Framtidens energisystem i Norge og Europa

og

FoU-utfordringer det byr på

Forskningsleder Michael M. Belsnes

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Balansekraft, mye mer enn bare energi!

Storskala mot
småskala løsninger

Rettferdig fordeling
av kostnad og
inntekt

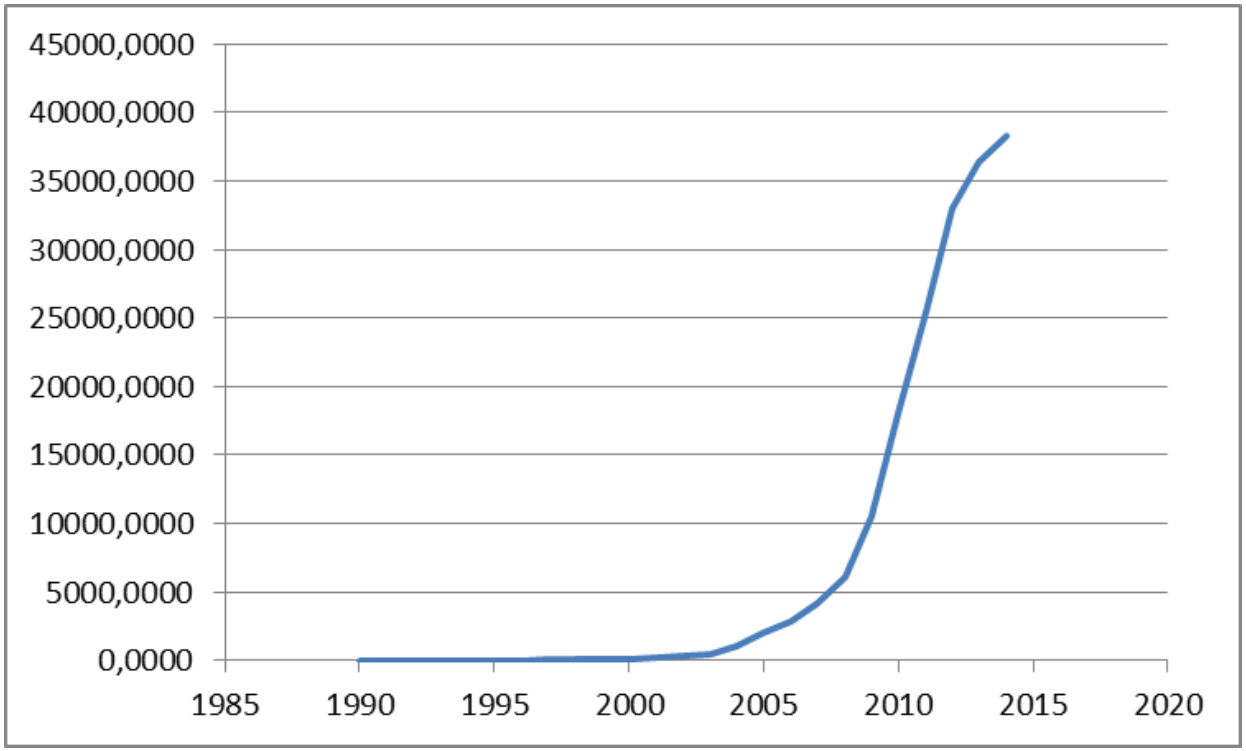
Vannkraft mot andre
tekniske løsninger

Vassdrag mot vassdrag

Lokale mot
globale
miljøvirkninger

Lokal forsyningssikkerhet
mot systemsikkerhet

Solkraft i Tyskland MW(tid)



Tyskland 2014

Fornybar: 87,5 GW

Termisk: 89,6 GW

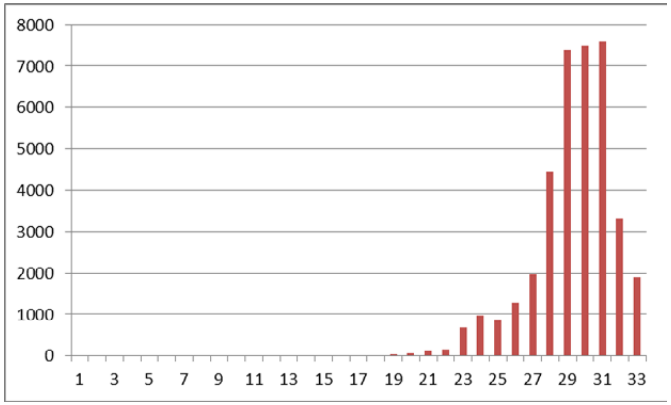
Fornybar: 156,6 TWh

Termisk: 238,9 TWh

Eksport ~34 TWh

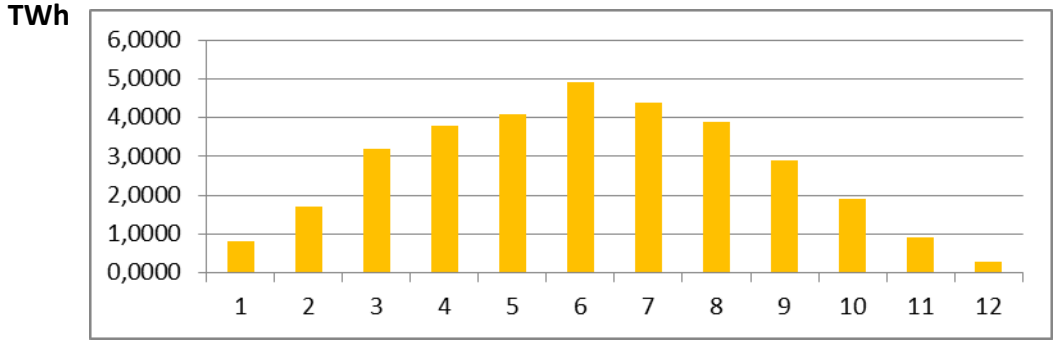
inklusiv atomkraft

Δ Solkraft MW/år

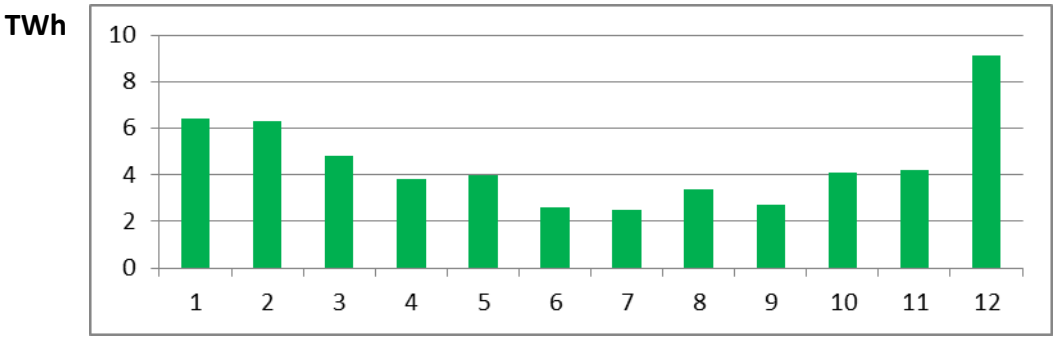


Source: Federal Ministry for Economic Affairs and Energy, for capacity figures[29]:7 and other figures[29]:14–38

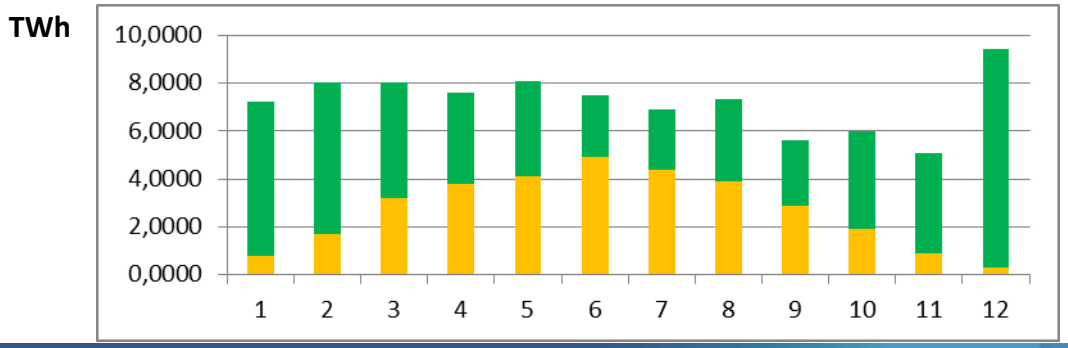
Samspill sol og vind i Tyskland 2014



Min. døgnproduksjon 0,022 TWh



Maks. døgnproduksjon 0,676 TWh

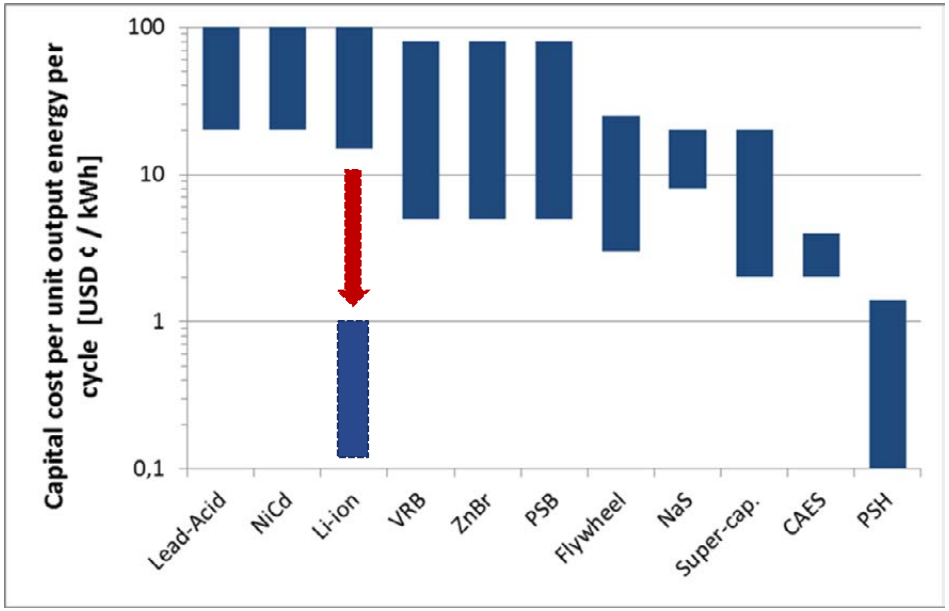


Forskjell snitt produksjon 27,3 GW/time

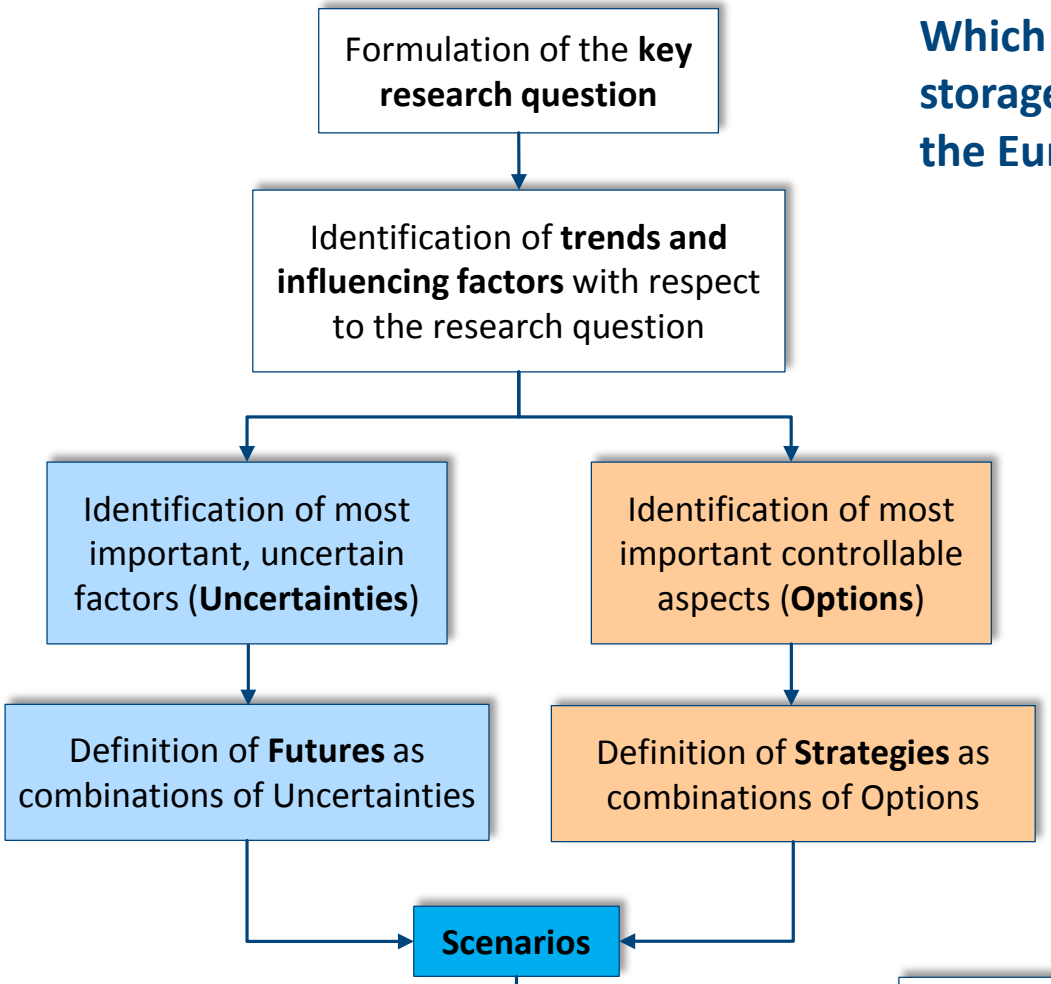
Kilde Stromerzeugun aus Solar – und Windenergi im Jahr 2014, Fraunhofer Prof. Dr. Bruno Burger

Game changers

- Over 10000 MW solselle og vindkraft økning per år i tyskland.
- Energy Consumers becoming energy Prosumers
  - Torsten Amelung, Statkraft Markets Germany
- "Less politics more markets"
  - Terje Gjengedal, Sogn og fjordene Energi



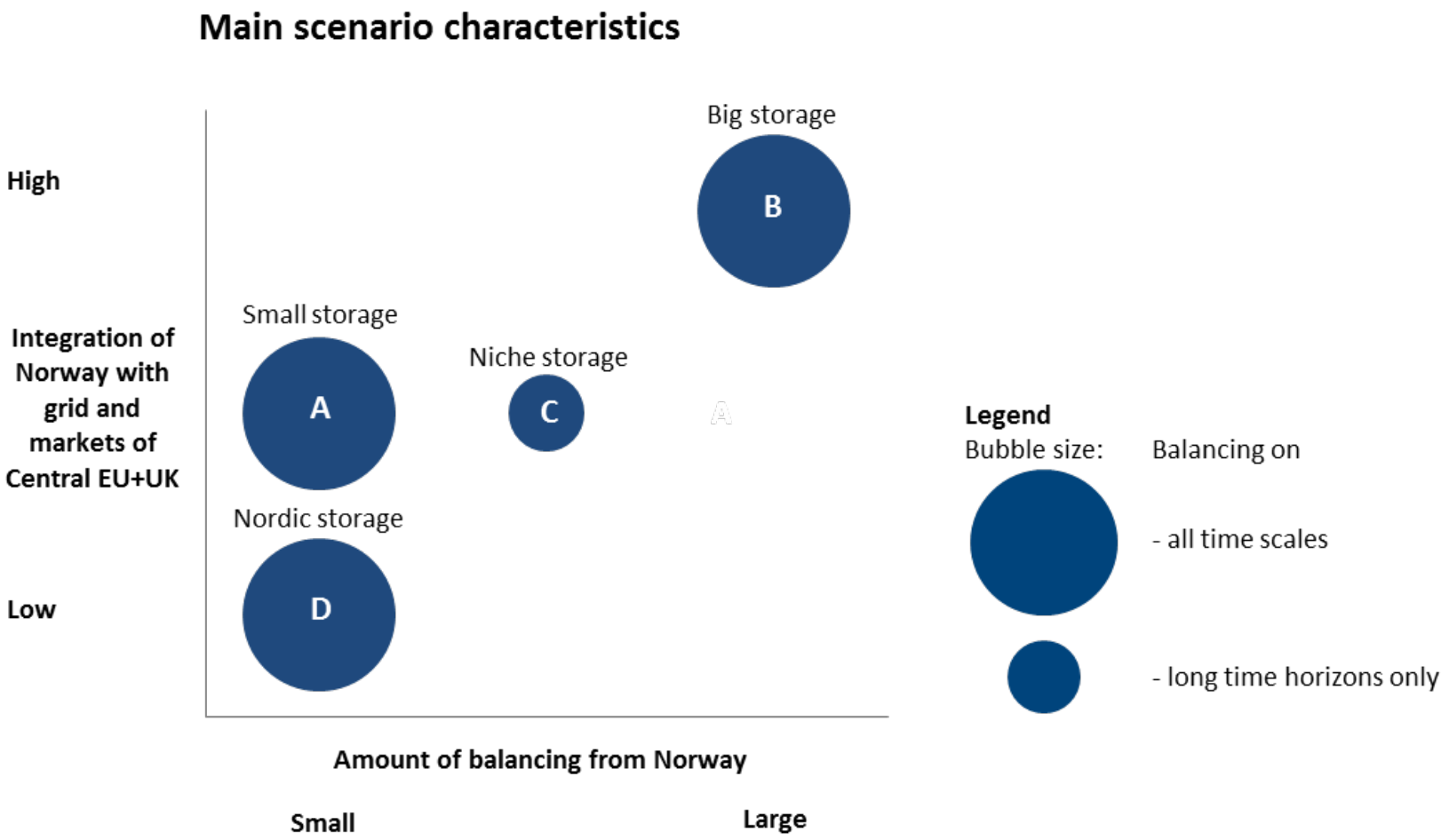
Scenario building approach



Which role can energy balancing and storage by Norwegian hydropower play in the European electricity market in 2050?

= Combination of *Options* which Norwegian decision makers have control on

Fire scenarioer med tre dimensjoner



Scenarios

Liten lager

- Middels integrasjon
- Lite volum
- Alle tidshorisonter

Stor lager

- Høy integrasjon
- Stort volum
- Alle tidshorisonter

Uncertainties in Future 1	**Medium Demand**	**Various flexibility**
Technology		
Variable RES share of electricity generation	Medium	High
Expansion of European transmission grid	Moderate	Strong
Deployment of CCS	Yes	No
Market		
Competition from alternative flexible technologies	Low	Low
EU regulatory framework and market integration	Fully integrated	Fully integrated
Policy		
Ambitions of countries to connect to Norway	Moderate	Strong
Options in Strategy 2	**Moderate expansion**	**Active climate policy**
Expansion of Norwegian transmission grid	Moderate	Strong
New and upgrade of existing hydro plants	Moderate	Strong
Support of variable RES in Norway	Moderate	Strong
Ambitions of Norway to build interconnectors	Moderate	Strong

Scenarios

Nisjelager

- Middels integrasjon
- Middels volum
- Lange tidshorisonter

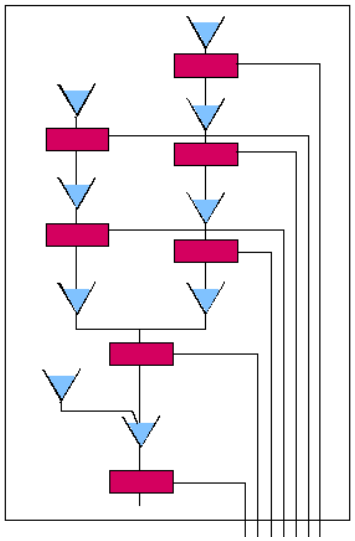
Nordisk lager

- Lite integrasjon
- Lite volum
- Alle tidshorisonter

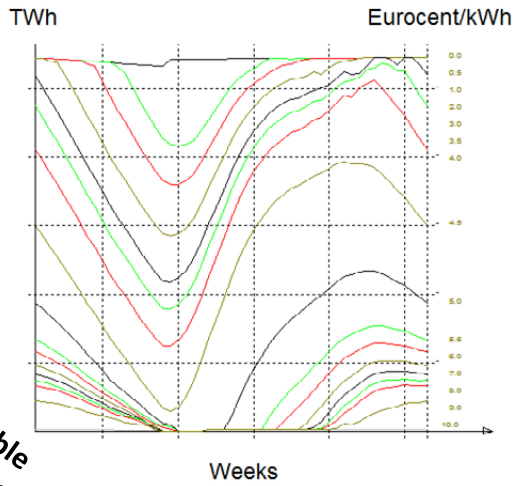
Uncertainties in Future 1	**Niche market**	**Critical supply**
Technology		
Variable RES share of electricity generation	High	High
Expansion of European transmission grid	Moderate	Limited
Deployment of CCS	No	No
Market		
Competition from alternative flexible technologies	High	Low
EU regulatory framework and market integration	Day-ahead only	Day-ahead only
Policy		
Ambitions of countries to connect to Norway	Moderate	Strong
Options in Strategy 2	**Value creation**	**Nordic only**
Expansion of Norwegian transmission grid	Strong	Strong
New and upgrade of existing hydro plants	Strong	Limited
Support of variable RES in Norway	Limited	Strong
Ambitions of Norway to build interconnectors	Strong	Weak

Omsette scenarier i konsistent system utvikling

Storage possibilities



Strategy by (SDP/SDDP)

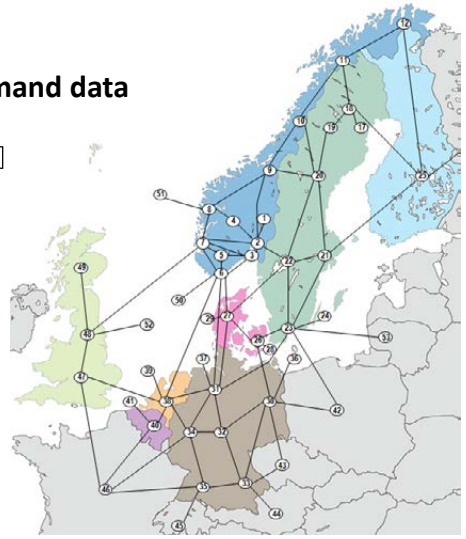


Feasible solution

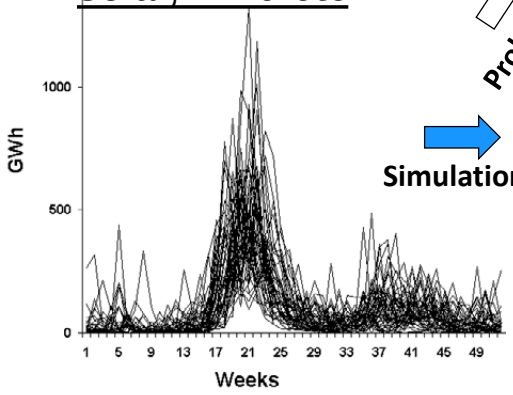
Vannverdi

Markets and prices

Supply/demand data



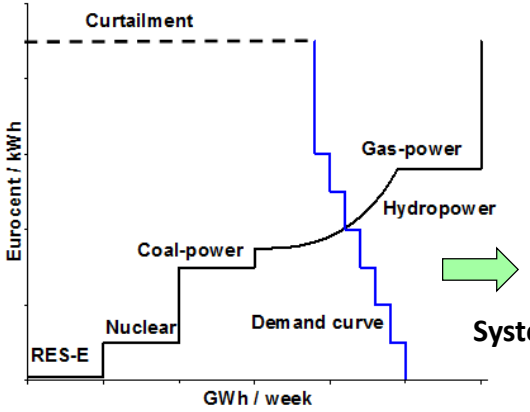
Stochastic, inflow solar, wind etc



Probability

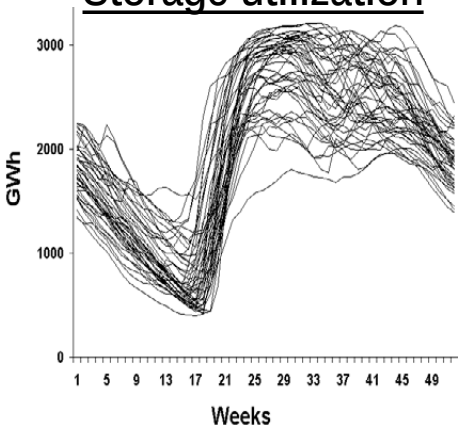
Simulation

Simulating markets (LP)

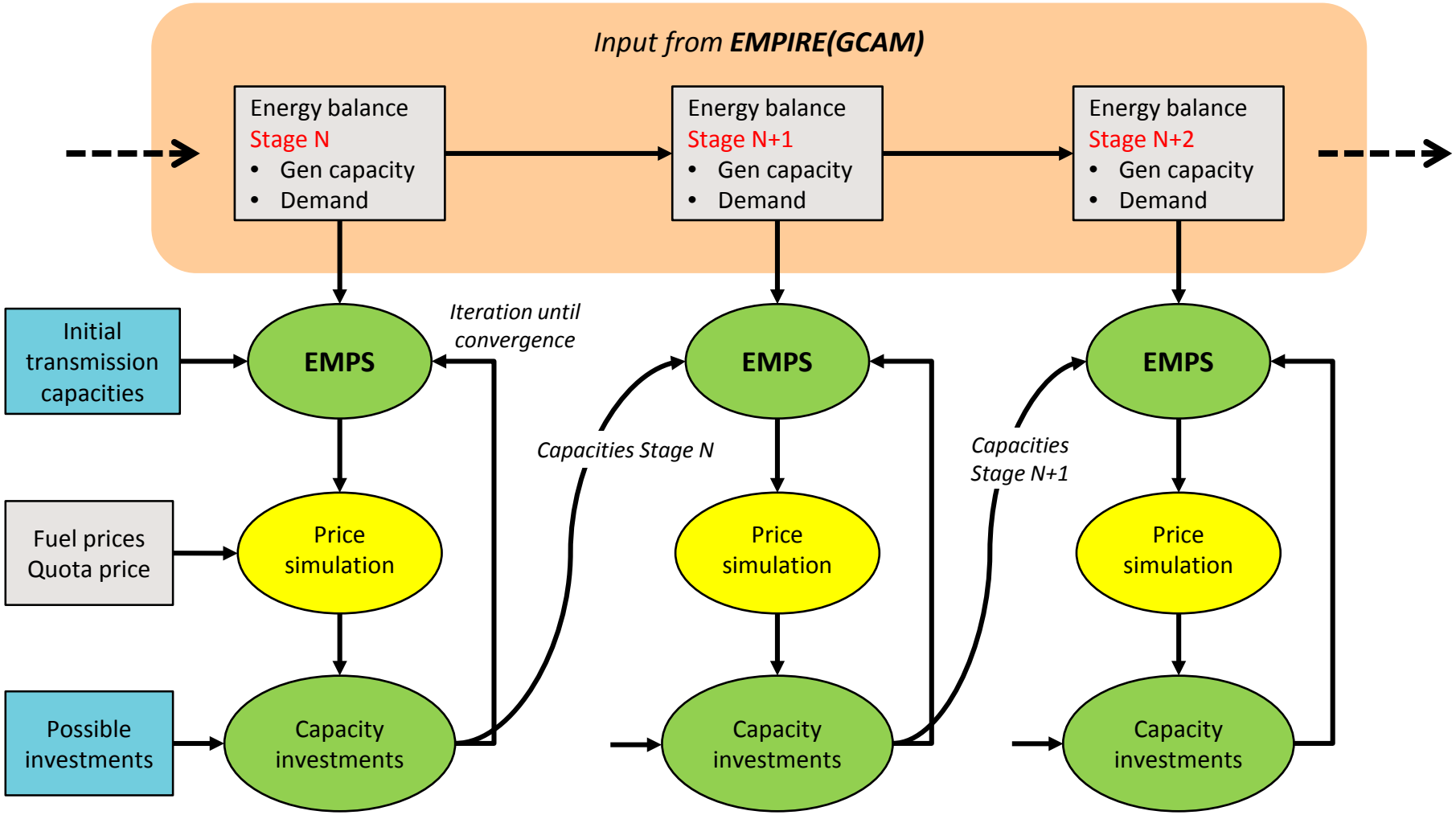


System operation

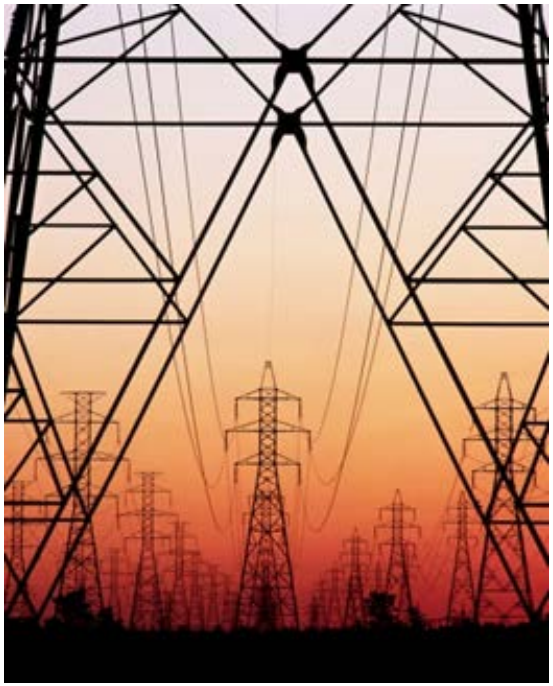
Storage utilization



Konsistent utvikling over tid, global modell med energisystem modell GCAM (EMPIRE)/EMPS



Kan ikke lengre forutsette at kraftnettet til enhver tid kan flytte nok energi



Omsette scenarier i miljøkonsekvenser

Vassdragsdrift
Produksjon
Magasin
Tilsig

ECO verktøy

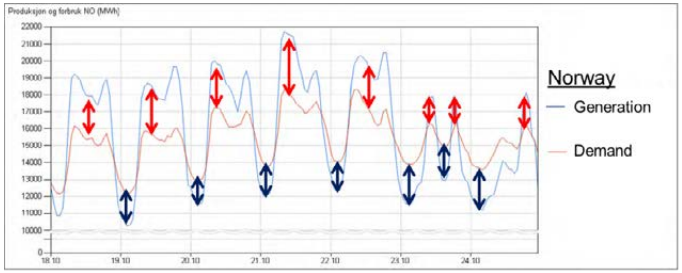
ECO konsekvenser

ECO tiltak

Reberegning av vassdragsdrift

Forskningsutfordringer (I)

- Verdiskaping:
  - Flere markeder med avhengighet på tvers
  - Krav til finere tidsoppløsning og flere detaljer
  - Samspill med nye teknologier
  - Flerbruk av vann



Source: Jan Hystad, Statnett

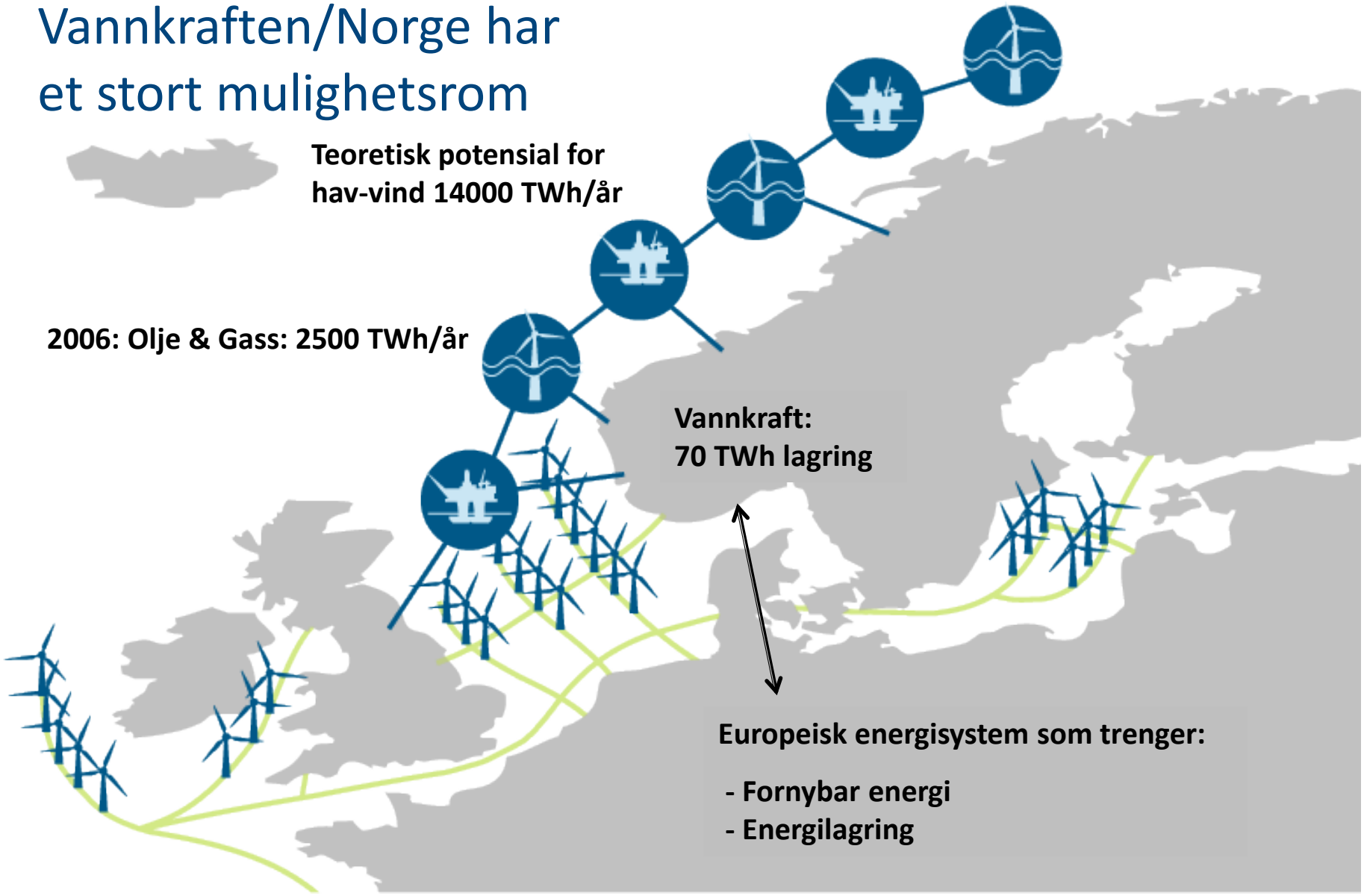
Export
Import

- Miljø:
  - Nye driftsmønster får konsekvenser vi ikke har sett før.
  - Internasjonal utbygging
  - Ikke monetære verdier
  - Tiltak for økt økologisk-verdi, miljødesign

Forskningsutfordringer (II)

- Teknologi
  - Fleksible vannkraftstasjoner som tåler regulering
  - Slitasje, levetid og vedlikehold
  - Optimale beslutninger ved investering
  - Sikkerhet og stabilitet
- Samfunn
  - Rammevilkår og politikk
  - Prosesser for endring
  - Samlet CO2 konsekvens
  - Akseptabel sosialisering av kostnader
  - Ressurssituasjon og samfunnsutvikling

Vannkraften/Norge har et stort mulighetsrom



CEDREN Centre for Environmental Design of Renewable Energy

CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH