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SECONDARY RESERVES – How to procure ?

A comparison of Denmark and Vietnam with considerations for the future

Ulrik Møller

Senior Economist, Electricity Market department

Danish electricity system operator, Energinet

(+45) 2333 8535

ULM@energinet.dk

Background

Mr. Ulrik has specialized in power system economics, and for the past 20 years he has been working intensively with energy market design and energy policy. He has extensive knowledge of the energy sector and the Nordic and European power systems, from employment at the Danish TSO and the Danish economic consultancy, Copenhagen Economics. At Copenhagen Economics he was responsible for clients within the energy sector. Currently Ulrik works with different market design projects and with market design training, e.g. Nordic TSOs on improved grid utilization through better grid representation in the market operation model (so-called Flow Based Market Coupling). Ulrik has been responsible for the power market training activities towards Energinet's global collaborators (TSOs, utilities and energy regulators). Ulrik headed the sub project on training in power market design and launching a short-term power market in East Africa. From 2013 to 2022 Ulrik has done teaching in micro economics and power system economics as external associate professor at Southern Danish University.

BA HOAI NGUYEN

Deputy Manager of Renewable Energy Management Department

National Power System and Market Operator Company (NSMO)

(+84) 90 2277793

hoainb@nsmo.vn

Background

Mr. Nguyen Ba Hoai has been working for the National Power System and Market Operator (NSMO, formerly EVNNLDC) for more than 10 years. He is currently the Deputy Manager (in charge) of the Renewable Energy Management Department. He received both his Bachelor's and Master's degrees in Electrical Power System from Universiti Tenaga Nasional (UNITEN), Malaysia. His responsibilities include the application of science and technology in developing tools for renewable energy operations, such as monitoring, forecasting, and management renewable energy. He also serves as the key focal point for international cooperation with other system operators around the world. Prior to this role, he gained extensive experience in the field of SCADA/EMS, particularly with AGC and state estimation.

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POWER SYSTEM COMPARISION

Vietnam - Denmark

POWER SYSTEM STRUCTURE

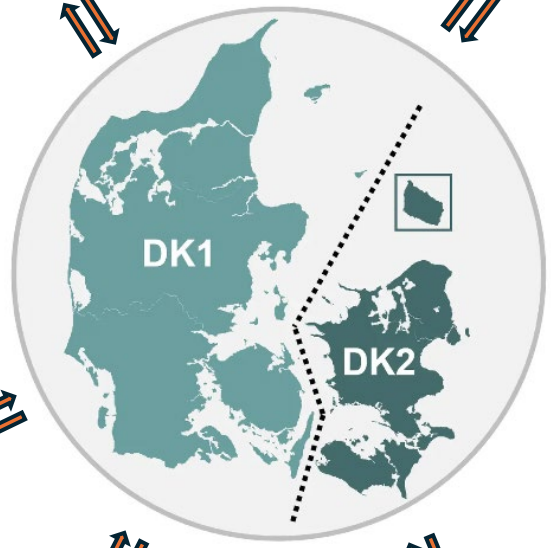
Danish power system

DK1-NO2
400 kV HVDC
~1700 MW

DK1-SE3
400 kV HVDC ~740 MW

DK1-GB
525 kV HVDC ~1400 MW

DK2-SE4
400 kV AC ~1700 MW



DK1-NL
320 kV HVDC ~700 MW

DK1-DE
400 kV AC ~1780 MW

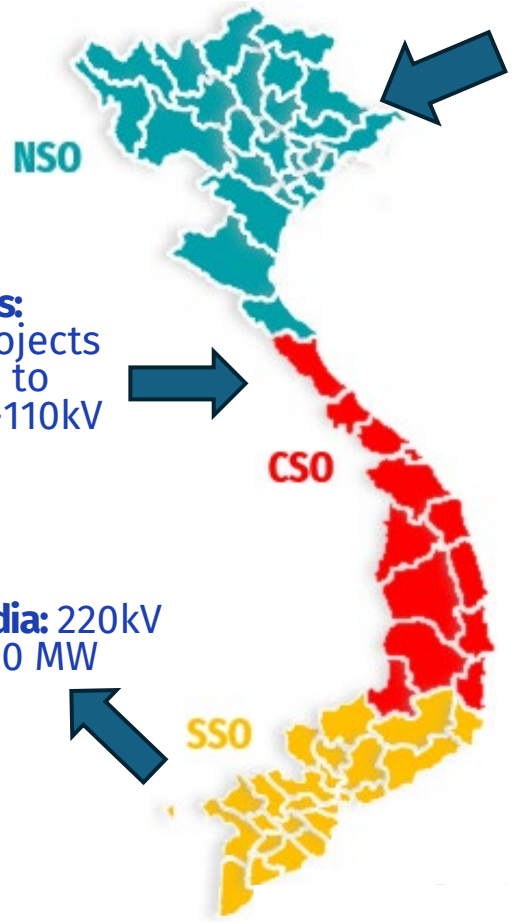
DK2-DE
400 kV HVDC ~600 MW

Vietnam power system

From China: 220kV and 110kV AC ~ 500 MW

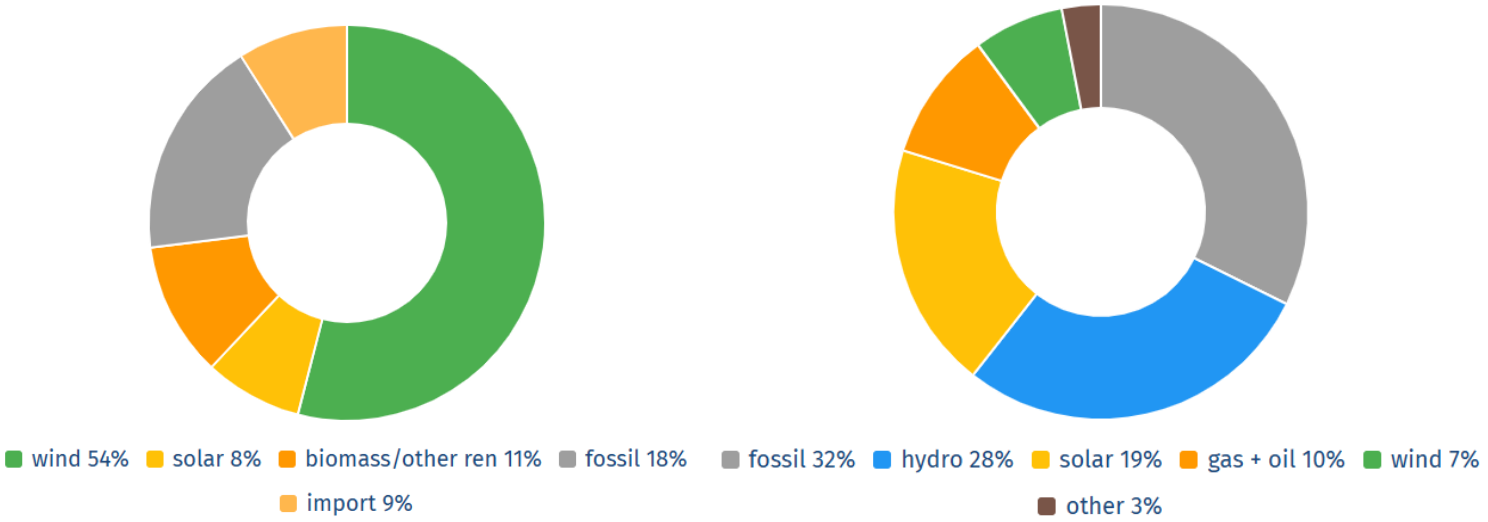
From Laos: individual projects connected to 500kV-220kV-110kV AC

To Campodia: 220kV AC ~250 MW



OVERVIEW COMPARISON

Features	Denmark	Vietnam
Installed capacity	18 GW	86 GW
Peak load	6.5 GW	48 GW
Population	5.9 million	98.9 million
Annual power consumption	44 billion kWh	310.65 billion kWh



OVERVIEW COMPARISON

Feature	Denmark	Vietnam
Interconnection	Highly interconnected and interdependent within Nordic and Europe	Stand-alone system with limited asynchronous interconnections
Configuration	DK1 (synchronous with Continental Europe) & DK2 (Nordic synchronous area)	Three regionals (Northern, Central, Southern) connected by 500 kV backbone
Bidding zone	**2** bidding zones in DK and a total of **12** in Nordic region	**1** bidding zone
RES penetration	**62%** installed capacity	**28%** installed capacity

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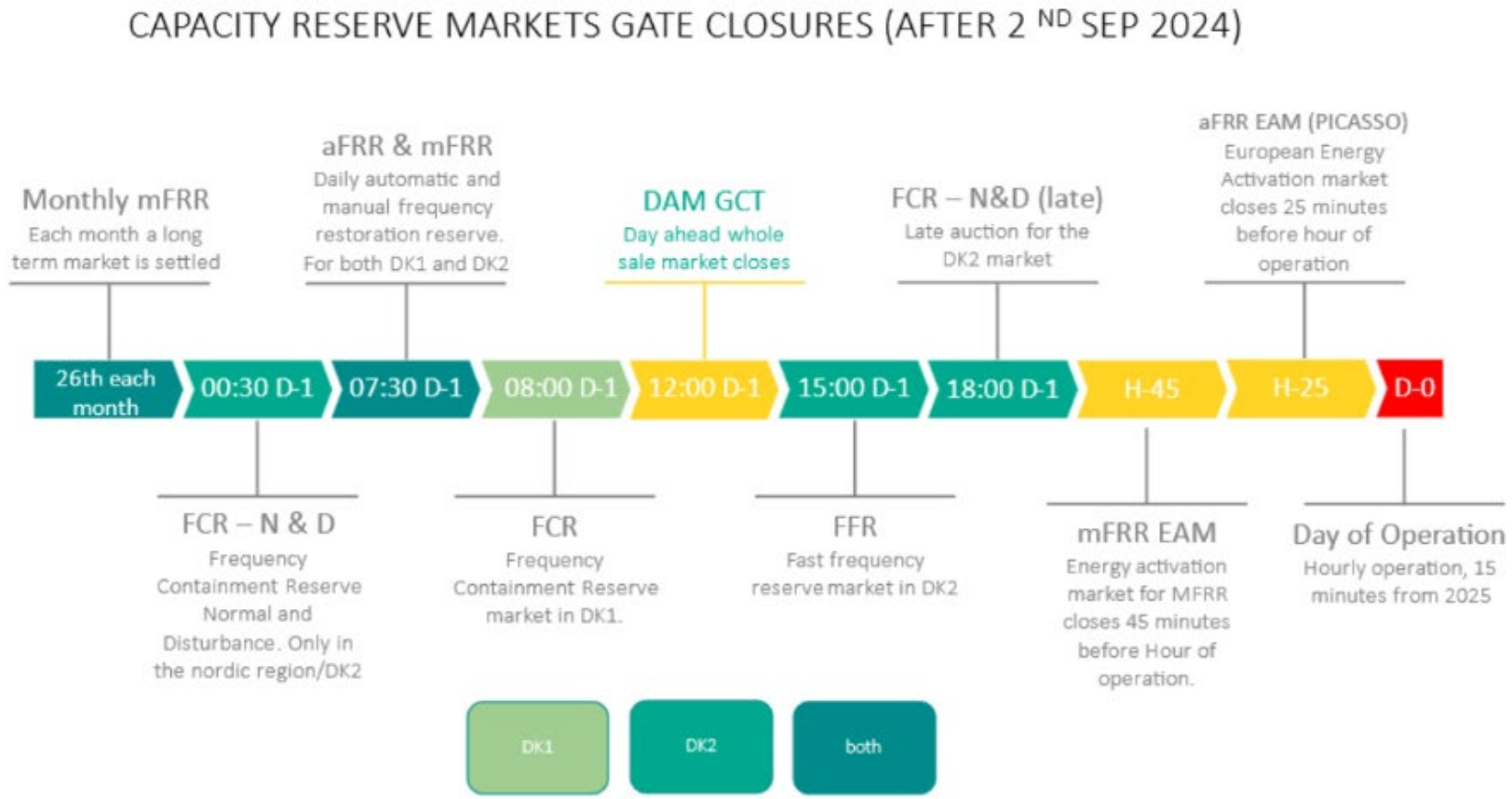
SECONDARY RESERVE

Vietnam - Denmark

SEQUENTIAL SETUP IN DENMARK (NORDIC)



Market structure and Gate closure times in Denmark

DENMARK, NORDIC ANCILLARY SERVICES MARKET

Secondary Reserve (aFRR - Automatic Frequency Restoration Reserve)

Deliver within 5 mins

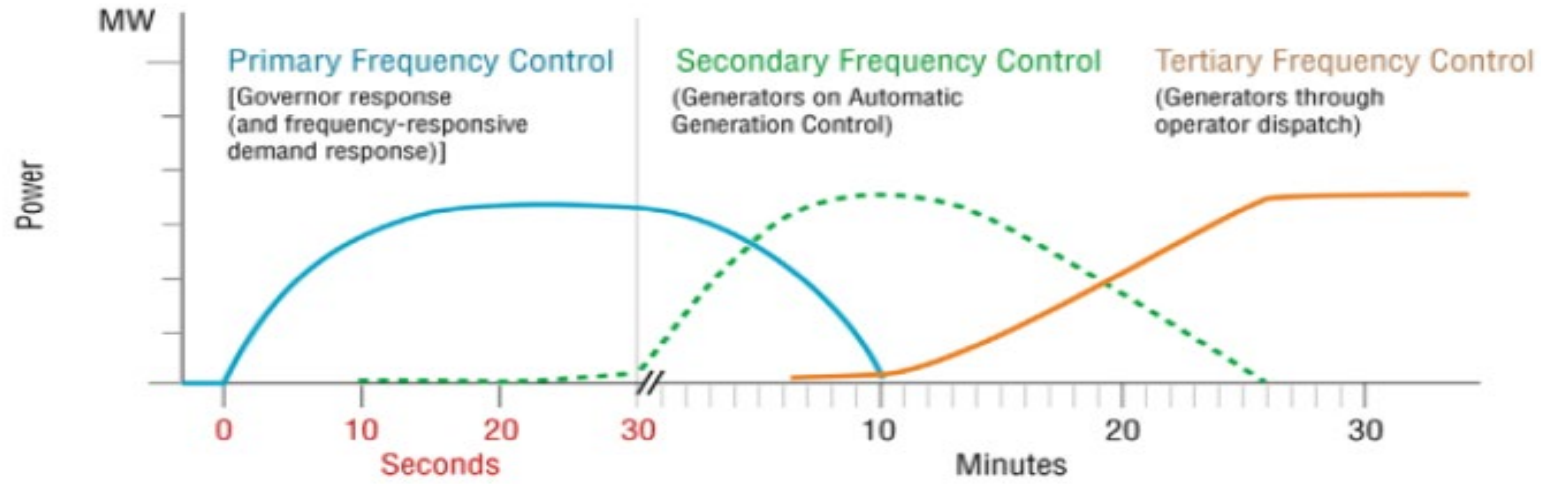
Characteristic: Medium-fast reserve; all power delivered within 5 minutes of activation.
Main Purposes: Releases FCR, corrects minor imbalances, restores interconnector balance and handles remaining imbalance after mFRR.
Activation: TSO (Energinet) signal to Balance Responsible Parties (BRPs).
Procurement: Capacity via hourly auctions (Nordic aFRR CM); energy via PICASSO.

Tertiary Reserve (mFRR - Manual Frequency Restoration Reserve)

Deliver within 12 mins

Characteristic: Manually committed capacity; full response within 12.5 minutes of activation.
Purpose: Addresses significant imbalances from unplanned production/consumption changes.
Activation: Direct signals from Energinet.
Procurement: Capacity via trilateral mFRR market with Sweden and Finland and energy via joint Nordic mFRR energy activation market.

VIETNAM FREQUENCY REGULATION



Primary Frequency Control

Immediate & Automatic

Automatic, by generator governors; mandatory for all connected units.

150 ~ 180 MW

Secondary Frequency Control

AGC System

Via Automatic Generation Control (AGC) to restore frequency to nominal range.

~716 MW

Tertiary Frequency Control

Manual Dispatch

Dispatching order to stabilize frequency economically.

SECONDARY RESERVES COMPARISION

Feature	Denmark - aFRR	Vietnam Secondary Reserve
Concept Name	aFRR (Automatic Frequency Restoration Reserve)	Secondary Reserve
Balancing Philosophy	**Balancing in advance**: Forecasts inform mFRR scheduling; remaining imbalances handled by faster products (mainly aFRR)	**Balancing in Real-time (no market)**: AGC calculates setpoints based on frequency deviation
Characteristics	Automatic activation **after 30s**; Full **Activation: 5 min**	Start delivery **within 20s** of AGC signal; **Full activation in 10 min; Sustain for ≥15 min**
Capacity Procurement	Common total Nordic: **325** MW up, **375** MW down.	**716** MW (both directions) (Assigned by NSMO)
Energy Activation	PICASSO (Common European EAM – **15 minutes**) (TSO signal to BRPs – **4 seconds**) Denmark max. possible aFRR activation DK1: **200** MW, DK2: **100** MW	TSO AGC signal to plant units – **8 seconds**

VIETNAM'S KEY CHALLENGES AND DEVELOPMENT NEEDS

Secondary frequency regulation reserve capacity: 716 MW

Practices

- **Ancillary Services Market:** No ancillary services market currently exists.
- **Primary Frequency Control:** Primary Frequency Control is mandatory for all units.
- **Secondary Frequency Control :** Using large Hydro Power Plant via AGC signal.

Requirement

- **High RES Integration:** Essential given high RES penetration goals.
- **Carbon Neutrality:** Required for 2050 targets.
- **Urgency:** Need to accelerate AS market as RES with high uncertainty accounted for 28% of total installed national capacity. Revised PDP8 RES will account for 40-48%.

DANISH EXPERIENCE CAN HELP VIETNAM

Danish Experience

- **Common Nordic aFRR market:** Has already evolved significantly since its beginning in 2022 where it transitioned from combined capacity and balancing energy market –to today with separate capacity and balancing energy activation.
- **Start is always hard:** High prices and low volumes characterized the initial stages. Competition and liquidity have increased over time.

Lessons learnt can be useful for Vietnam

- **Danish experience:** Market development is a step-by-step process and continuous problem-solving is necessary. Lots of design choices to be made!
- **Co-optimisation:** Energinet takes part in the European R&D on the potential application of co-optimisation of aFRR and mFRR balancing capacity with the European Day-ahead market.

Partnership Goals: Denmark can provide valuable input to Vietnamese market development efforts

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ONGOING STUDY

Sequential and Co-optimization setup

COMPARISON OF TWO MARKET ARCHITECTURES

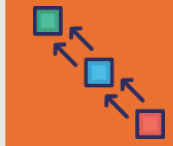
(NSMO & Energinet ongoing study)

Objective

Evaluate advantages and disadvantages of two market architectures and provide recommendations for Vietnam's ancillary services market deployment

Sequential Market Setup

Separate Optimization



Co-optimization Market Setup

Simultaneous Optimization

Study Focus: Market Structure Analysis • Economic Efficiency Evaluation • Implementation Recommendation for Vietnam

SEQUENTIAL MARKET SETUP

Key function

Mechanism: Separately clears the day-ahead energy market and balancing capacity market.

Allocation: Forecasts decide cross-zonal transmission capacity reservation for reserves before the energy market.

Constraints: Respects physical grid constraints.

Integration: Energy dispatch and reserve capacity are determined sequentially.

Theoretical pros and cons

- **Transparency:** Simpler market steps make roles and revenues easy to understand and estimate.
- **Broader Participation:** The simplicity lowers entry barriers, encouraging wider participation which can increase competition and ease implementation.
- **Cost Inefficiency Risk:** Separate clearing can misallocate resources and capacity which may increase system costs.

Definition

Separate optimisation of wholesale electricity markets (day-ahead) and reserve capacity procurement

CO-OPTIMIZATION CONCEPTS

Key function

Mechanism: Jointly clearing the day-ahead energy market and balancing capacity market.

Allocation: Efficiently allocates cross-zonal transmission capacity between energy dispatch and secondary reserve procurement.

Constraints: Respects physical grid constraints.

Integration: Energy dispatch and reserve capacity determined simultaneously.

Theoretical pros and cons

- **Cost Optimization:** Minimizes total system costs by jointly considering energy and reserve needs.
- **Efficiency:** Unlike sequential approaches, avoids suboptimal allocation, allow better utilization of resources and capacity.
- **Market complexity:** increase demand on operational and computational market structure.

Definition

Simultaneous optimization of wholesale electricity markets (day-ahead) and reserve allocation

EVALUATING MARKET DESIGNS: PROS AND CONS

Criteria	Sequential Market Setup	Co-optimization Market Setup
Operational Efficiency	**Lower** – Separate procurement leads to inefficient resource allocation	**Higher** – Simultaneous clearing optimizes total system costs
Complexity & Market Expansion	**Simple – Clear,** encourages broader participation	**Complex**, potential barriers to entry if not managed
Infrastructure Requirements	**Lower** infrastructure/computational demands; easier initially	**Complex - robust** infrastructure, regulatory frameworks, clear understanding for participants

VIETNAMS FUTURE ANCILLARY SERVICES MARKET?

Why Co-optimization ?

- **Resource Efficiency:** Theoretically more efficient resource allocation, reduced total system costs.
- **Grid Management:** Effective management of cross-zonal transmission allocation.
- **System Isolation:** Vietnam's largely isolated system simplifies cross-border complexities (no need for international agreements).

Key benefits

- **Joint Procurement:** Efficient joint procurement of energy and reserves.
- **System Responsiveness:** Enhanced system responsiveness to changing conditions.
- **Reserve Optimization:** Better resources allocation such as updated input parameters.
- **VRE Flexibility:** Improved VRE flexibility and integration.

Analysis result: ***Further study of*** *Co-optimization market in Vietnamese context,* ***simulation*** *needed with the new Vietnam market model design*

IMPLEMENTATION CHALLENGES

Increased market complexity

Combining energy and ancillary services into one market clearing process makes rules and bidding structures more complicated.

Stronger Regulatory Oversight Needed

This setup will demand clear regulation, continuous monitoring, and fair access rules for all participants.

Higher computational and infrastructure demands

Requires complex algorithms, real-time data processing, and powerful computational capacity, necessitating major system upgrades.

Challenges in expanding market participation

Difficulty in attracting a sufficient number of participants can lead to a shallow market and undermine overall efficiency.

CONCLUSION

Key Conclusions

- With 28% share of VRE, Vietnam is going to design and build the ancillary service market.
- The main goal of study is to learn reserve model and how to apply to Vietnam context.
- Co-optimization theoretically may be a compelling path for Vietnam and should be the working assumption for the upcoming phases

Recommendations for NSMO

Technical Validation: Continue detailed simulations and technical validation of co-optimization models tailored to Vietnam.

Implementation Roadmap: Develop a phased implementation roadmap, addressing infrastructure, regulatory, and market participant readiness.

Partnership Strengthening: Leverage the NSMO-Energinet partnership for ongoing knowledge exchange and support.

Questions & Discussion

Thank You

Partnership Program

Vietnam-Denmark TSO Partnership