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## Perspectives on next generation market models

Sintef Energy Research  
Energy systems



# Perspectives on ngLTM

- I. Background
- II. Proof-of-Concept ngLTM
- III. Long-term strategy





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# Market models are a result of a long-term commitment



## Market models for hydropower systems

SINTEF together with NTNU develops software tools for stakeholders in the Nordic power market / system.

The fundamental market models represent an important part in the chain for creating value from Norwegian renewable energy sources.

These decision support tools are applied for analyses, planning and dispatch, by various stakeholders.

- System operators, Regulators, Power producers, Consultants, Academia

Successful model development is made possible by continuous R&D based on a partnership of public authorities, the power sector and providing world-leading research environment during several decades.



Grand challenges in society



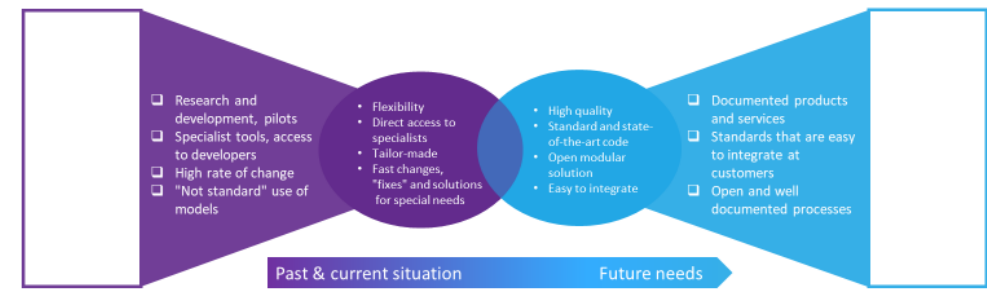
### Strategic project portfolio

<b>Industry projects</b> Reserve clustering, Best Profit, Gate optimization, Physical simulation, Operationalisation, API, Model portal, GoHydro, ProdRisk simulator, Model audits	<b>Commercial models</b> EMPS, EOPS, SHOP, ProdRisk, Samnett, Samlast
<b>IPN-projects</b> VannFly, SumEffekt, Raket, IScheduling, MAD, MonitorX	
<b>KPN-projects</b> PriBas, MultiSharm, HydroConnect, CleanExport, PowerDig, FlexBuild	
<b>Research centres</b> HydroCen, CEDREN, NTRANS, NorthWind	<b>EU-projects</b> OpenEntrance, Fithydro, FlexPlan

Research agenda



## Market models in tension between research forefront and industrial standard



- SINTEF has successfully been developing solutions in accordance with customers' challenges and needs.
- Customer requirements are turning towards a greater degree of standardization and integration with customer solutions as well as flexibility for market changes.


# Nåsituasjon

Energisystemet transformeres av gjennomgripende endringer som er sterkt økende både med hensyn på omfang og tempo.

Nye teknologier og digitalisering er en utfordring og mulighet i det fremtidige kraft- og energisystem.

Vi trenger nye fundamentalmodeller som gir oss evne til å forstå og styre utviklingen av det fremtidige energisystemet.

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## Method for ngLTM – knowledge base

Model	Prosjekt	Detailed simulation	Value – Season	Value – Long	Comment
FanSi	SOVN	X	X	X	Relevant kompetanse/erfaringer for alle 3 deler. Stor del av kildekode skrevet fra "scratch". Brukt i forskningsprosjekter
EMPS-W	MAD	X		X	Simuleringsmodellen lik som FanSi, uten scenariovifte, med vannverdier fra EMPS. Testet og sammenlignet med EMPS.
Primod	PRIBAS	X			Flere tekniske detaljer i simuleringsdelen enn FanSi og EMPS-W. Høynivå modellgenerator (Python/Pyomo).
ReOpt	Verdien av fleks. Vannkr.	X		X	Forløper til EMPS-W. Vi kan anta at erfaringer fra denne modellen er videreført med EMPS-W.
ProdMarket	Intern	X	X		Basert på ProdBid og geografisk dekomponering. Metode brukt inn i videreutvikling av FanSi i Rakett.
Samplan	Ca 1995-2005			X	Metode for verdisetting: SDDP.
EMPS	Siden ca 1975			X	Detaljrikdom i dokumentasjon av anvendt funksjonalitet. Vannverdimetoden (SDP) + kalibrering. Tappefordelingslogikk for detaljert vannkraft.

Teknologi for et bedre samfunn

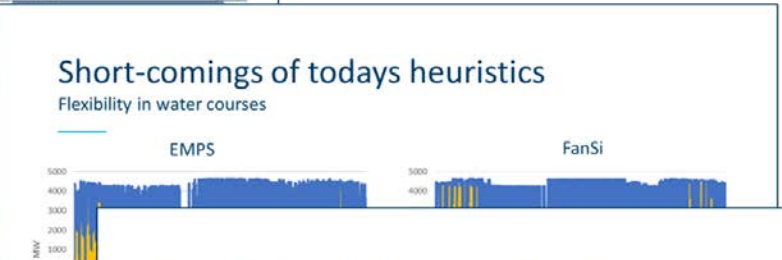
## EMPS API

Objective:

- Ability for large-scale data in- and output to models (detailed datasets, time series, ...)
- Potential to present more and more detailed results
- Efficient model interface

Lesson 1

- The underlying idea of the API project is good and future oriented. Ho



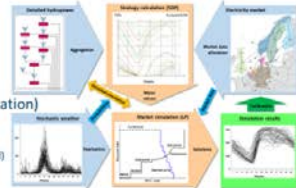
## Draw-down heuristics (tappefordeling)

- Developed for finding dispatch for > 1600 hydro modules
- Heuristics, developed for hydro-thermal power systems
  - For a dispatch with a predefined pattern (similar each day, limited amount of periods)
  - With a low share of variable renewable energy sources
  - Challenges: to optimise long water courses with reservoirs in series

Lesson 2:

- It is difficult to assume that large parts of the existing heuristics can be adapted / further developed to respond to expected future variability and flexibility in the power system.

## Complexity in hydropower planning models



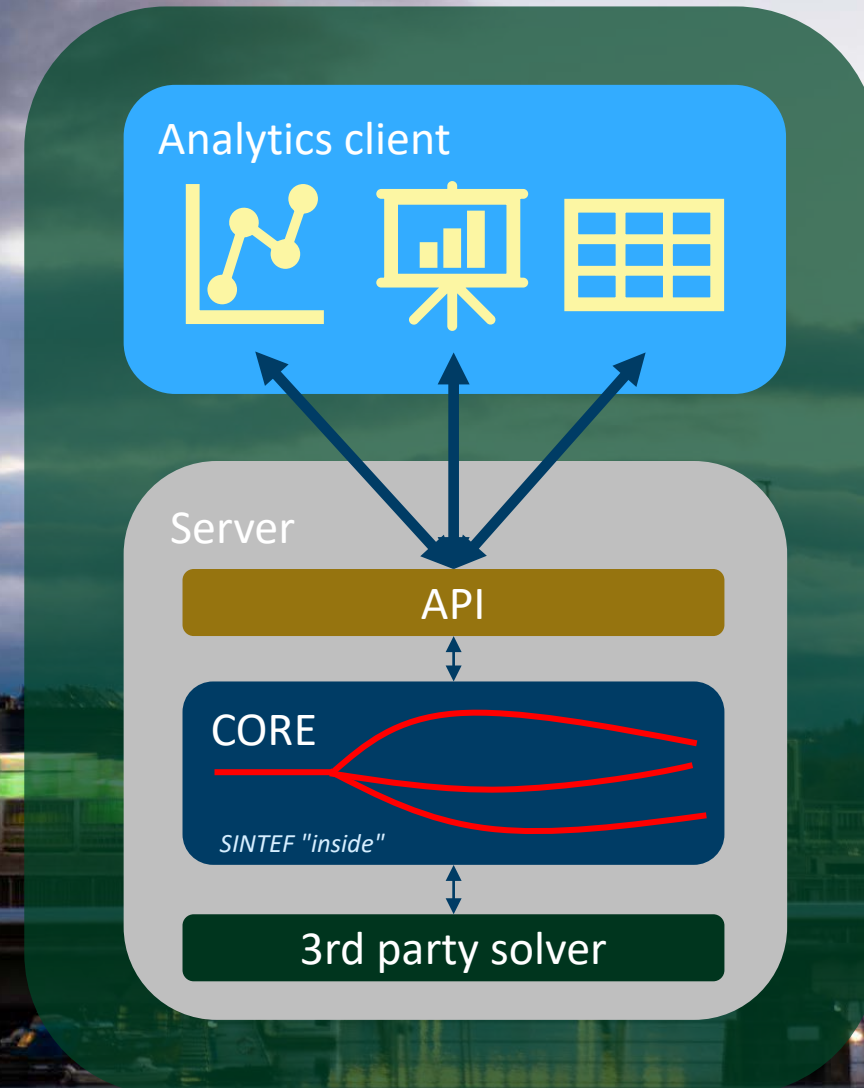
- EMPS comprises an advanced multi-stage solution concept for long-term hydropower planning to:
  - solve the problem at all and solve it fast and robust (aggregation, water-value calculation, disaggregation, simulation)
- Future challenges:
  - More variability and uncertainty
  - Importance of modelling physical flows
  - New market design
  - New technologies (production and load)
  - Coupling to other energy sectors

Lesson 3:

- New solution methods are necessary to reply to future challenges, but at the same time techniques for decomposition, parallelisation and approximation are essential for limiting computation time.

# Project sketch based on conclusions from the pre-project

SINTEF focuses on the development of a state-of-the-art calculation CORE for a fundamental market model with a well documented interface for the integration with third-party / customer solutions.





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# Proof-of-concept (POC)

Next generation market models



# What is the concept?

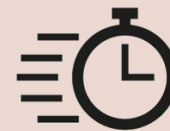
- I. The concept "*Next generation market model*" describes:
  - I. the mathematical **method** that is to be applied in future market models
  - II. how this method is **implemented** in software, documented and supported
  - III. and the **process** of the software development and customer involvement

## POC Focus areas

Quality



Speed

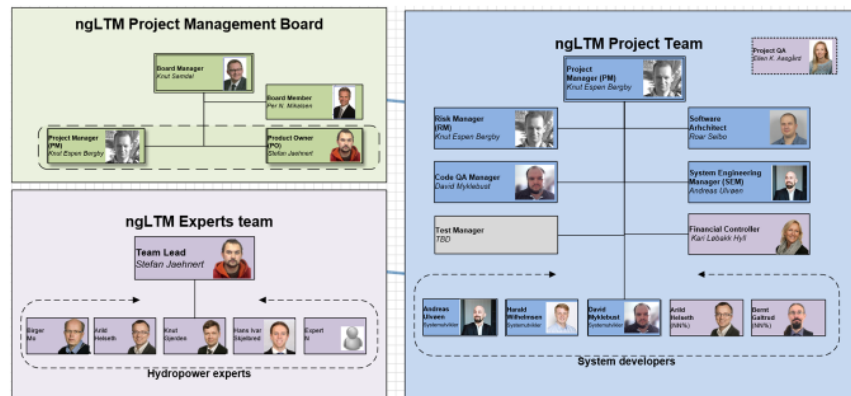


Implementation





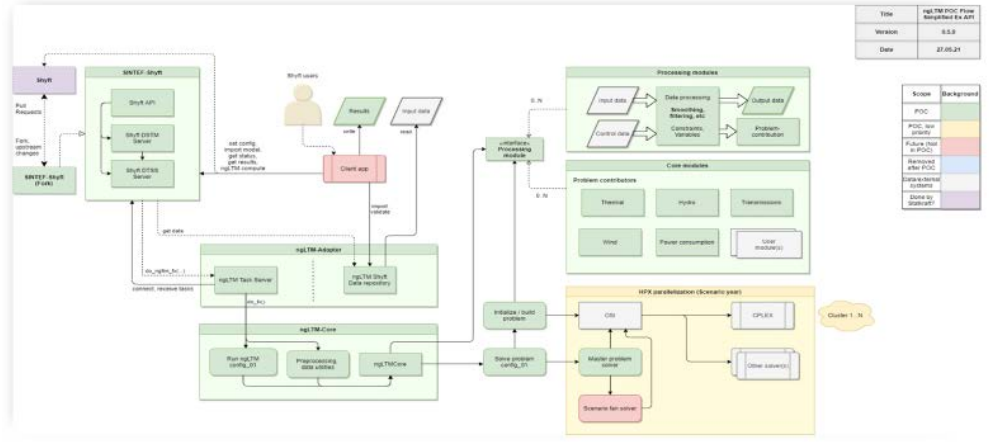
## Project organization - SINTEF



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## Implementation – Architecture

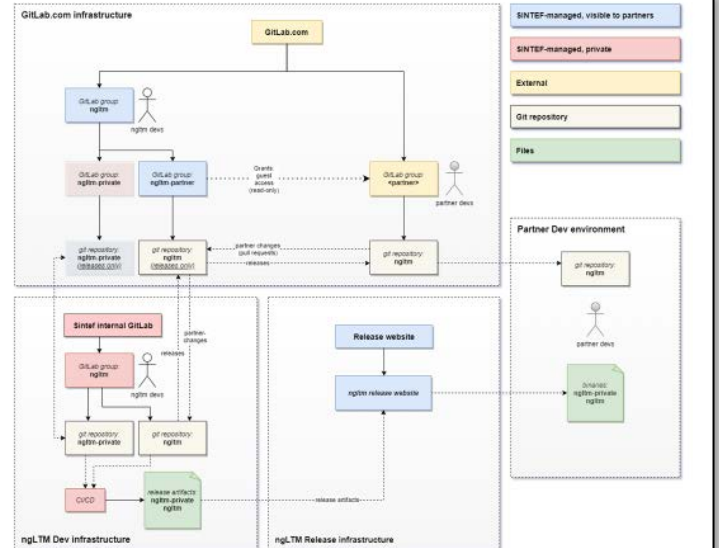


Title	ngLTM POC Flow description Ex API
Version	0.5.0
Date	27.05.21

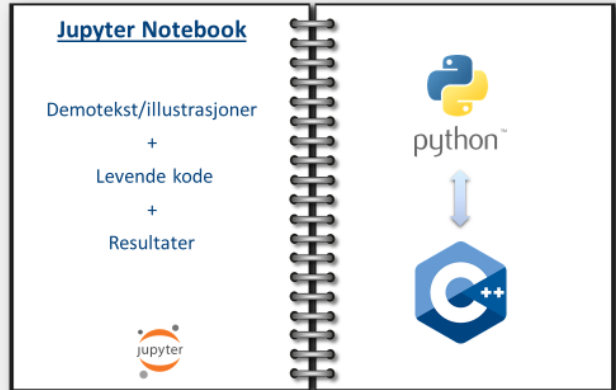
Scope	Background
POC	Green
POC: user priority	Yellow
POC: user in POC	Orange
POC: user in POC	Red
POC: user in POC	Purple
POC: user in POC	Blue
POC: user in POC	Black
POC: user in POC	White
POC: user in POC	Grey



## Samarbeid via GitLab

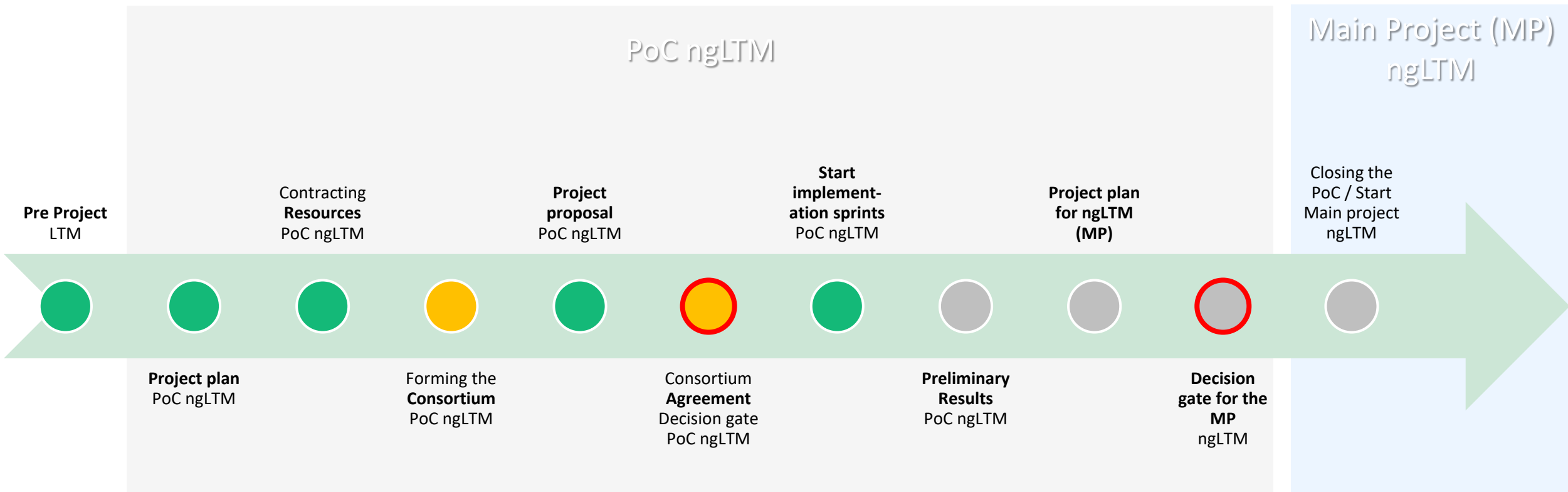


## [ Demo ]





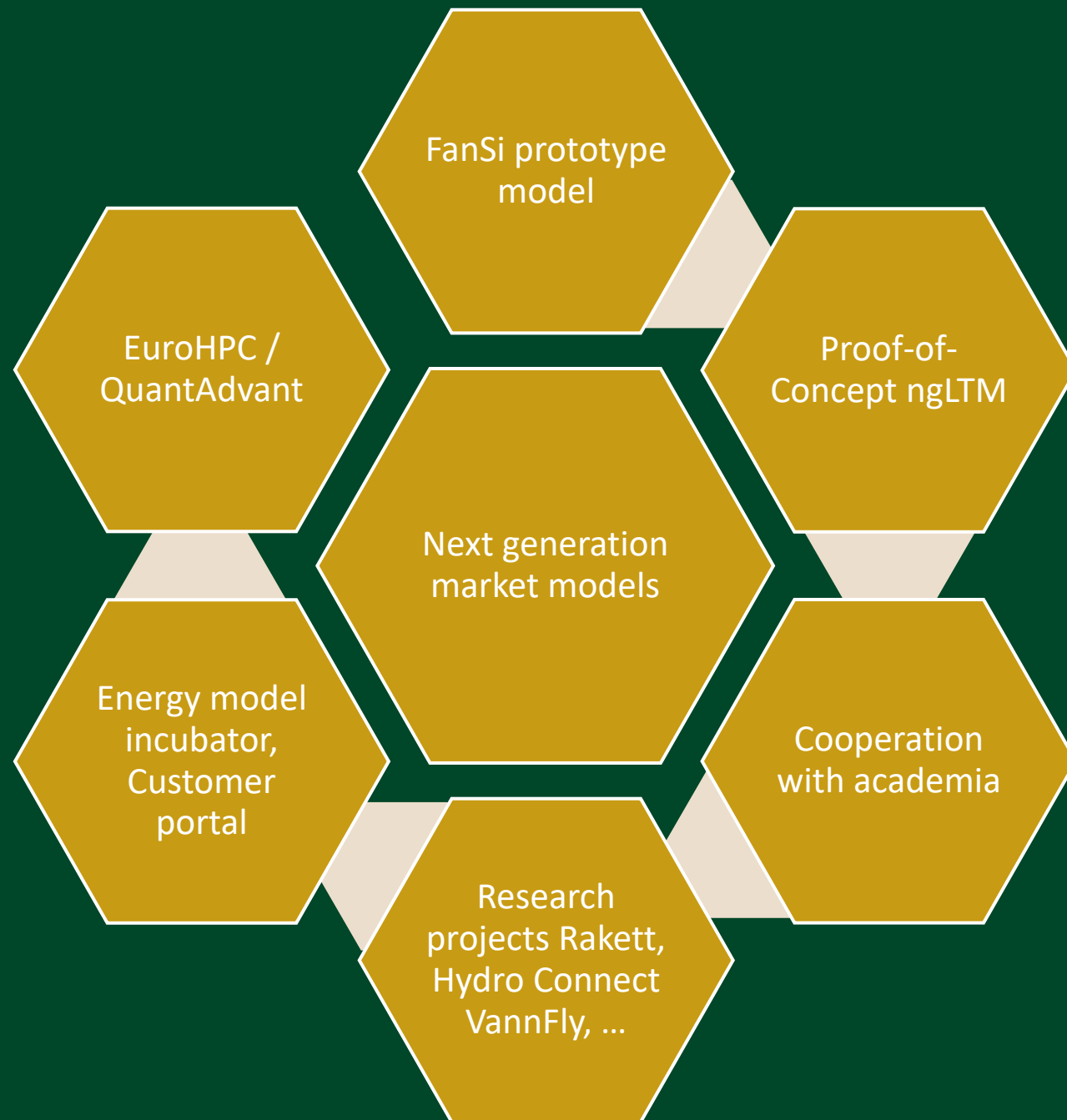
# Timeline for the PoC and main project





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# Stepwise development og next generation market models



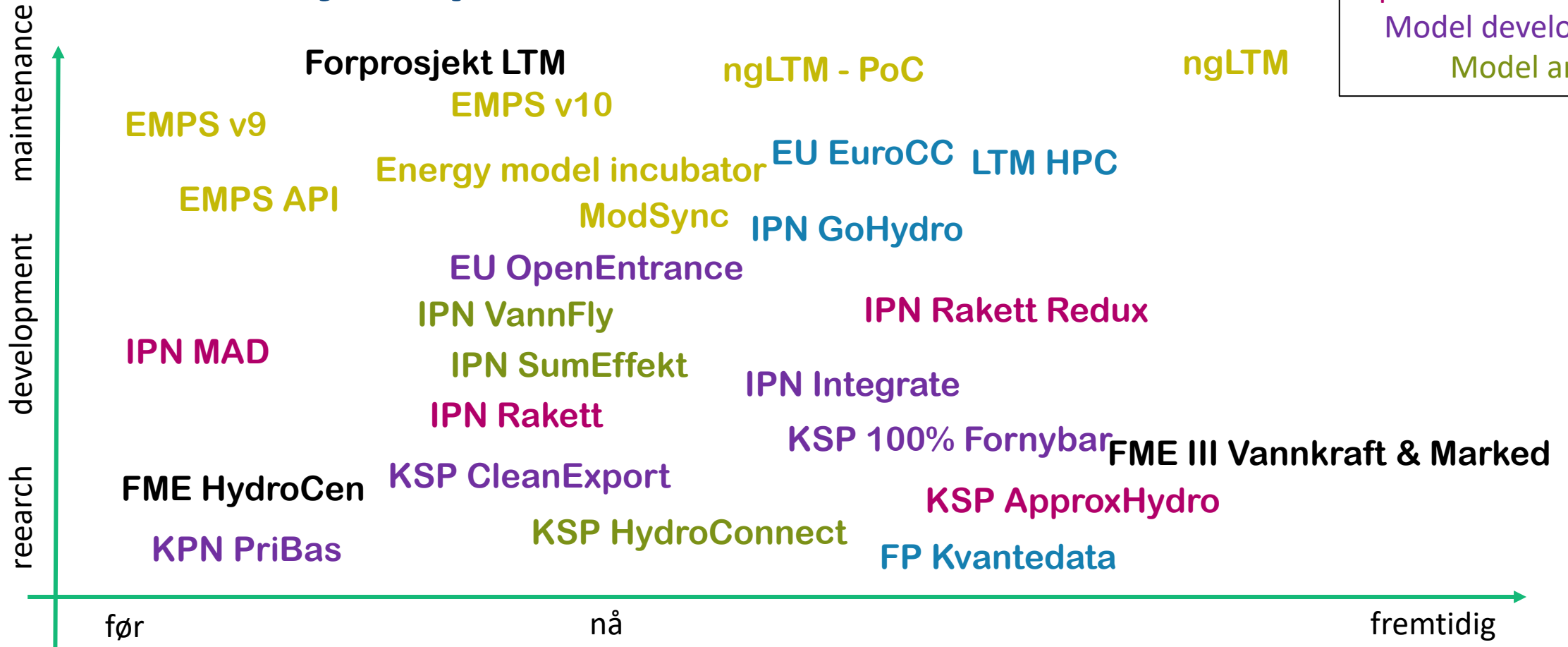


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# Project portfolio

Tematisk:

- Implementation
- ML / HPC
- Optimisation methods
- Model development
- Model analyses

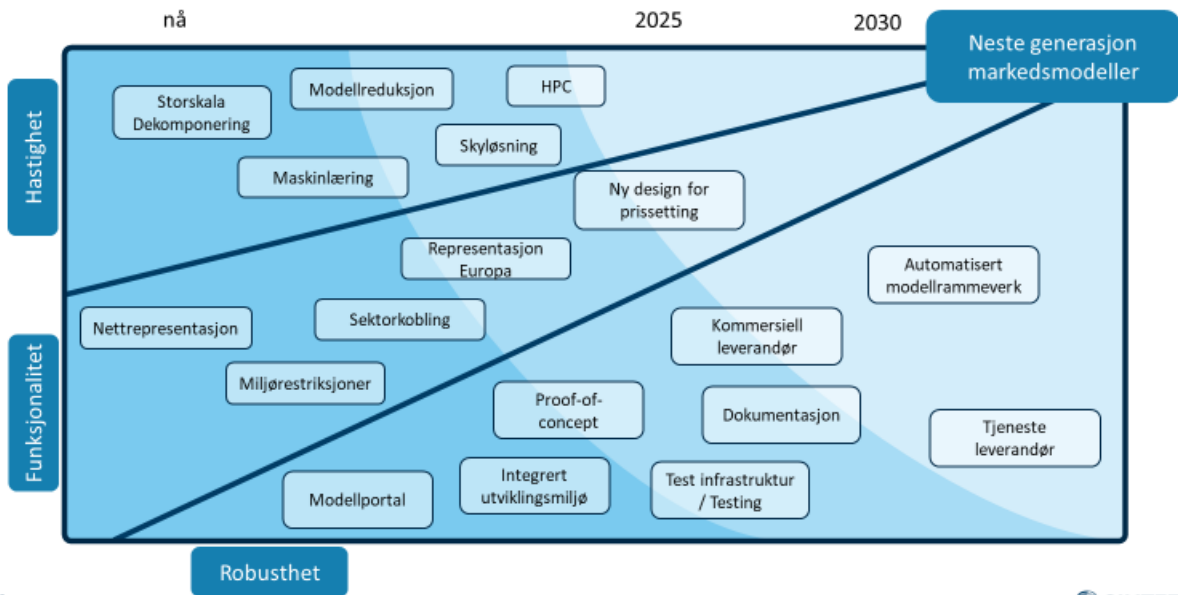




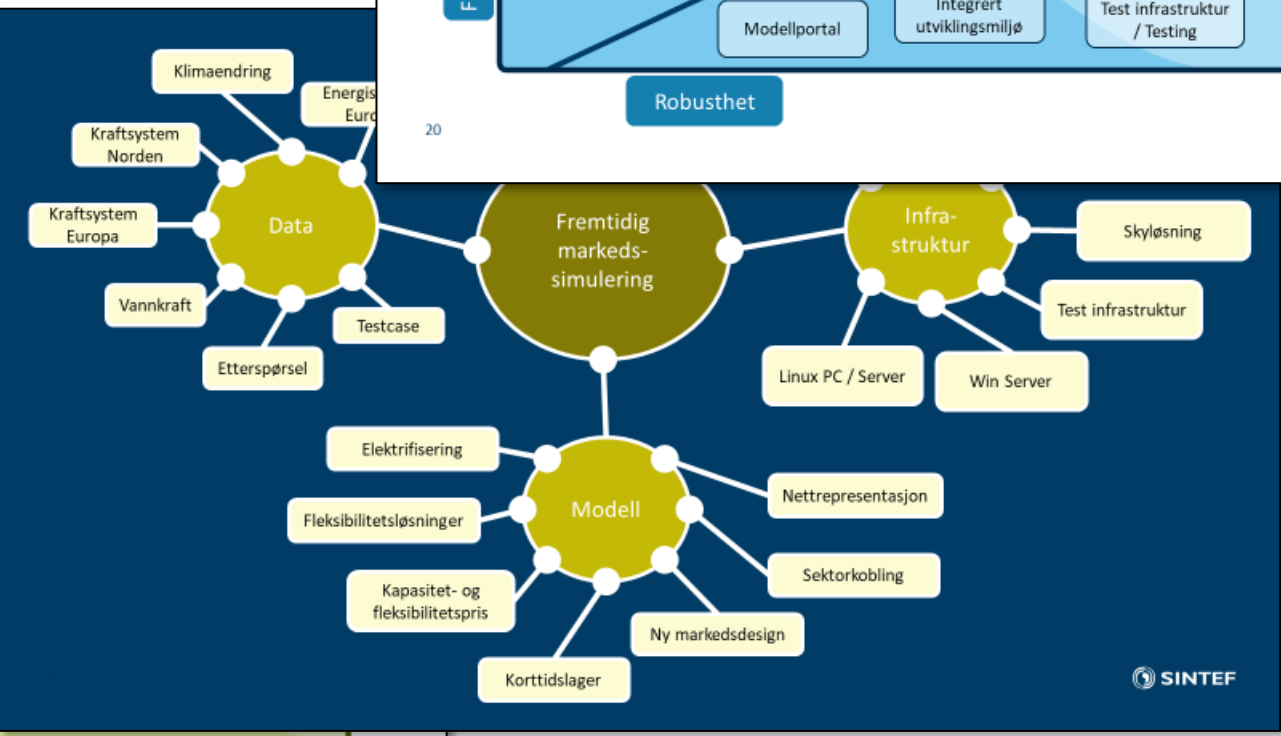
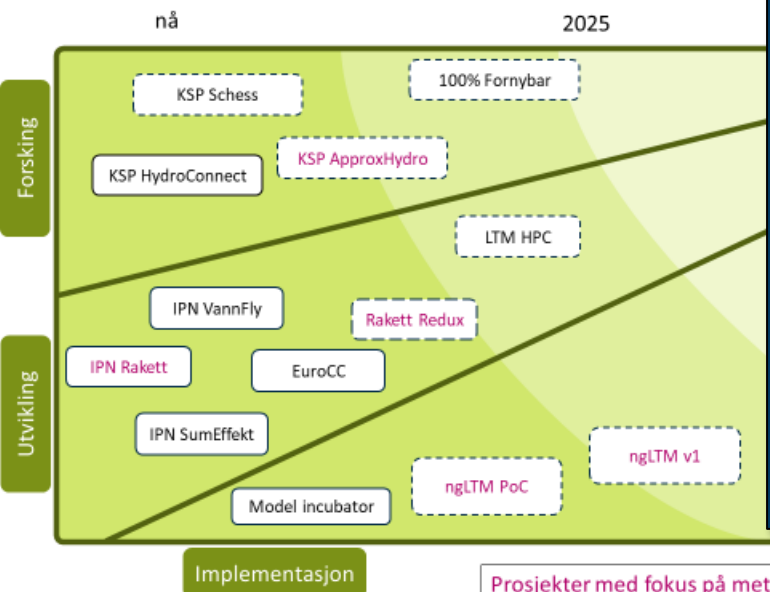
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# Langsiktig strategi

# Work in progress



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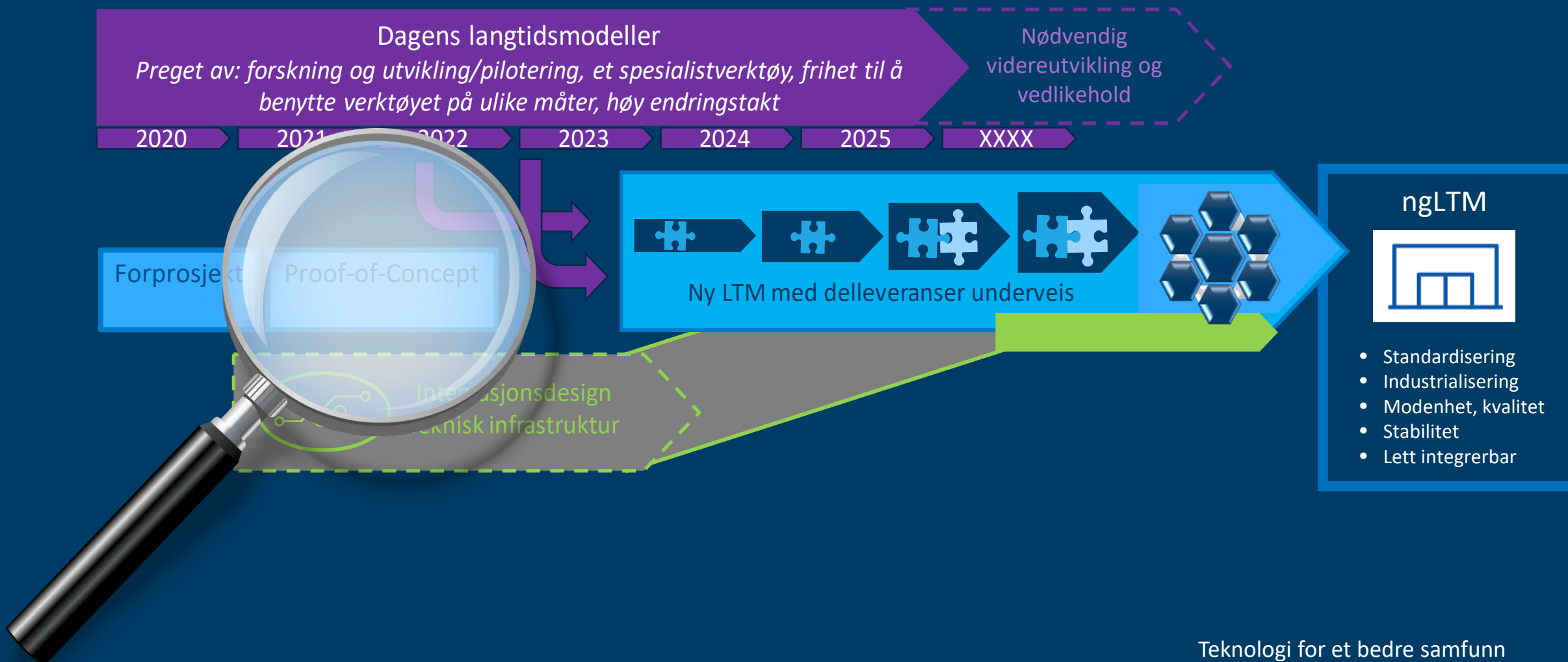


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Prosjekter med fokus på metode / modellutvikling  
Prosjekter som bidra til modellkompetansebygging

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# Tidslinje for neste generasjon markedsmoedeller





— **70 years** —  
1950-2020

Technology for a better society