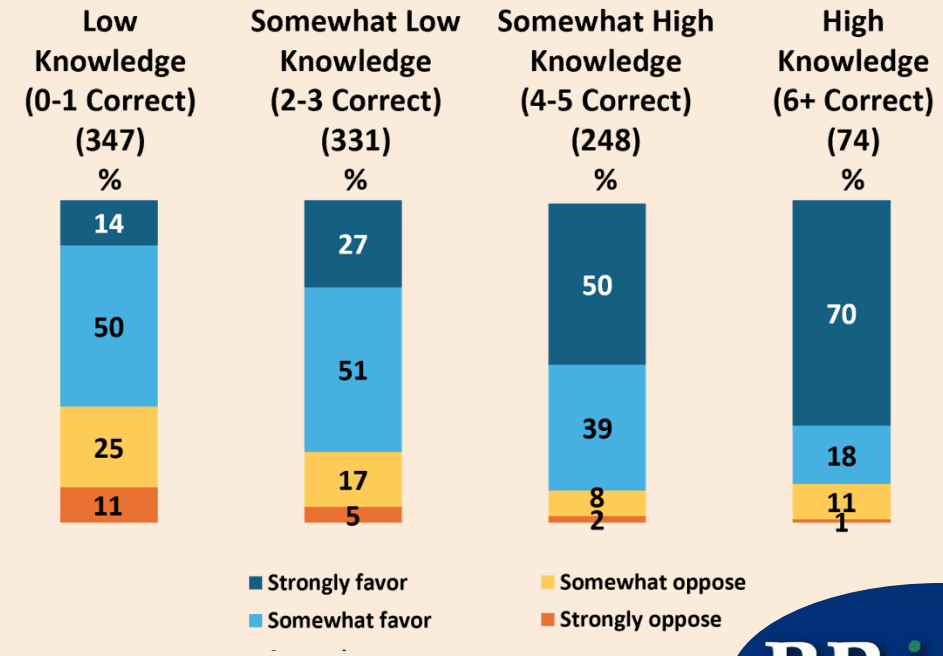
Source:(Bisconti Research, Inc. (2022) "Reverse NIMBY: Nuclear Power Plant Neighbors Say "Yes"".)

Hva sier de som bor nært eksisterende kjernekraftverk?

Innovative Small Modular Reactors, known as SMRs, are a new advanced alternative for supplying electricity. Would it be acceptable to you or not acceptable to you to add a Small Modular Reactor (SMR) at the site of the nearest nuclear power plant? (%)



Overall, do you strongly favor, somewhat favor, somewhat oppose, or strongly oppose the use of nuclear energy as one of the ways to provide electricity in the United States? (Number of correct answers out of 10)

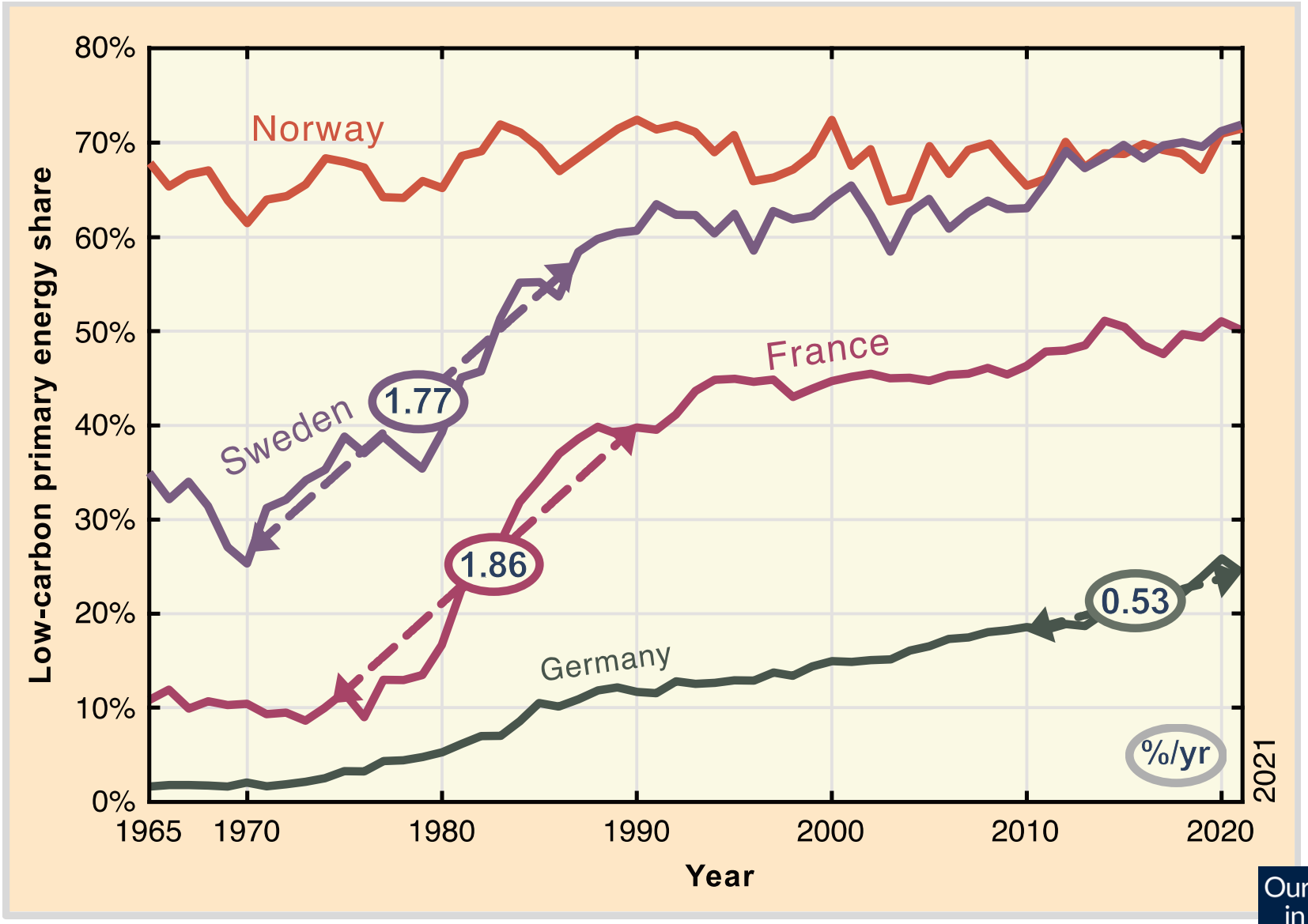


BRi
Public Opinion and Communications Research

Source:(Bisconti Research, Inc. (2022) "Reverse NIMBY: Nuclear Power Plant Neighbors Say "Yes"".)
(Bisconti Research, Inc. (2024) "Knowledge vs. Facts".)

Common perceptions

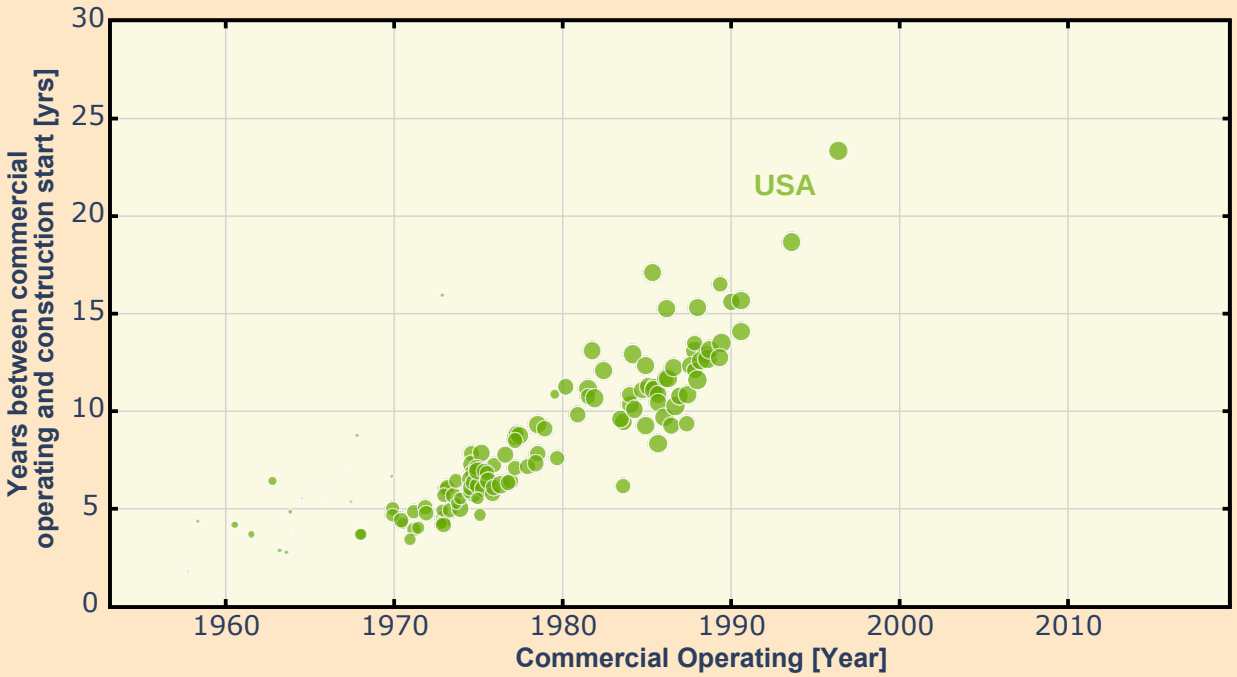
It takes too long time to build..

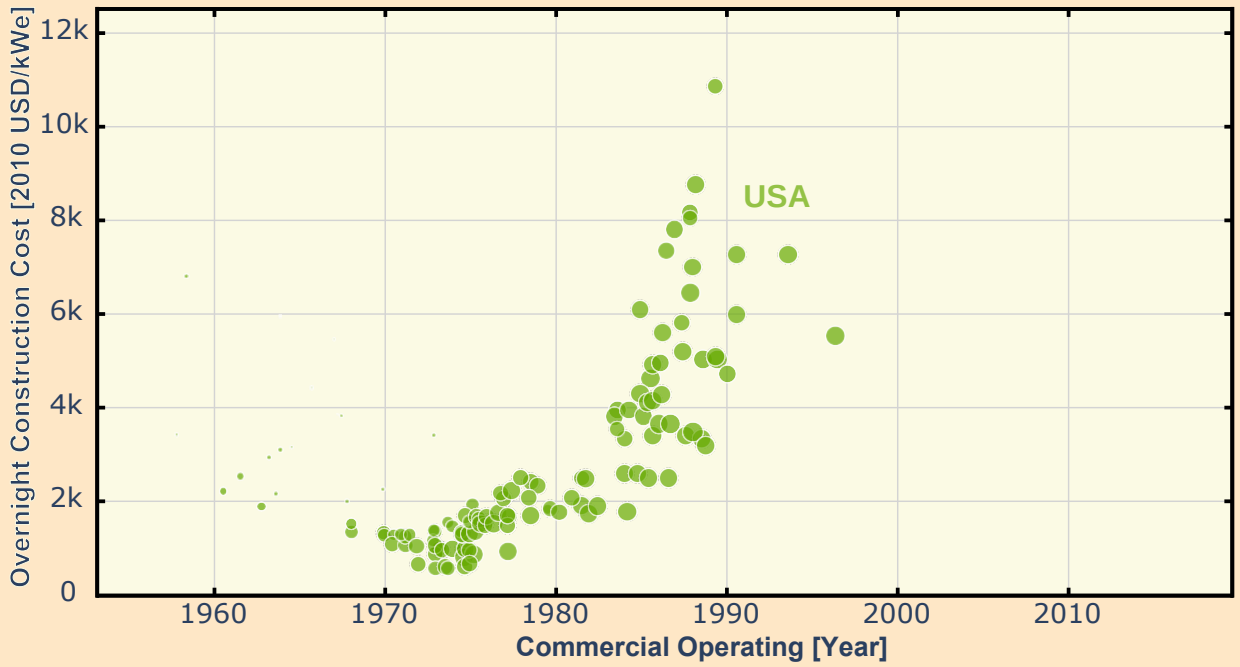

Low-carbon primary energy share
80%
70%
60%
50%
40%
30%
20%
10%
0%
1965
1970
1980
1990
2000
2010
2020
Year
Norway
Sweden
1.77
France
1.86
Germany
0.53
%/yr
2021
Our World in Data

It is too expensive!

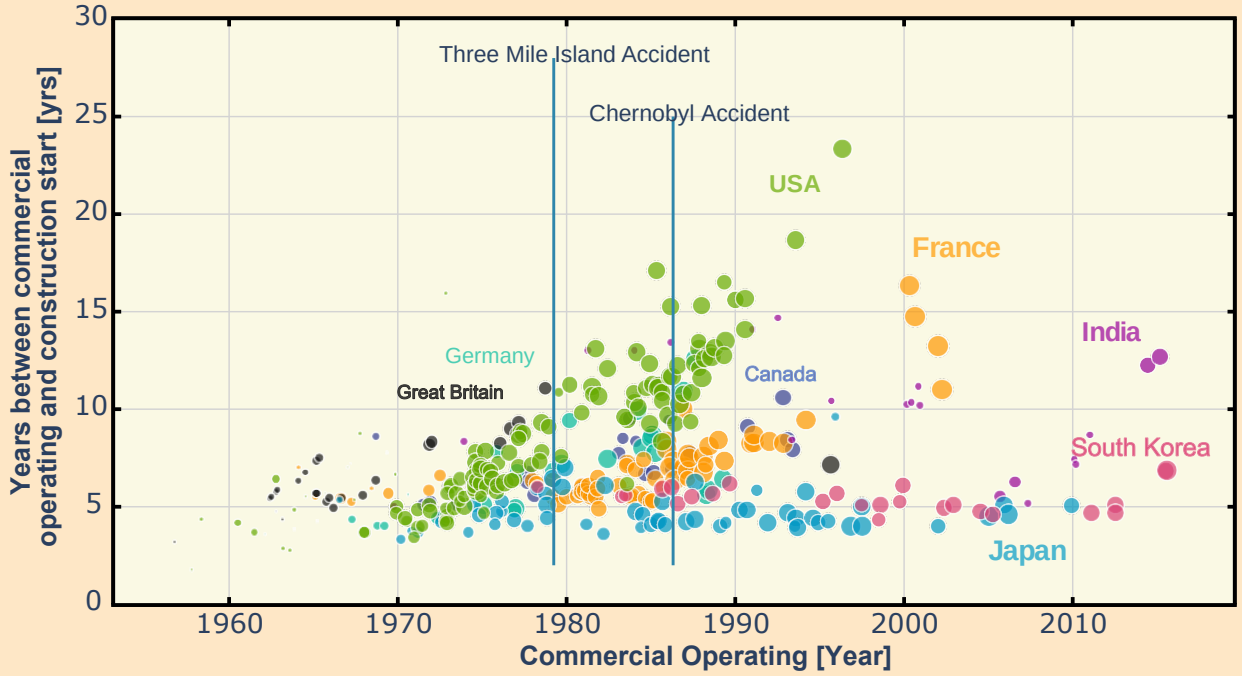
Time to build …

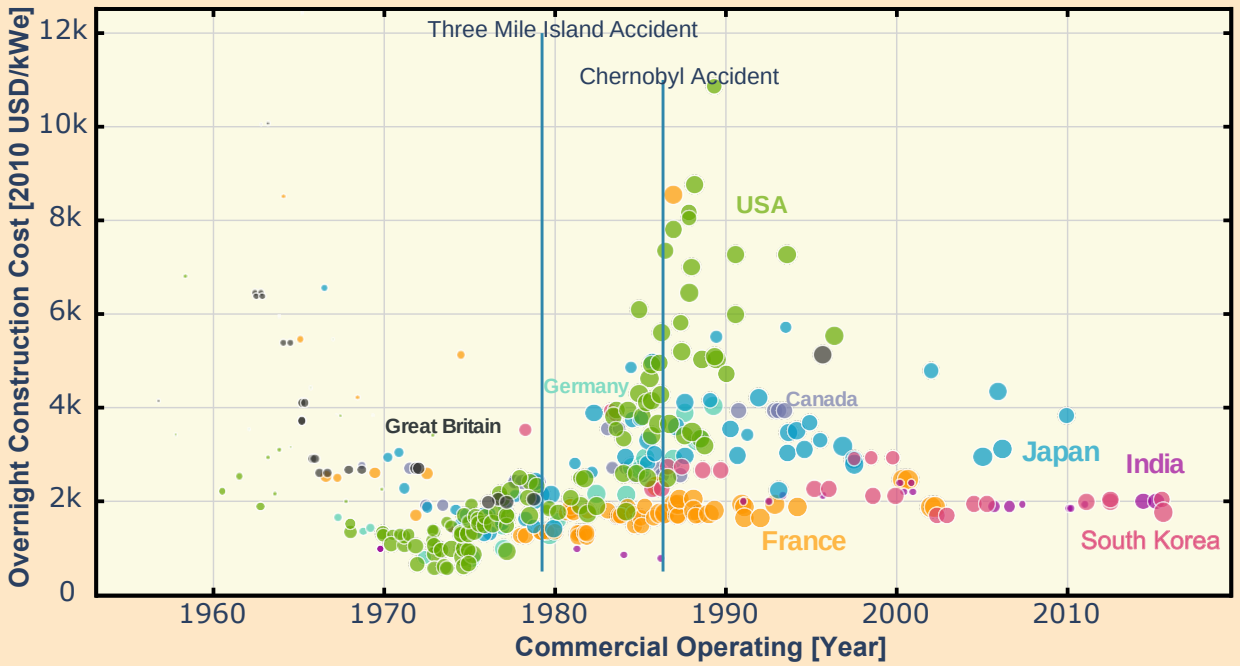
.. and cost





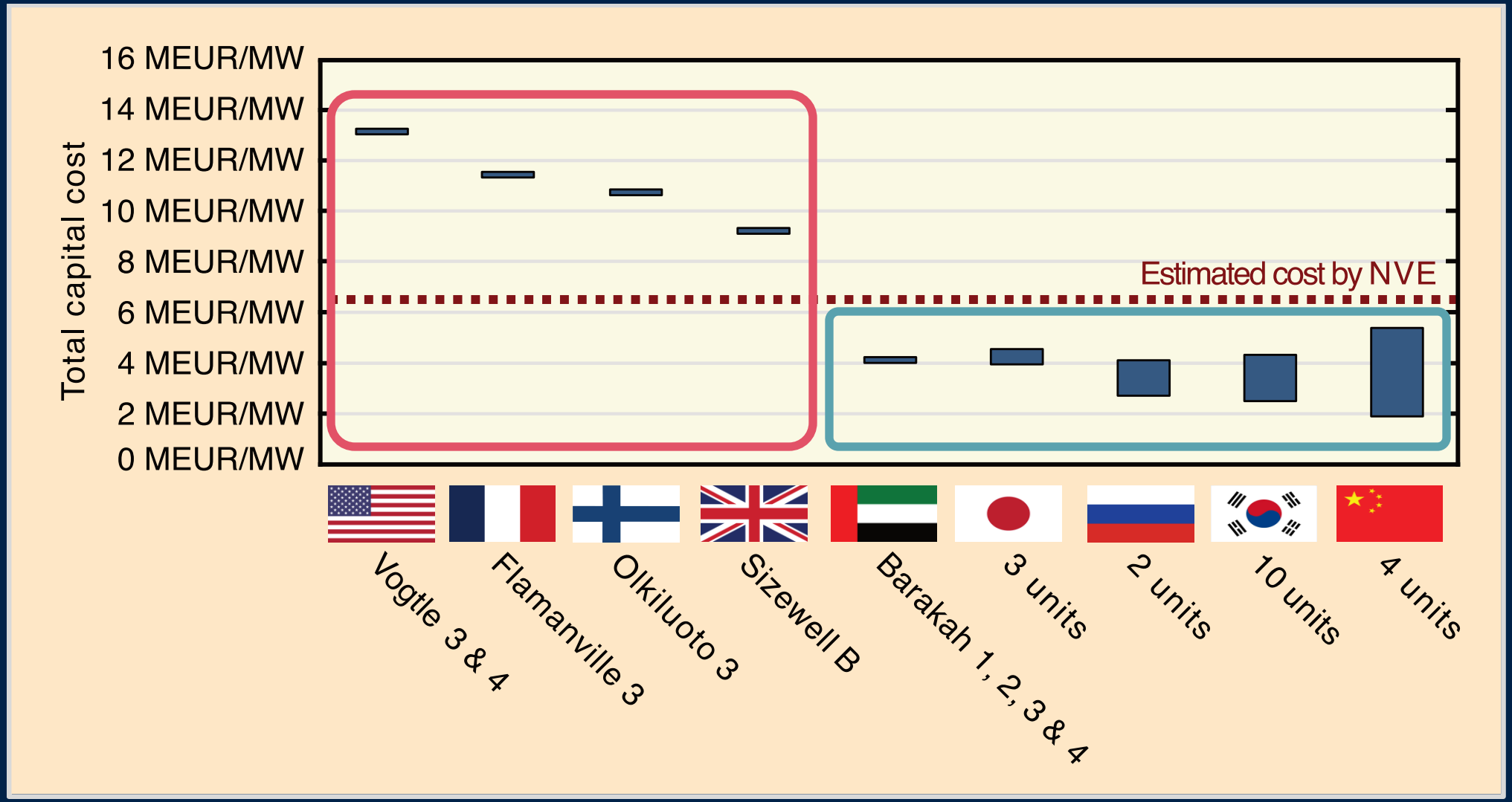
Source:(Lovering, J. R., et. al. (2016). Historical construction costs of global nuclear power reactors. Energy Policy, 91(April), 371–382.)



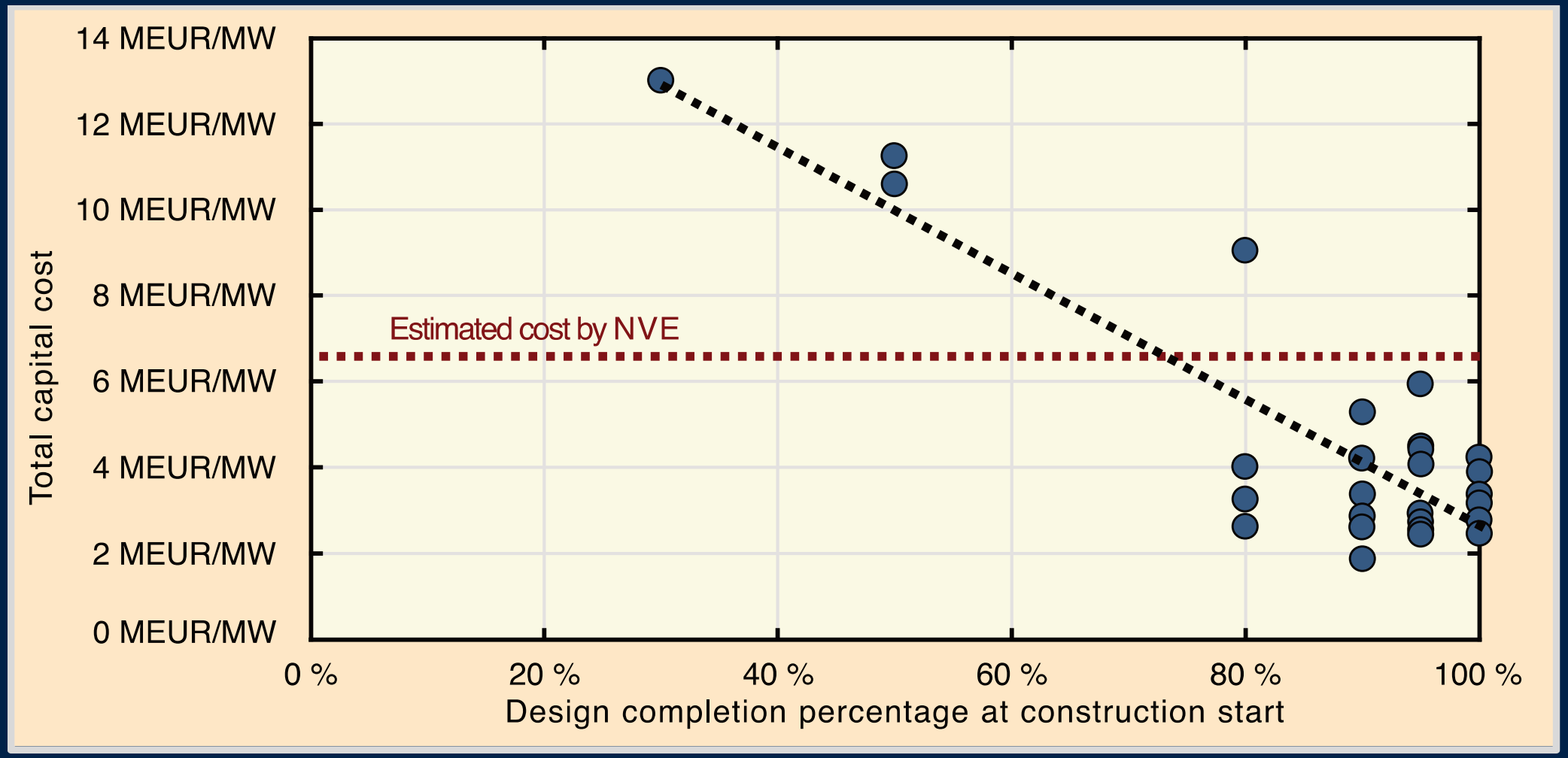


South Koreas “secret sauce”
Stable regulations, single utility overseeing construction, two and two reactors built onsite.

Source:(Lovering, J. R., et. al. (2016). Historical construction costs of global nuclear power reactors. Energy Policy, 91(April), 371–382.)



Source: (The ETI Nuclear Cost Drivers Project – Full Technical Report (lucidcatalyst.com), Unlocking Reductions in the Construction Costs of Nuclear: A Practical Guide for Stakeholders (oecd-nea.org)



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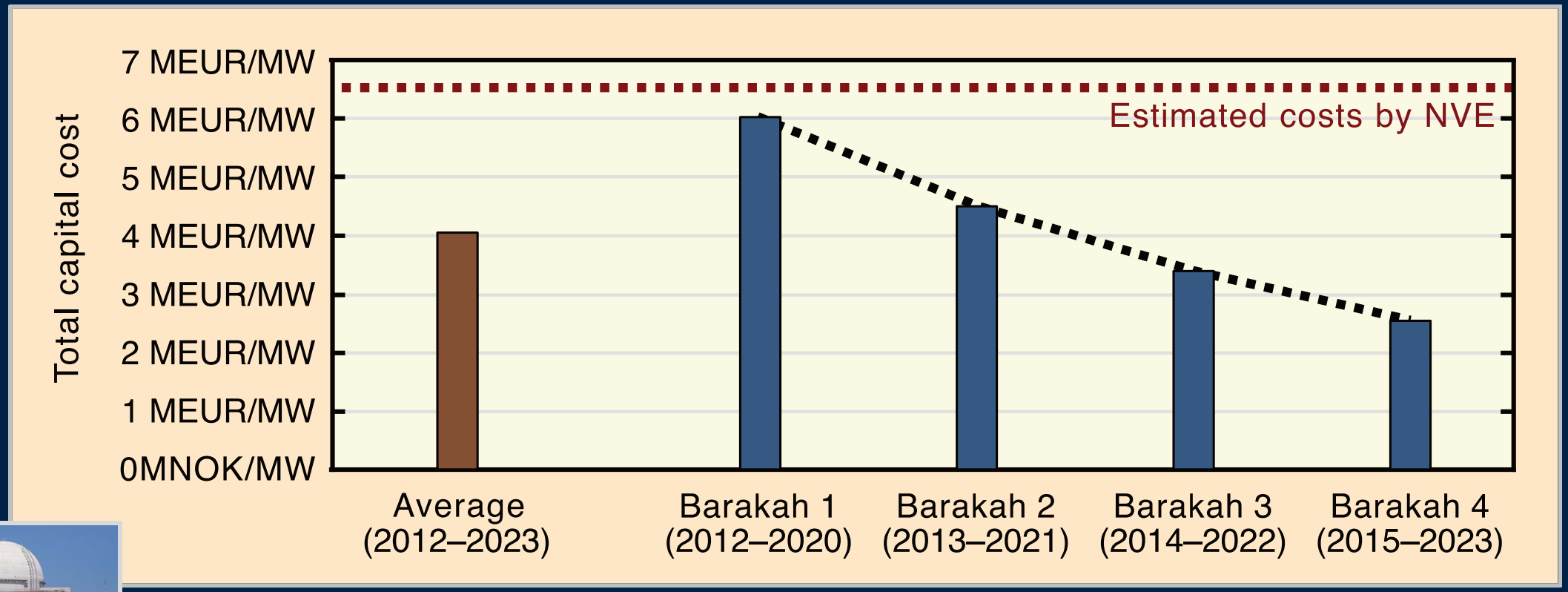


Source: (The ETI Nuclear Cost Drivers Project – Full Technical Report (lucidcatalyst.com), Unlocking Reductions in the Construction Costs of Nuclear: A Practical Guide for Stakeholders (oecd-nea.org)

Its not flexible..!

Conventional nuclear power plants can provide flexibility to the power system.

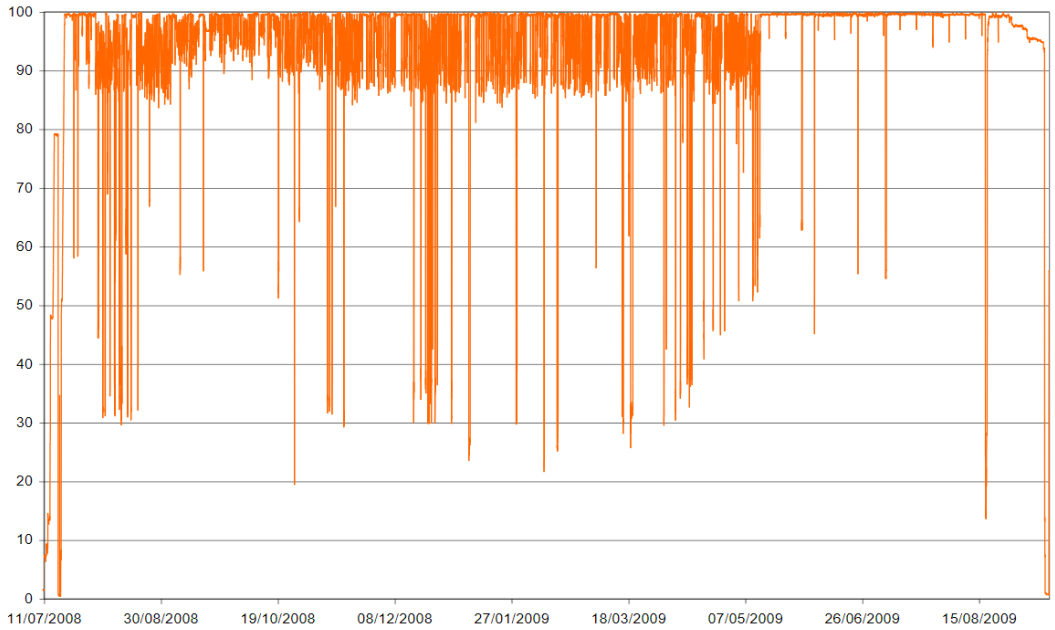
Conventional nuclear

OECD NEA
*Nuclear plants can generally contribute **5-10% of rated capacity to reserves**, depending on reserve product definitions and reactor ramp rates.*

According to the European Utilities Requirements (EUR) nuclear must at least be capable of **daily load cycling between 50% and 100%**, with a **rate change of 3-5% per minute**.

MIT Study
"We find that flexible nuclear operation lowers power system operating costs, increases reactor owner revenues, and substantially reduces curtailment of renewables."

Historic power output from a French reactor



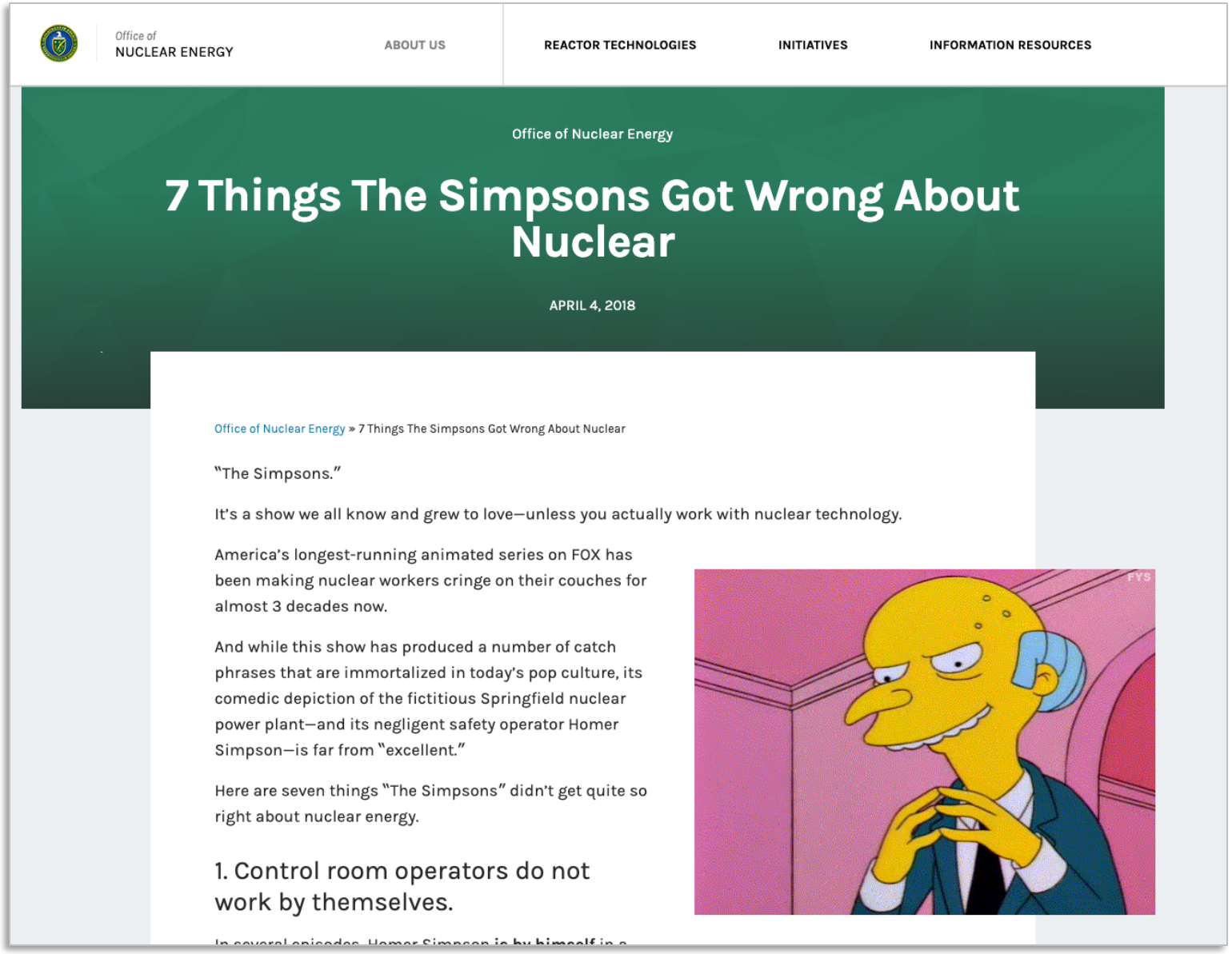
Source:(Jenkins, J. D., et. Al. (2018). The benefits of nuclear flexibility in power system operations with renewable energy. *Applied Energy*, *222*, 872–884.)
(OECD NEA. (2011). *Technical and Economic Aspects of Load Following with Nuclear Power Plants*)

The waste..!?


DAILY
SIMPSONS

Key takeaways

- All US high-level waste fits on a football field 10 m high.
- Waste can be recycled, only around 5% of the energy has been used.
- The high-level waste is in solid form.
- No known fatalities related to nuclear waste management.
- Granite counter top gives you more radiation than living by a nuclear power plant.



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Office of Nuclear Energy

7 Things The Simpsons Got Wrong About Nuclear

APRIL 4, 2018

Office of Nuclear Energy » 7 Things The Simpsons Got Wrong About Nuclear

"The Simpsons."

It's a show we all know and grew to love—unless you actually work with nuclear technology.

America's longest-running animated series on FOX has been making nuclear workers cringe on their couches for almost 3 decades now.

And while this show has produced a number of catch phrases that are immortalized in today's pop culture, its comedic depiction of the fictitious Springfield nuclear power plant—and its negligent safety operator Homer Simpson—is far from "excellent."

Here are seven things "The Simpsons" didn't get quite so right about nuclear energy.

1. Control room operators do not work by themselves.

In several episodes, Homer Simpson is by himself in a

Source:(energy.gov)

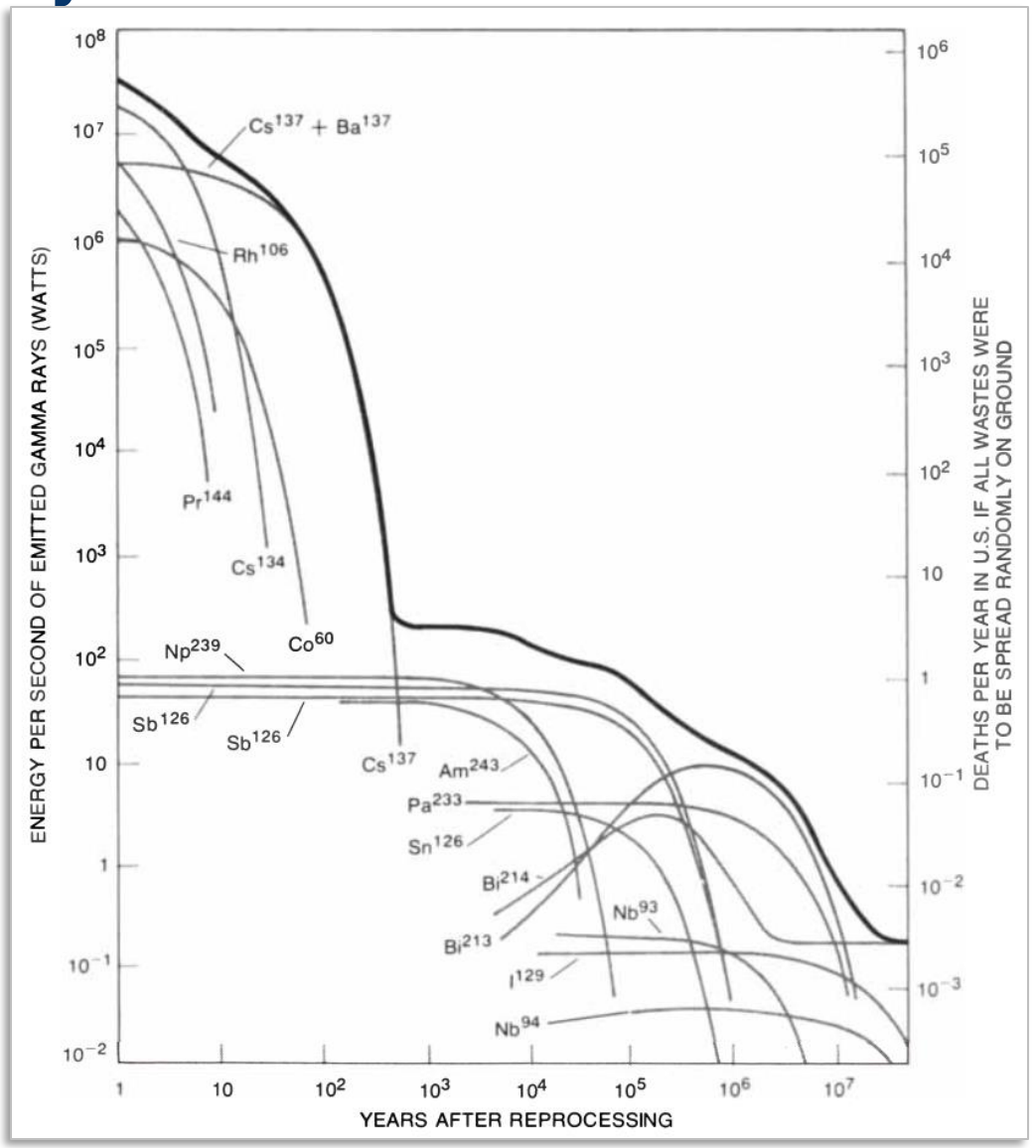
Nuclear waste is radioactive for million of years, it is just not very radioactive after 600 years..

Established 1845 SCIENTIFIC AMERICAN June 1977 Volume 236 Number 6

The Disposal of Radioactive Wastes from Fission Reactors

A substantial body of evidence indicates that the high-level radioactive wastes generated by U.S. nuclear power plants can be stored satisfactorily in deep geological formations

by Bernard L. Cohen



Source:(Cohen, B. L. (1977). The Disposal of Radioactive Wastes from Fission Reactors. *Scientific American, 236*(6), 21–31.)

Financing of nuclear waste management

Swedish nuclear waste fees 2022-2023

Permit holders with nuclear reactors	Nuclear waste fees	Credit risk amount (MSEK)	Risk margin (MSEK)	Pledged collateral (MSEK)
Forsmarks Kraftgrupp AB	3,0 öre/kWh	5 485	15 834	21 319
OKG AB (Oskarshamn)	5,6 öre/kWh	6 113	8 628	14 741
Ringhals AB	4,5 öre/kWh	5 846	14 219	20 065
Barsebäck Kraft AB (BKAB)	0 kronor per år	0	3 052	3 052

Other examples of waste funds

USA

- Nuclear Waste Policy Act of 1982
- Utilities pays a quarterly fee to DoE for the purpose of constructing and operating a permanent waste repository.
- 43 billion USD by 2018

France

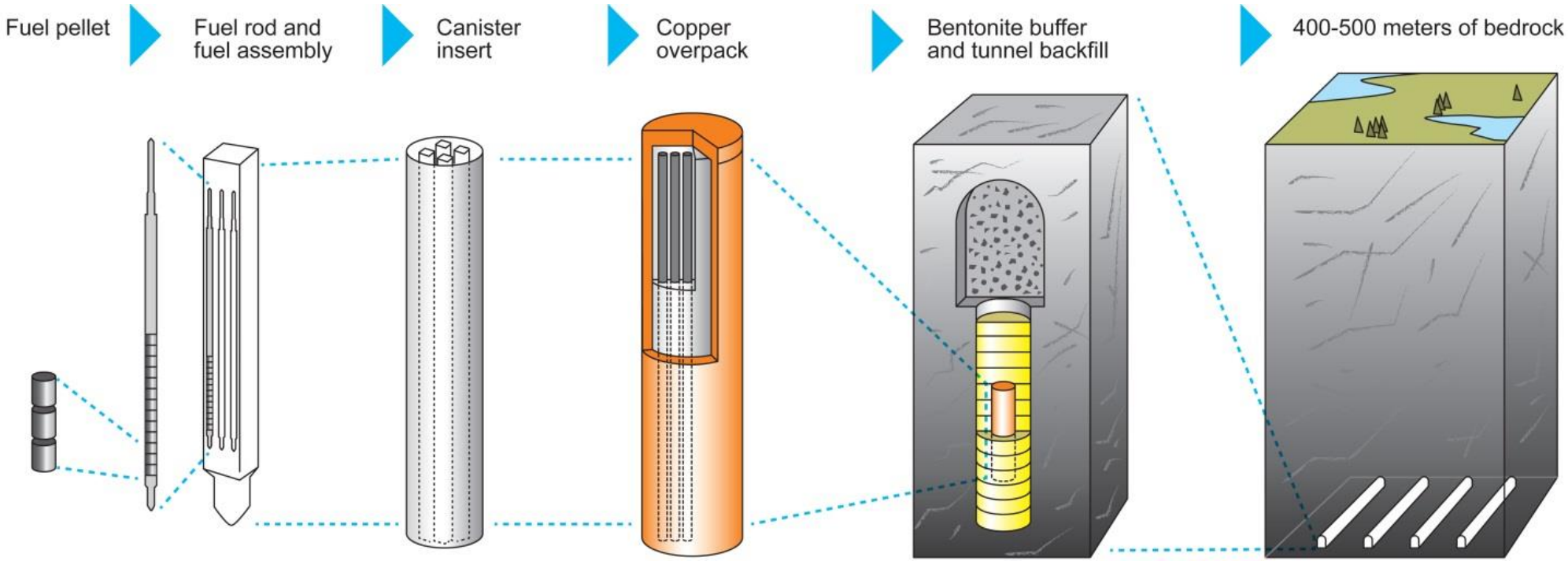
- Each nuclear operator manages funds which stay inside the company, backed by assets of sufficient security and liquidity.
- Audits every three years to administrative authority.

South Korea

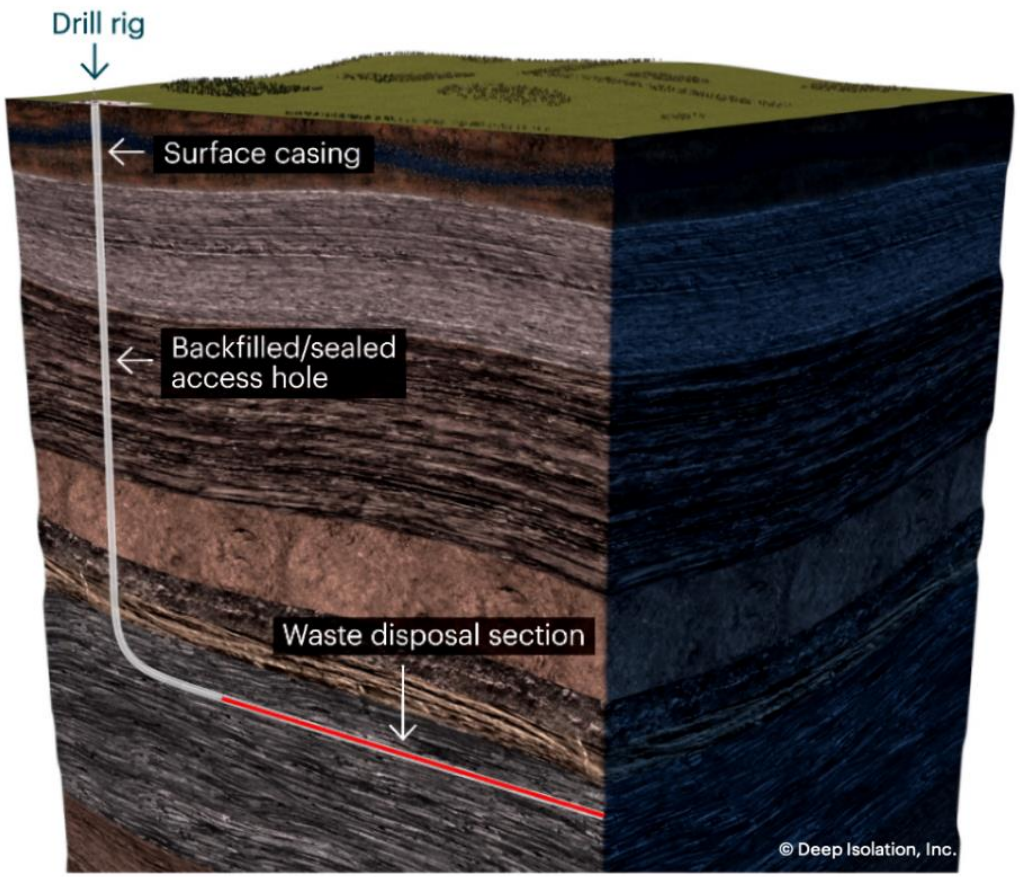
- Nuclear plants pays yearly fees for decommissioning and management of waste.

Source: (Karnavfallsfonden.se)
(How is nuclear waste management to be financed?)
(Radioactive waste management in rep. of korea)
(Radioactive waste management programmes in OECD/NEA member countries)
(Nuclear Waste Policy Act)

Existing storage solution used in Finland and soon Sweden



Drilling technology from oil and gas might enable cheaper solutions



DEEP HORIZONTAL BOREHOLE REPOSITORY FOR NUCLEAR WASTE

Nuclear energy in a Norwegian context

Vi har ikke bare en energikrise, men også en effektkrise.

«Fram mot 2030 forventer vi en betydelig vekst i kraftforbruket i Norge, hovedsakelig drevet av økt forbruk i kraftintensiv industri og elektrifisering av transport. Samtidig ser vi at mye av den nye produksjonskapasiteten de siste årene har kommet i form av småkraft og vindkraft»

> *«Vi går dermed mot en trend der det **nasjonale effektbehovet øker**, samtidig som det bygges ut **lite ny regulerbar produksjonskapasitet**»*

*«For eksempel var topplasten 25,2 GW vinteren 20/21, mens den laveste tilgjengelige produksjonskapasiteten var 25,8 GW. Ser man for seg mer ekstreme situasjoner, med kaldere vær, mindre vind eller forbruksvekst, skal det likevel **ikke mye til før effektbalansen i Norge nærmer seg 0, eller blir negativ**»*

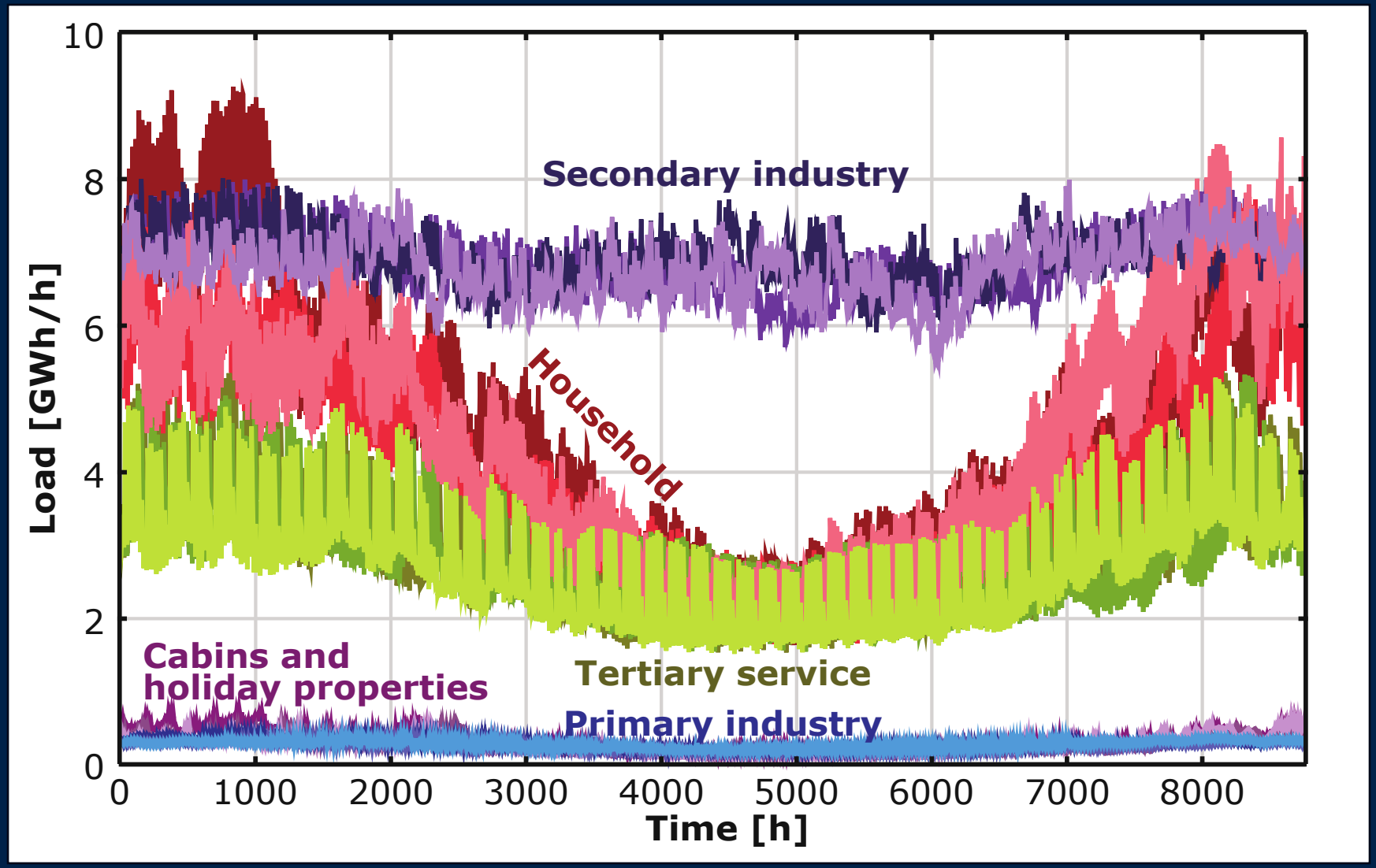
> *«Vi har sett på de timene i året med 1 prosent høyest forbruk, og deretter funnet maksimum og minimum vind- og solkraft i disse timene for værårene 1981–2010. Modellen gir et minimumsbidrag på 0 prosent av installert vindkraft for hvert budområde i Norge, og 3 prosent for hele Norge.»*

*«Dette viser at **de samme værsituasjonene kan prege store områder**, og gi **lite tilgjengelig uregulerbar kraft** i flere land samtidig»*

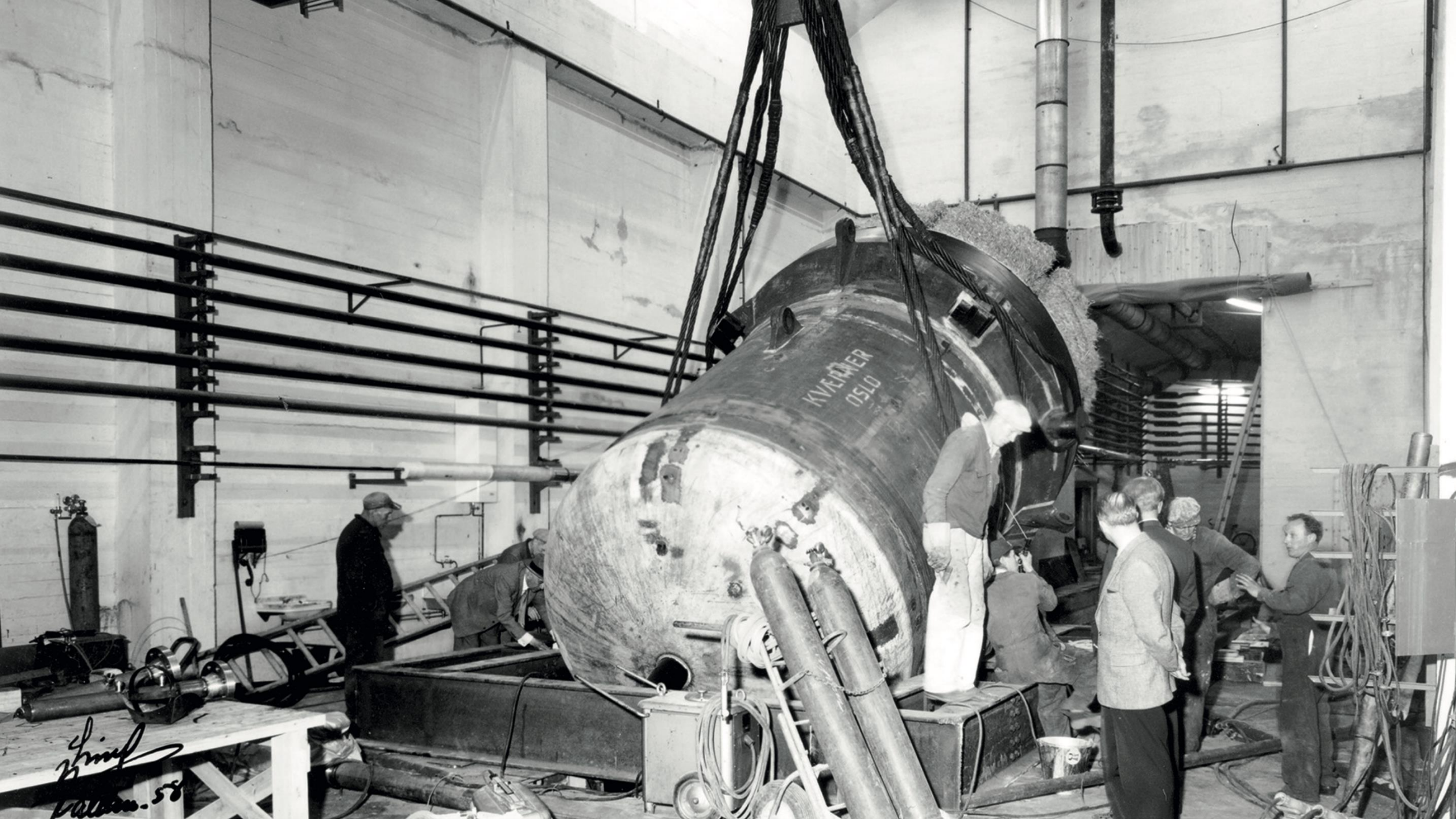
> *«**I år med lite vannkrafttilsig er vindkraftproduksjon lav og det er kaldt.** Norge er et langstrakt land med stor variasjon i vær mellom regionene. Dette fører blant annet til at det blåser på forskjellige tidspunkter i Sør- og Nord-Norge. **Det produseres mer vindkraft på vinteren når kraftforbruket er høyt, men i dagene med høyest kraftforbruk blåser det ikke mye**. **Hurtig reduksjon i solkraft og vindkraft er krevende for kraftsystemet** fordi det kan bli utfordrende å opprettholde den øyeblikkelige balansen.»*

Source: ("Sjokkrapport fra NVE og Statnett", Nettavisen.no, 2022)
(Buvik, M., et. al. (2022). *Norsk og nordisk effektbalanse fram mot 2030.*)
(Koestler, V., et. al. (2020). *Det svinger mer med fornybar strøm Sammenhengende vaer i Nord-Europa skaper utfordringer i et fornybart kraftsystem.*)

Halvparten av norsk kraftforbruk er grunnlast



Hjelmeland, M., Nøland, J. K., & Korpås, M. (2024). "*Influence of nuclear investment costs and baseload demand on the optimal energy mix*." in Proceedings of the 2024 International Conference on the European Energy Market (EEM 2024).


KVÆRNER
OSLO

Multiphase flow technology

Going from this …

… to this

Source:(Viktor Wikstrøm, ”Verdiskaping i IFE”)

“OLGA led the foundation for Norwegian subsea industry”

Dag Terje Rian, frm. CEO SPT Group

Source:(Vikor Virkstrøm, ”Verdiskaping i IFE”)

Multiphase flow technology

Aftenposten

Han har spart oljebransjen for milliarder

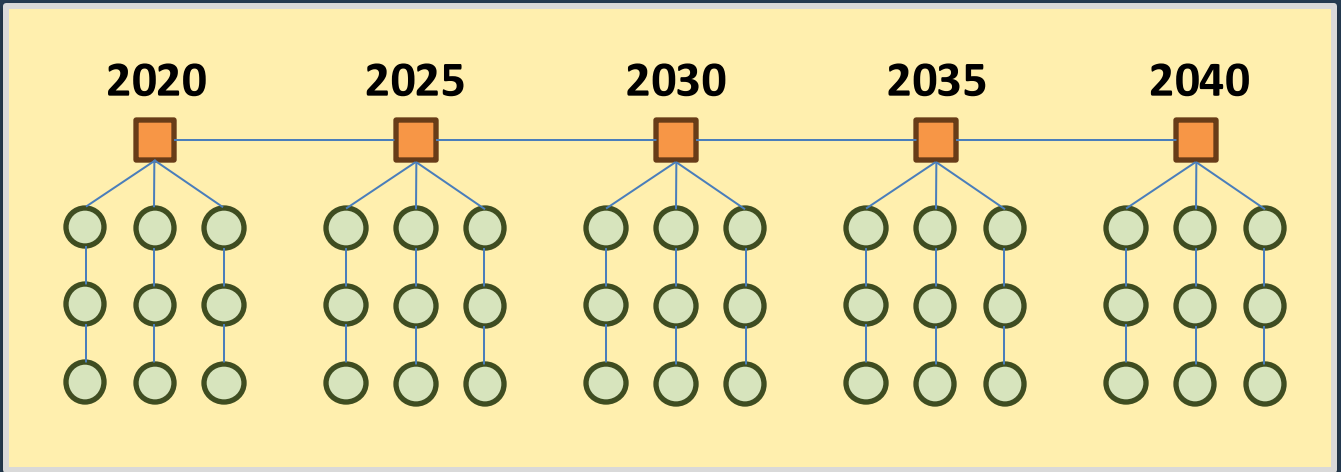
Aftenpostens fagjury var ikke i tvil om at flerfaseteknologien er Norges beste oppfinnelse etter 1980. Teknologien har spart oljebransjen for flere hundre milliarder kroner og er tatt i bruk av oljeselskaper over hele verden.

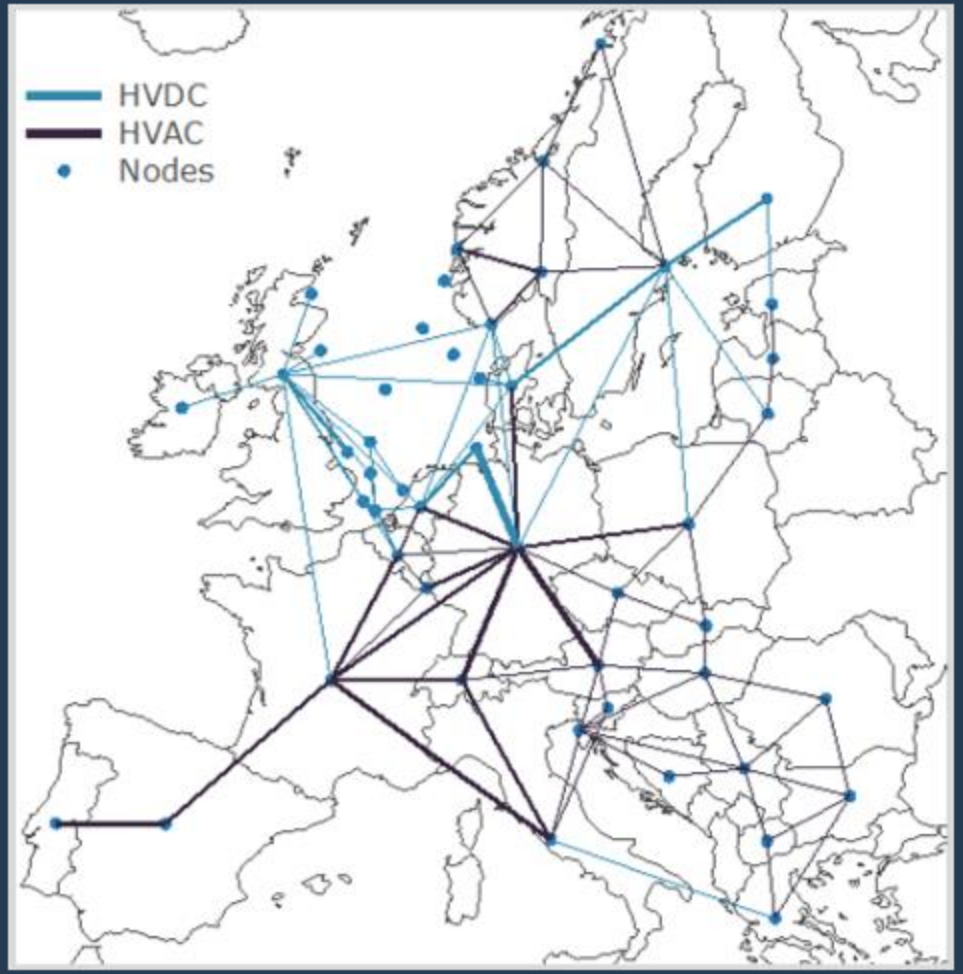
Source:(Viktor Wikstrøm, "Verdiskaping i IFE")

Europeisk energisystemanalyse

OpenEMPIRE: A capacity expansion planning model for energy systems

NTNU





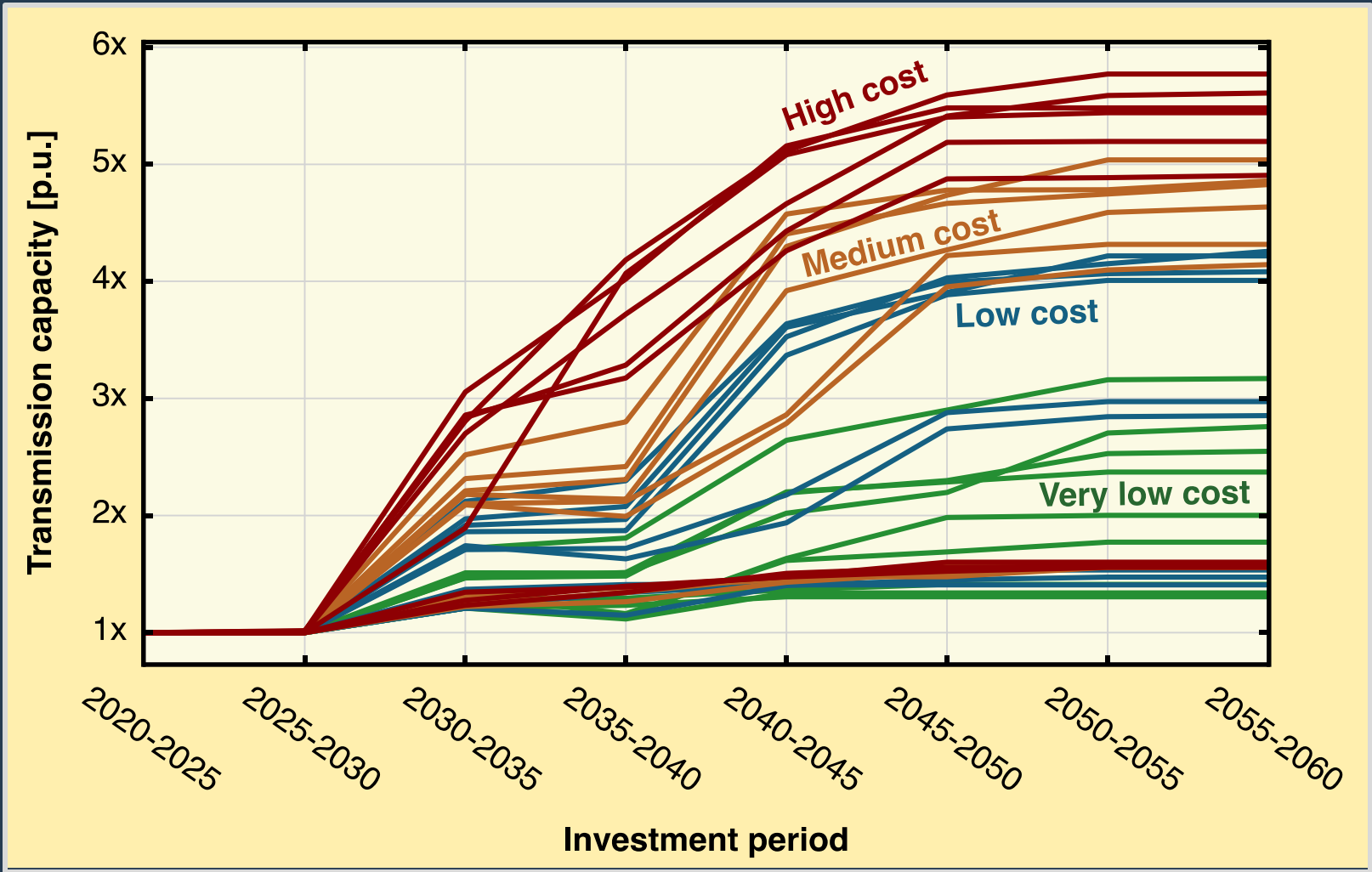
Hjelmeland, M., Nøland, J. K., Backe, S., & Korpås, M. (2024). "*The role of nuclear energy and baseload demand in capacity expansion planning for low-carbon power systems.*" Accepted for publication in Applied Energy.

Overordnede resultater

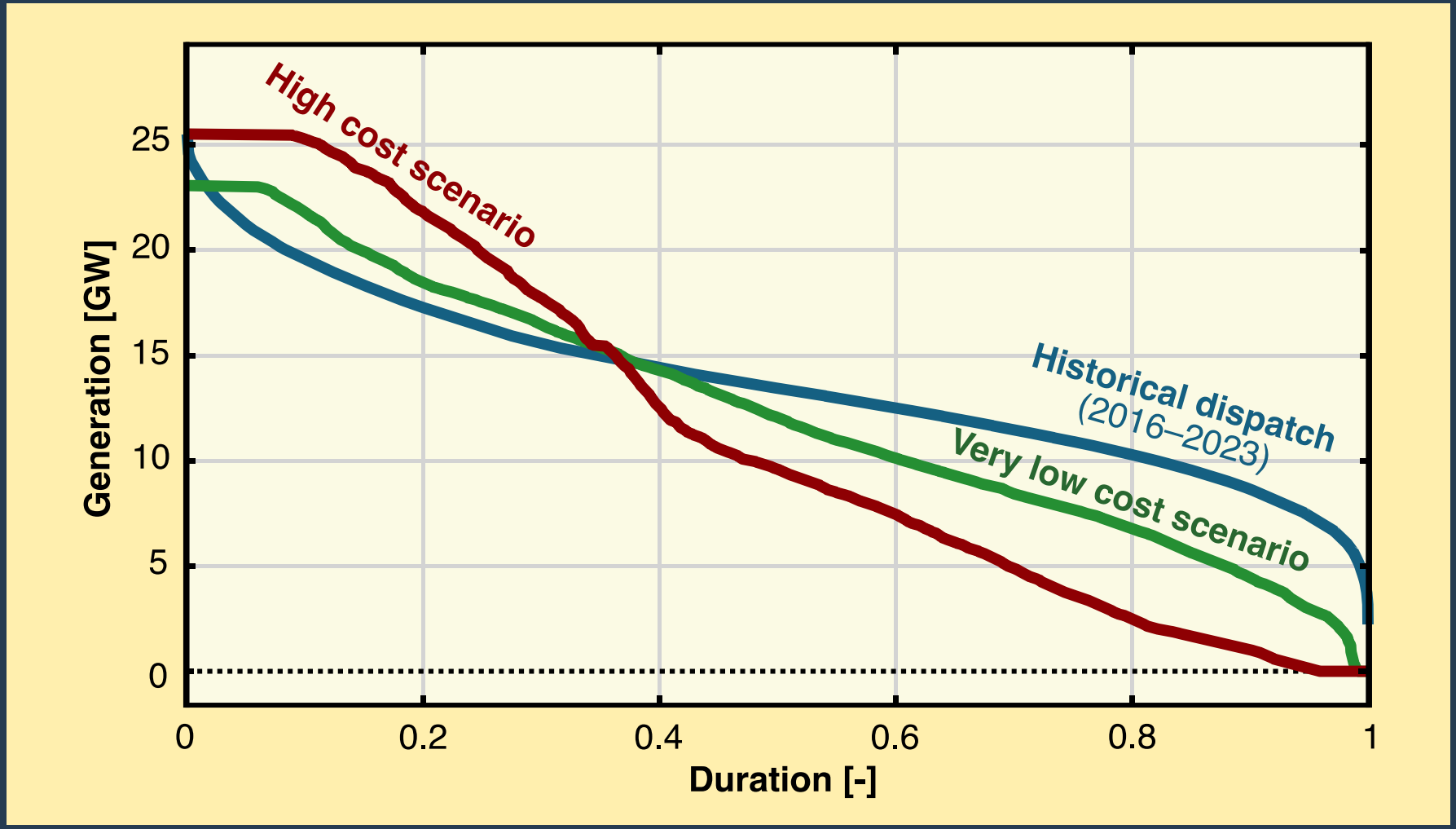
Nuclear OCC [€/kW]	System Cost [€/MWh]	Land Use [10^3 km^2]	Bio [%]	Gen. [TW]	VRE [%]	Nuclear [%]	Curtail. [TWh]	Grid [GW]	Storage [GW]	Storage [TWh]
3200 (Very low)	38.2	134.1	8.3	2.6	53.4	24.6	77.3	392.0	87.8	2.6
4200 (Low)	40.6	204.4	20.9	3.1	60.9	17.0	130.0	441.7	107.6	2.7
5300 (Medium)	42.5	283.7	33.3	3.4	66.5	11.9	200.1	488.5	146.2	2.8
6900 (High)	44.3	404.9	47.0	3.9	72.0	7.3	334.5	515.3	223.9	2.9

Hjelmeland, M., Nøland, J. K., Backe, S., & Korpås, M. (2024). "*The role of nuclear energy and baseload demand in capacity expansion planning for low-carbon power systems.*" Accepted for publication in Applied Energy.

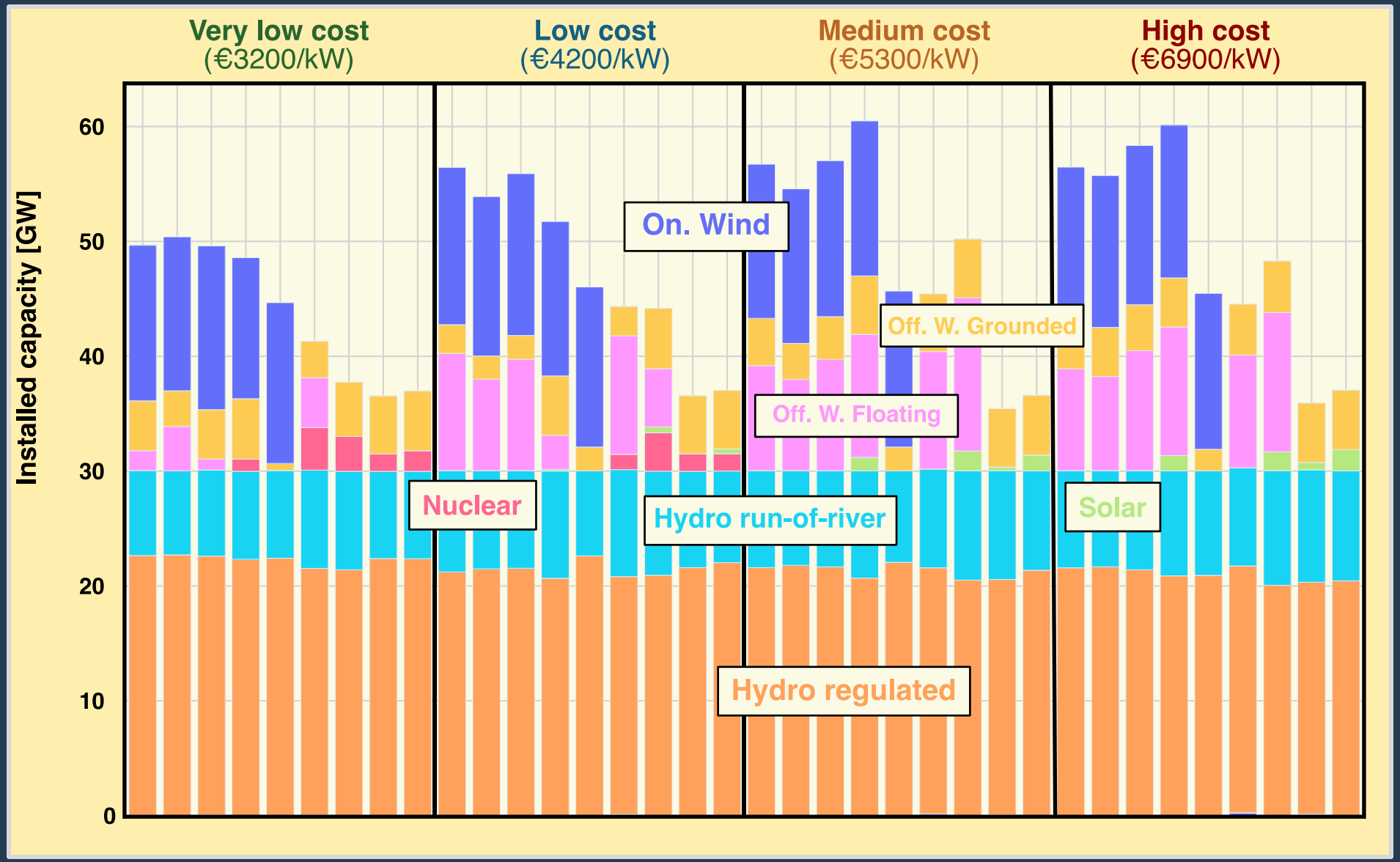
Dyr kjernekraft gir økt utvekslingskapasitet for Norge



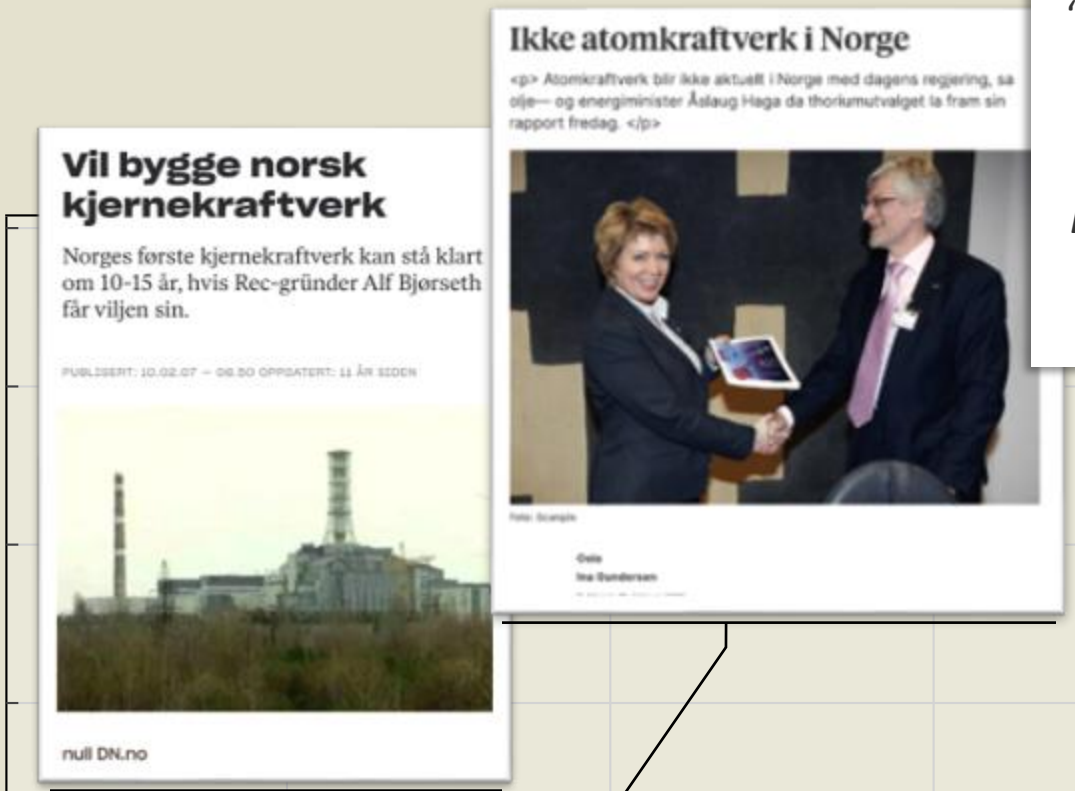
Lav andel kjernekraft krever mer fleksibel vannkraft



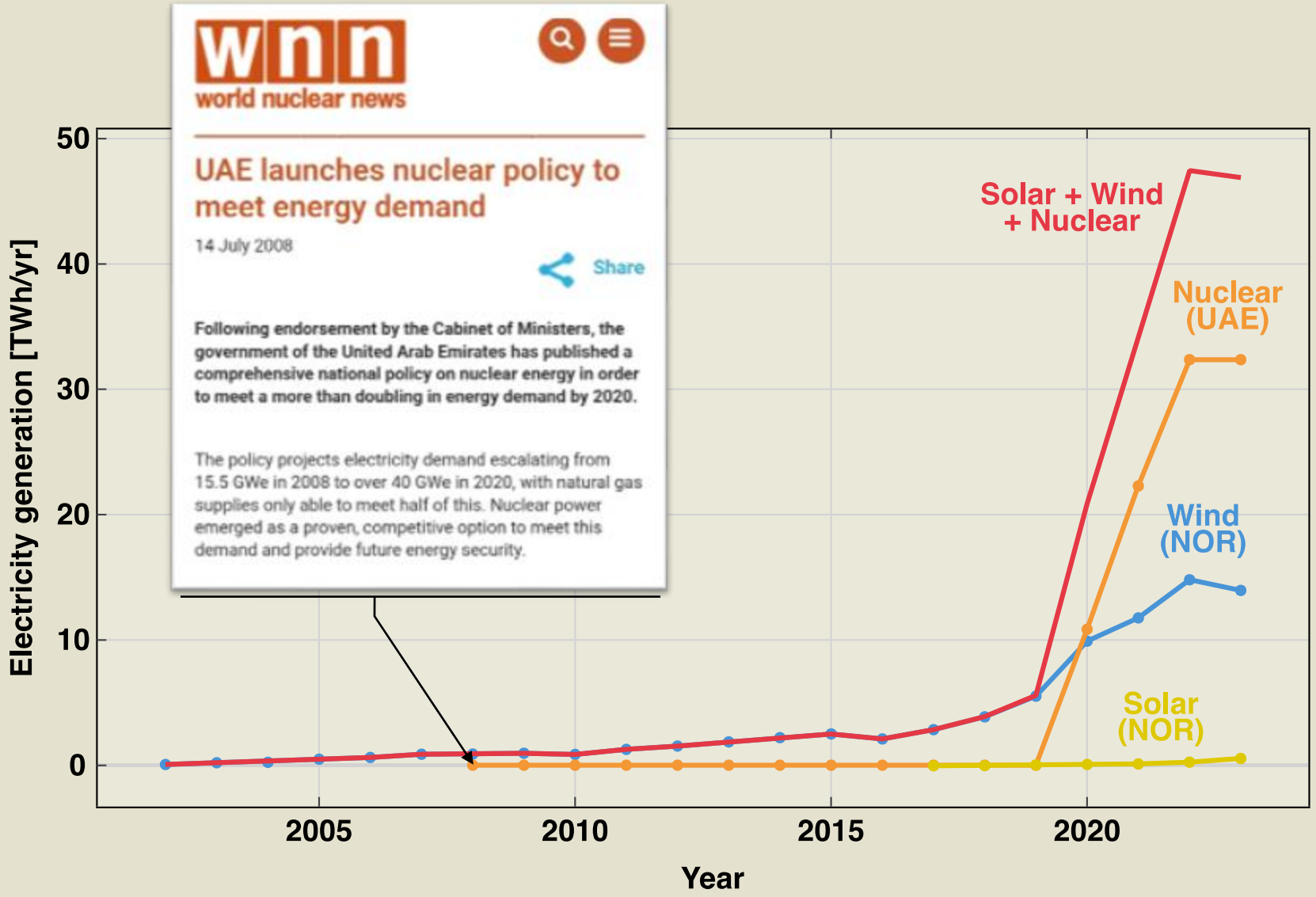
Norsk energimiks 2055-2060 for ulike scenarioer



"Det er ingen planer om å tillate bygging av kjernekraft i Norge. Regjeringen vil prioritere utbygging av fornybar energi. Dette ligger nærmere i tid, og vi trenger å handle raskt."
-Åslaug Haga, 2008



Source: Energifaktanorge.no, nve.no, world-nuclear.org



Source: Energifaktanorge.no, nve.no, world-nuclear.org

Veien gjennom det grønne skiftet går via kortsiktige og langsiktige løsninger!

Are oil & gas companies looking into nuclear?

From oil and gas to nuclear?

Monday, 26th of August, 19:00-20:00

Vågen Stavanger, ONS+ Energy Square tent

Moderator

Martin Hjelmeland
Postdoc - NTNU

Doug Sandridge
SVP – Fulcrum Energy Capital Funds

Nathan Snoke
New Energies Global Account Manager – Halliburton

Øystein Stjern
Deputy CEO – IKM Group AS

Mark Hinaman
Principal – Fire2Fission

Scott Livingston
President, Energy Products and Services – NOV Inc.

Several oil & gas companies are exploring nuclear options

Company	Scope
HALLIBURTON	Drilling technology
NOV	Project development
Baker Hughes	Supplier of parts
worley DELIVERING SUSTAINABLE CHANGE	Floating concept

Combining two mature and successful technologies

NUCLEAR TECHNOLOGY · VOLUME 194 · 1–14 · APRIL 2016

ANS

The Offshore Floating Nuclear Plant Concept

J. Buongiorno,* J. Jurewicz, M. Golay, and N. Todreas

Massachusetts Institute of Technology, Nuclear Science and Engineering Department, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139

Received April 24, 2015
Accepted for Publication August 28, 2015
http://dx.doi.org/10.13182/NT15-49

Abstract — *A new offshore floating nuclear plant (OFNP) concept with high potential for attractive economics and an unprecedented level of safety is presented. OFNP creatively combines state-of-the-art light water reactors and floating platforms similar to those used in offshore oil/gas operations. A reliable and cost-effective global supply chain exists for both technologies; therefore, robust expansion in the use of nuclear energy becomes possible on a timescale consistent with combating climate change in the near future. OFNP is a plant that can be entirely built within a floating platform in a shipyard; transferred to the site, where it is anchored within 12 nautical miles (22 km) off the coast in relatively deep water (≥100 m); and connected to the grid via submarine transmission cables. OFNP eliminates earthquakes and tsunamis as accident precursors; its ocean-based passive safety systems eliminate the loss of ultimate heat sink accident by design. The OFNP crews operate in monthly or semimonthly shifts with onboard living quarters, like on oil/gas platforms. OFNP is a reactor for the global market: It can be constructed in one country and exported internationally; it lends itself to a flexible and mobile electricity generation approach, which minimizes the need for indigenous nuclear infrastructure in the host country; and it does not commit the customer to a 40- to 60-year-long project.*

Keywords — *Offshore platforms, marine nuclear reactor, mobile plant.*

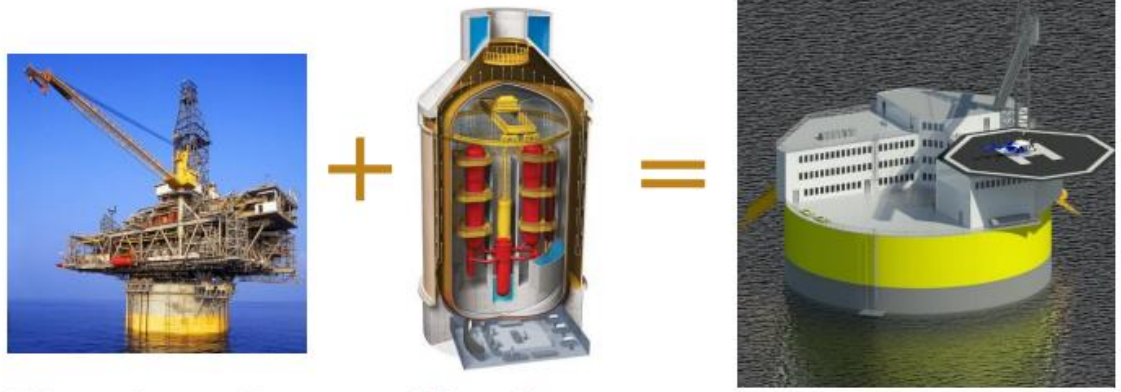
Note — *Some figures may be in color only in the electronic version.*

I. INTRODUCTION

With 73 reactors under construction worldwide, the nuclear industry is currently experiencing moderate growth. However, a more robust expansion is needed if nuclear is to play a significant role in combating climate change. The Electric Power Research Institute has estimated that 150 to 200 nuclear plants, each generating 1000 MW (electric), would generate enough electricity to enable conversion of the whole fleet of passenger cars and light trucks in the United States to plug-in hybrids, thus effectively ridding the United States of its dependence on oil and drastically reducing the emissions of greenhouse gases into the atmosphere. Nuclear heat can also be used to convert biomass to biofuel: If all liquid fuel used for transportation in the United States came from biomass (e.g., corn, potato waste), the energy required from nuclear plants (in the form of low-temperature steam) would be ~260 GW(thermal) (Ref. 1). The above figures are ambitious but not unrealistic since the current U.S. nuclear fleet comprises 99 reactors [~100 GW(electric) or ~300 GW(thermal)] that were built in a period of only 20 years. However, several challenges exist, the most important of which are the following:

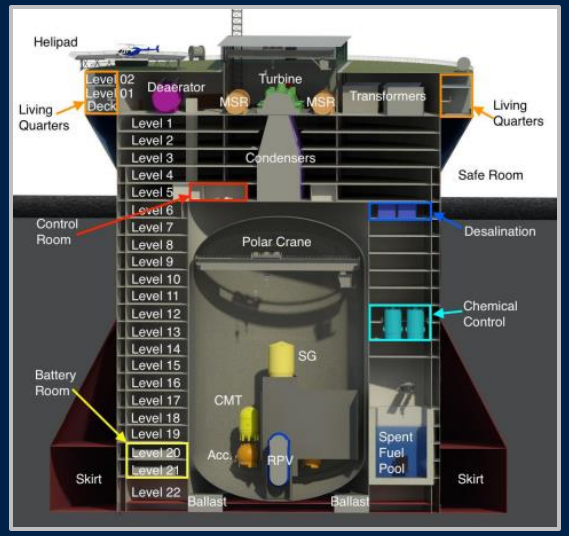
1. *Capital cost:* The capital cost of nuclear plants is high because of their many high-pressure components and heavy structures, which result in large amounts of concrete, steel, and wiring used in the construction of the plant. Current Gen3+ plants require an upfront capital investment of $3 billion to $4 billion per 1000 MW (electric) of installed capacity and take 5 to 7 years to build. Such long lead times also result in high interest payments during construction, which adds 30% to 40% to

*E-mail: jacopo@mit.edu



Key characteristics

- Shippyard construction
- Unlimited passive cooling
- Eliminiates earthquakes and tsunami accidents
  - Moored 10-20 km offshore



Source:(Buongiorno, J., et al. "The offshore floating nuclear plant concept." Nuclear Technology 194.1 (2016): 1-14.), (IAEA webinar on marine based SMRS)

Kjernekraft består hovedsaklig av spesialisert kompetanse?

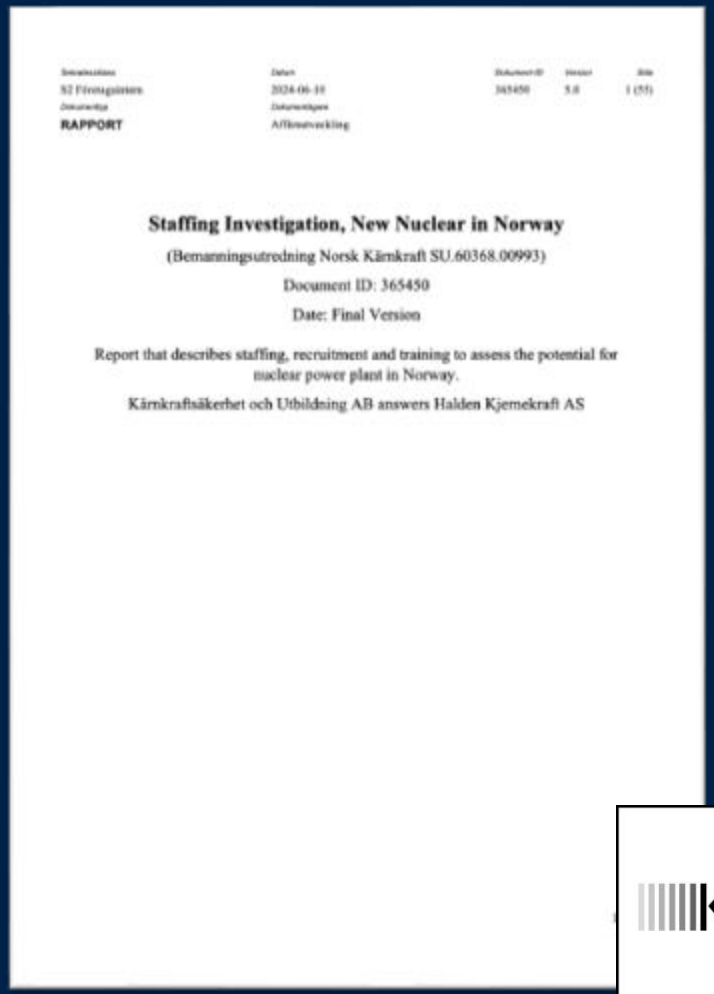
"Kjernekraft består av 90% konvensjonell kompetanse."

-Jan Blomgren, professor i kjernefysikk og tidligere "Senior Expert Nuclear Education" i Vattenfall

Svensk studie på kompetansebehov for kjernekraft i Norge

Stillinger	årsverk*	% av total
Nuclear Safety Review, Nuclear Fuels, Reactor Engineering, ALARA, Decon/Radwaste, Radiation Protection	**38**	**9%**
Management, Operations, Scheduling, Materials, Computer Engineering, Procurement Engineering, Project Management, Fire Protection, Communications, HR, etc.	**366**	**91%**

"Knowledge, skills and experience from working in process industry will definitely be a good ground for the work at NPPs. [..] Norway [..] and several other countries today are exploring the possibilities of reschooling personnel from other industries. Norwegian oil and gas rig workers have today very applicable knowledge."



RAPPORT

2024-06-10

Staffing Investigation, New Nuclear in Norway

(Bemanningsutredning Norsk Kärnkraft SU.60368.00993)

Document ID: 365450

Date: Final Version

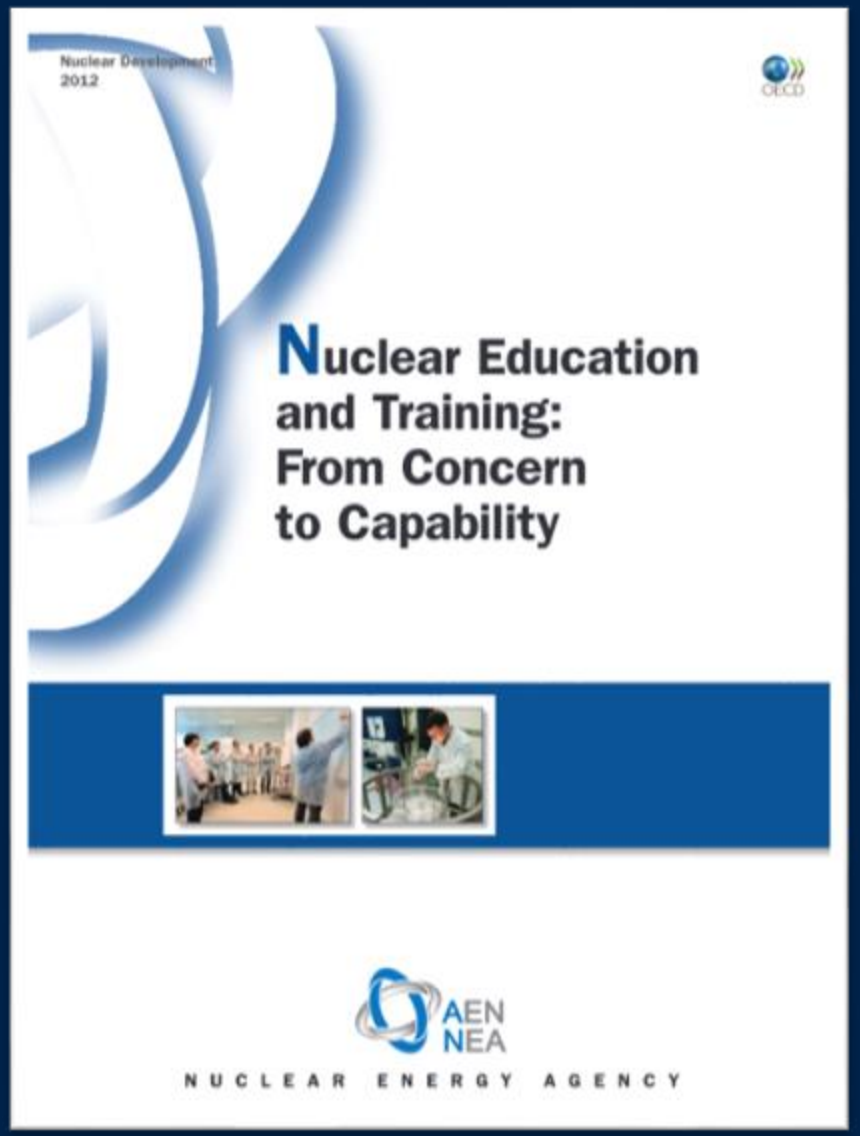
Report that describes staffing, recruitment and training to assess the potential for nuclear power plant in Norway.

Kärnkraftsäkerhet och Utbildning AB answers Halden Kjernekraft AS

Kärnkraftsäkerhet og Utbilding AB

***For kraftverk med 4 SMRer**

Source:(KSU (2024), "Staffing Investigation, New Nuclear in Norway")


Nuclear Development
2012
Nuclear Education and Training: From Concern to Capability
AEN NEA
NUCLEAR ENERGY AGENCY

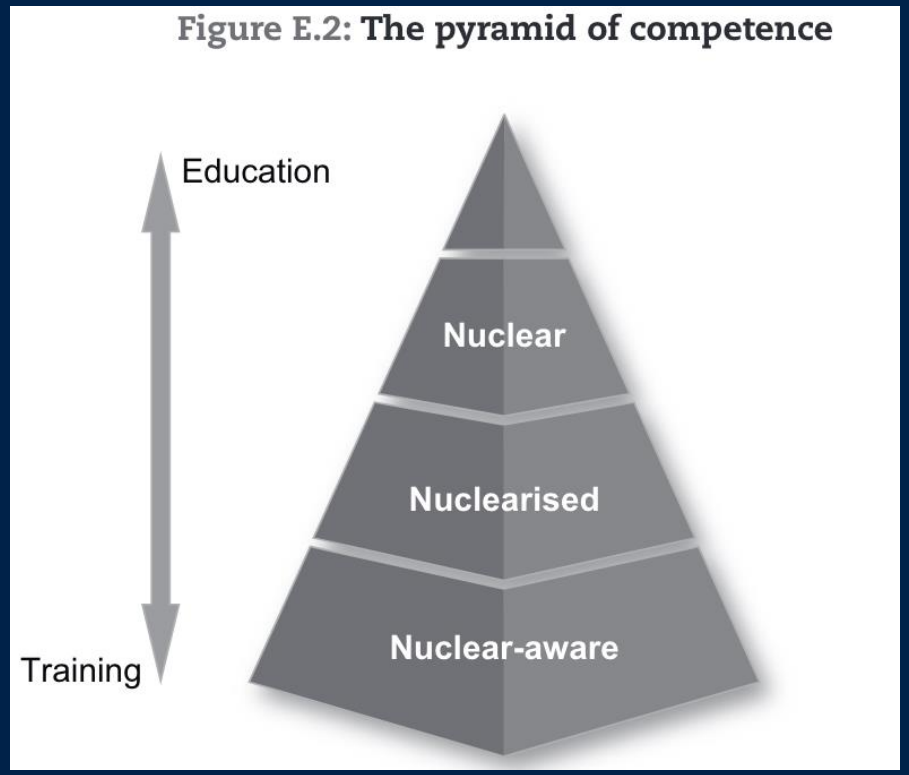
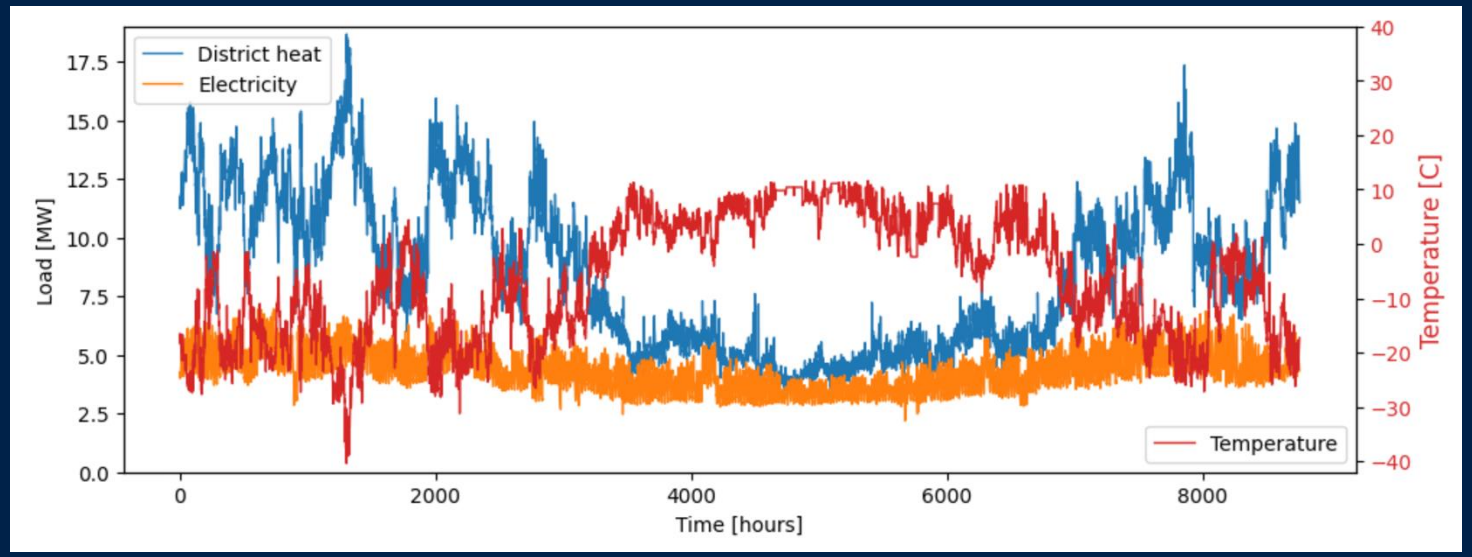


Figure E.2: The pyramid of competence
Education
Training
Nuclear
Nuclearised
Nuclear-aware

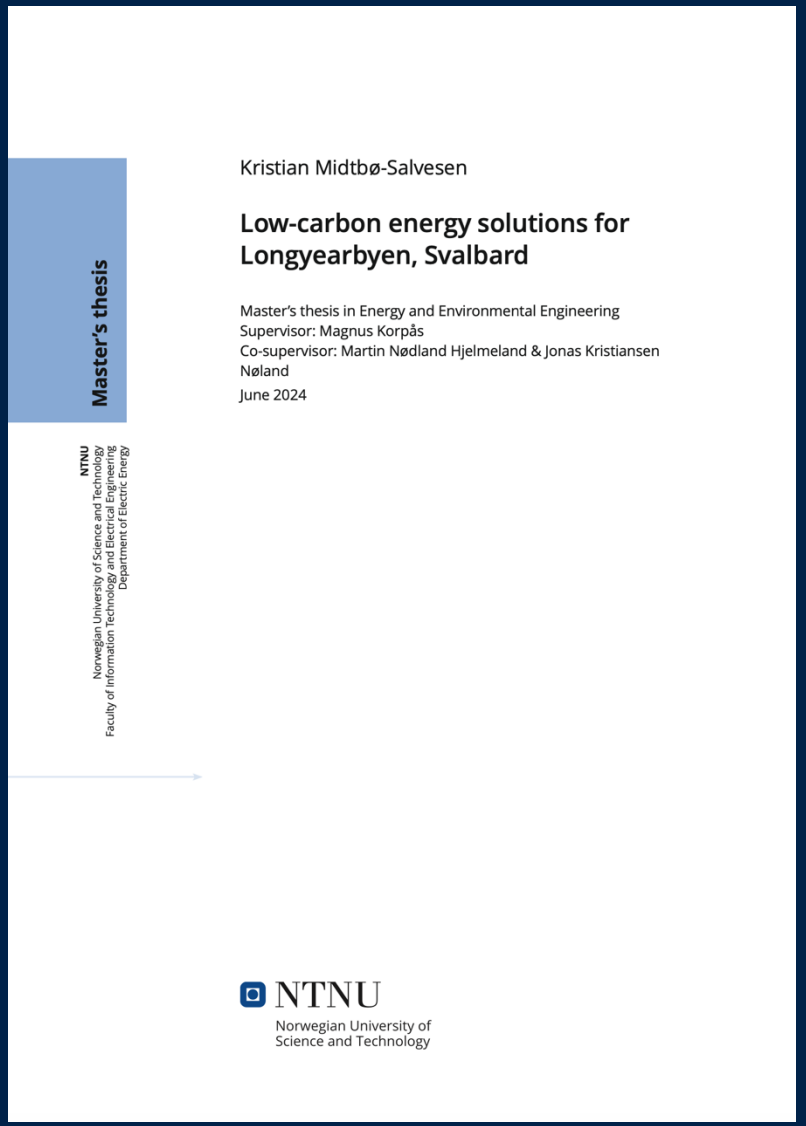
Svalbard, et mulig case for kjernekraft i Norge

Lite energisystem avhengig av kraft og varme



Longyearbyen Energiverk
12 MW elektrisk
16 MW fjernvarme

Reservekraft
3x 6 MW diselgeneratorer


Master's thesis

Kristian Midtbø-Salvesen

Low-carbon energy solutions for Longyearbyen, Svalbard

Master's thesis in Energy and Environmental Engineering
Supervisor: Magnus Korpås
Co-supervisor: Martin Nødland Hjelmeland & Jonas Kristiansen Nøland
June 2024

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Electric Energy

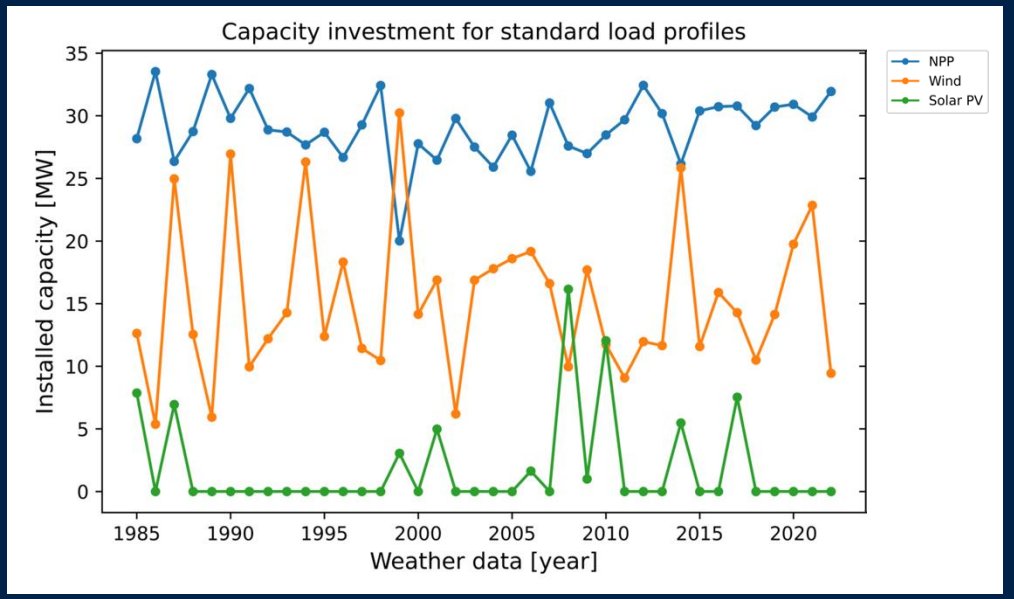
NTNU
Norwegian University of Science and Technology

Svalbard, et mulig case for kjernekraft i Norge

Potensielle leverandører av mikroreaktorer

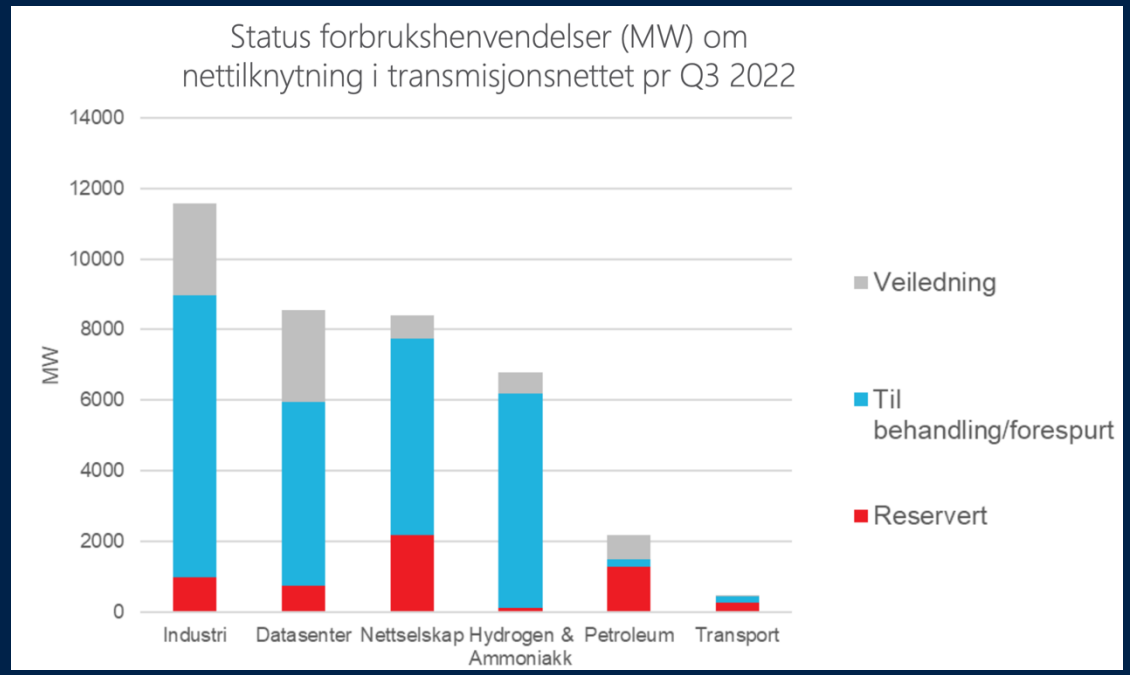
Reactor name	Vendor	Type	Capacity $[MW_e]$	Capacity $[MW_{th}]$	Plant footprint $[m^2]$	Source
eVinci	Westinghouse	Heat pipe	5	13	<8 000	[77][78]
Aurora power house	Oklo	LMFR	15 - 50	4 - 150	<4 000	[77][79]
MMR	USNC	HTGR	3.5 - 15	10 - 45	~ 8 000	[77][80]
HOLOS-QUAD	HolosGen	HTGR	3 - 13	5.5 - 22	30	[77][81]
BANR	BWXT	HTGR	-	50	100	[77][82]
MoveluX	Toshiba	Heat pipe	3 - 4	10	100	[77][83]

Investeringsbeslutninger for ulike værår



PyPSA

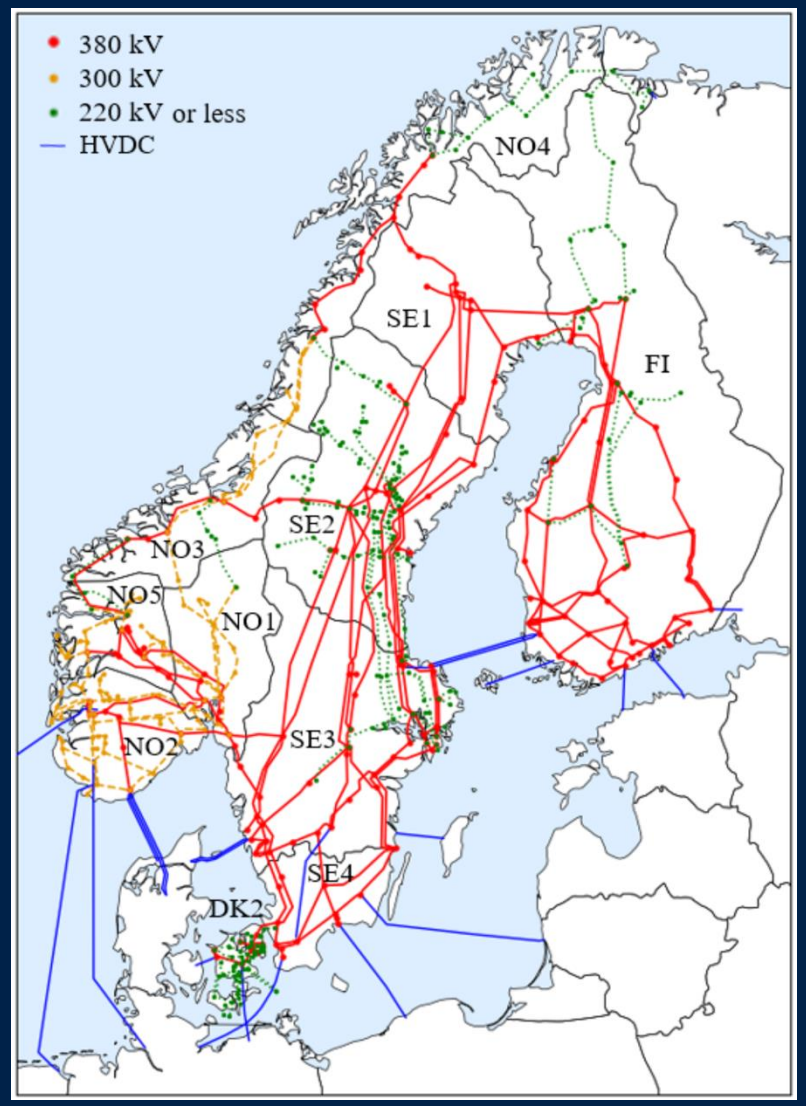
Statnett har ordreboken full av søknader for nytt forbruk

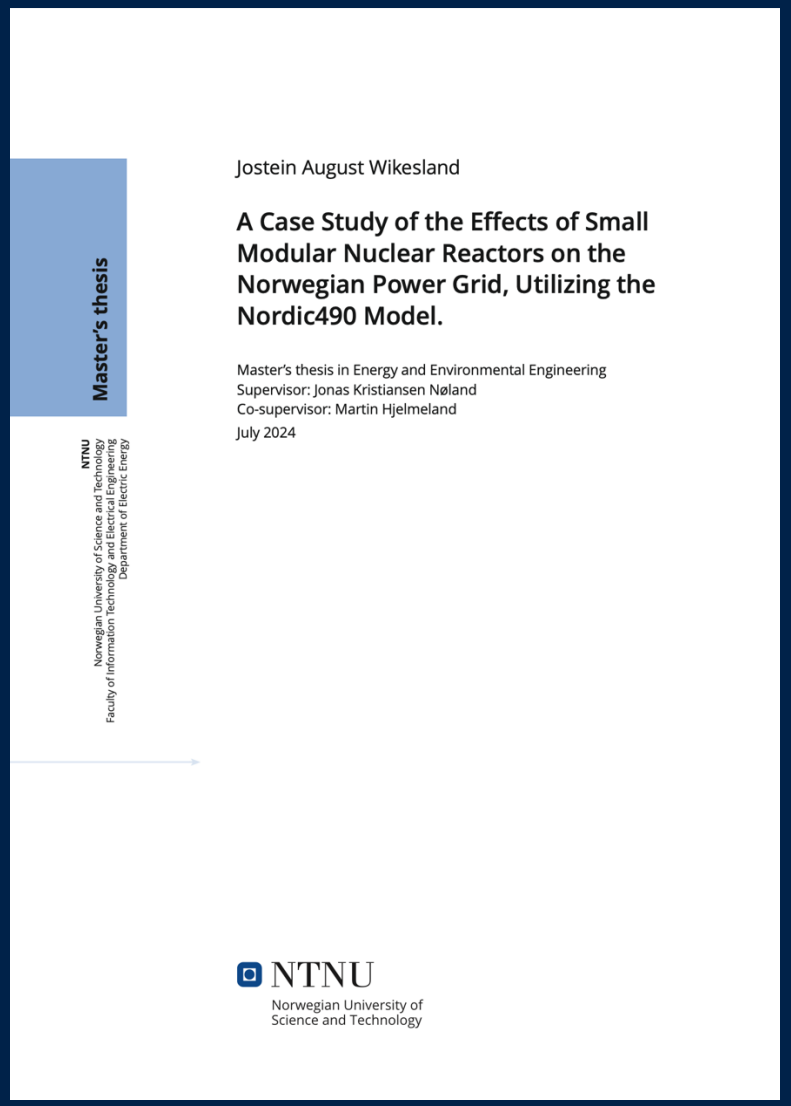


"Samlokalisering er viktig for god utnyttelse av nettet og for å få rask forbruksetablering
Det tar lang tid å planlegge og bygge nytt nett. Lokalisering av forbruket er sentralt for nettutviklingen, og store avstander kan gi behov for omfattende nettiltak. Statnett tilstreber en aktiv planrolle ved å veilede aktører slik at nettet blir utnyttet best mulig. Omstilling og elektrifisering av dagens forbruk er stedbundet, mens en del av det nye forbruket kan i større grad flyttes til steder med eksempelvis bedre tilgang på kraft. Statnett er opptatt av at det fleksible forbruket kommer på gunstige steder i nettet for å muliggjøre en raskere forbruksøkning. Mye av forbruket vi veileder ønsker å komme på etablerte industriplasser med øvrig god infrastruktur. Det er også viktig med en rimelig regional balanse mellom forbruk og produksjon. Vi ser derfor nytt forbruk og ny produksjon i geografisk sammenheng. Dette kan dermed også være med på å løse noe av transport- og nettbehovet."

Source:(Statnett (2022), "Forbruksutvikling I Norge 2022-2050")

Hvordan lokalisere kjernekraft for å avlaste nettproblematikk?




Master's thesis

Jostein August Wikesland

A Case Study of the Effects of Small Modular Nuclear Reactors on the Norwegian Power Grid, Utilizing the Nordic490 Model.

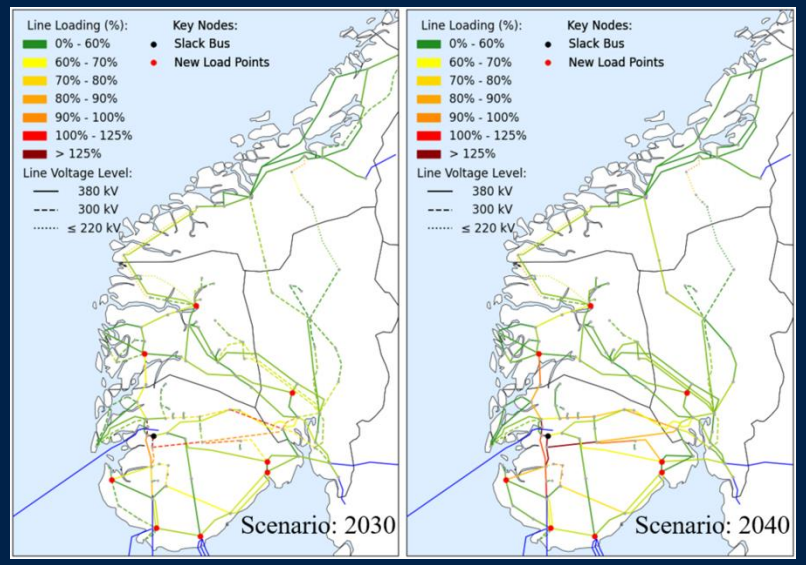
Master's thesis in Energy and Environmental Engineering
Supervisor: Jonas Kristiansen Nøland
Co-supervisor: Martin Hjelmeland
July 2024

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Electric Energy

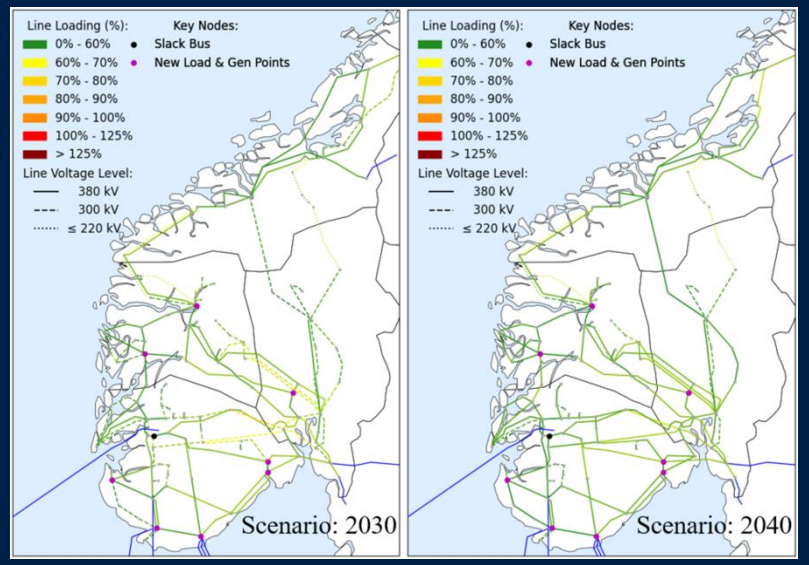
NTNU
Norwegian University of Science and Technology

Hvordan lokalisere kjernekraft for å avlaste nettproblematikk?

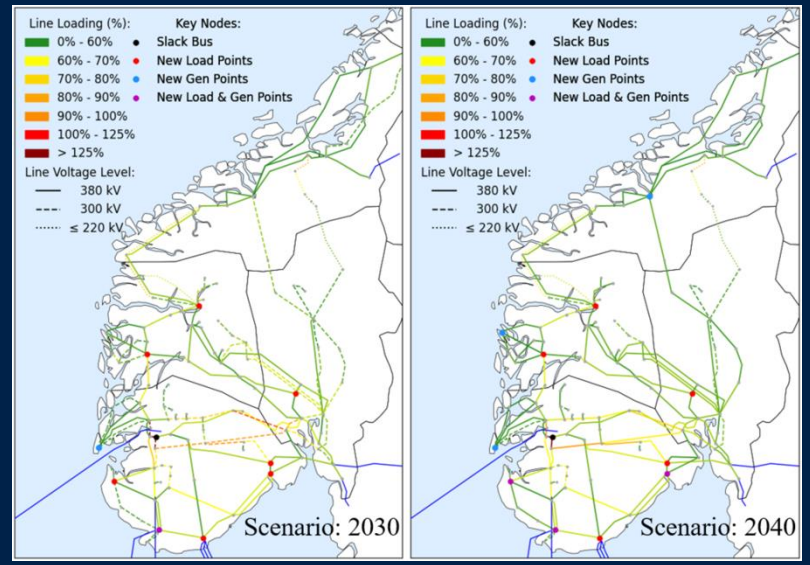
Benchmark (ingen ny kraftproduksjon)



Distribuert SMR (2x 300 MW)



Havvind (SN II & UN)



Hvordan lokalisere kjernekraft for å avlaste nettproblematikk?

Sammenliging mellom ulike case

Case	Overloaded Lines	Upgrade Costs	Critical Voltage
Load Benchmark:	(Amount of lines)	(million EUR)	(Amount of busses)
2030 Scenario	11	837	1
2040 Scenario	17	864	5
SMR Co-Location:			
2030 Scenario	-	-	-
2040 Scenario	-	-	-
SMR Cluster - Flesaker:			
2030 Scenario	6	222	-
2040 Scenario	6	172	-
SMR Cluster - Oslo:			
2030 Scenario	2	-	2
2040 Scenario	6	235	-
SMR Cluster - Sylling:			
2030 Scenario	3	105	-
2040 Scenario	6	184	-
Offshore Wind:			
2030 Scenario	9	710	-
2040 Scenario	5	212	-
Power Import:			
2030 Scenario	4	234	3
2040 Scenario	1	121	-

The shipping industry needs nuclear

300 mill tonnes Heavy Fuel Oil consumed per year

Green fuels will require 2.7 times EU power production

Then add:

- Aviation
- Large trucks
- Industrial heat
- The “four pillars of society”
    - Cement, steel, ammonia, plastics

Ulstein Thor concept

Source:(Ulstein.com, ”Is Thor’s superpower shipping’s silver bullet?”), (Prof. Jan Emblemsvåg, ”NuProShip I Status”)

Shippingnæring er på ballen

Kystens Næringsliv

Energi

Vard engasjerer seg i prosjekt for å utrede kjernekraft som energibærer for fremtidens skip

– Dette er noe vi har stor tro på litt på sikt. Da må vi komme tidlig på banen og være med i utviklingen samtidig som vi jobber med andre grønne energibærere.

Vard Group vil posisjonere seg for kjernekraft på skip. (Foto: Kristin Støylen/Vard Group)

Stig Erik Elliott
Bergen

Publisert 30. november 2022, kl. 05.31

Knutsen OAS Shipping

Norges Rederiforbund
Norwegian Shipowners' Association

VARD a Fincantieri company

DNV

Sjøfartsdirektoratet
Norwegian Maritime Authority

Wilhelmsen Ships Service

IDOM

ISLAND OFFSHORE

Wallenius Wilhelmsen

SinOceanic SHIPPING

OSM Thome

Cefor

Gallagher

ESCOLA SUPERIOR NÁUTICA INFANTE D. HENRIQUE

En ny tidsalder for kjernekraft?

1992

"*It's absurd that a rock group like us has to get involved to bring the facts out. BNFL says they stopped the public demonstration in the interests of public safety, which is a joke given* ***the danger public safety is under by installing a second nuclear reprocessing plant****.*"- Bono

2023

"*But now all the fear and dread in the atom and using it as a weapon of mass destruction, there may be clues for how we get out of the climate crisis. Fusion rather than Fission. Fission which is regular nuclear energy is getting safer and smarter and* ***we've campaigned against nuclear energy, but we have kind of turned around a little bit on that one****. So the lyric "atomic Sun for everyone" is that reference.*" - Bono

Tusen takk!