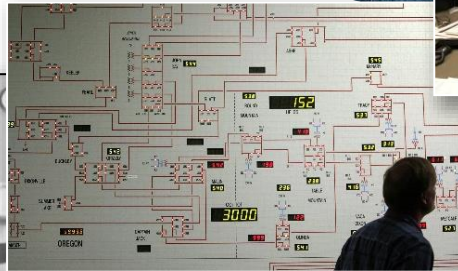


# Development and integration of PMU-based WAMPAC systems in Statnett



Knut Hornnes

**Statnett**

# The future is electric and the future is now

## RETAIL

### Smarter homes

- Hourly meters
- Flexible demand
- Battery/storage
- Own generation



### Smarter communities / cities

- Share resources
- Local generation
- Exploit local opportunities in storage, heating, cooling, geothermal, transport etc.



### Smarter markets & grids

- Overall system optimization
- Integrate across borders
- Integrate distribution and transmission



## WHOLESALE

### New generation mix

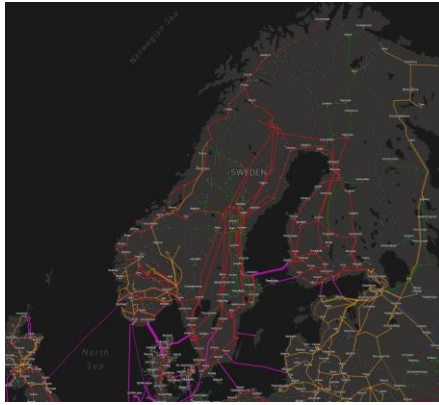
- Volatile renewables replace plannable thermal
- Digital solutions improve forecasts and optimization



**System operation must change because the system changes**

# The PMU

WIDE AREA



REAL TIME



FINER TIME RESOLUTION

**1 vs. 500**  
*(observations per 10 sec)*

SYNCHRONIZED



# Wide Area **M**onitoring, **P**rotection and **C**ontrol

## WAMS

Synchronized data  
provide more **insight**  
into system dynamics ...

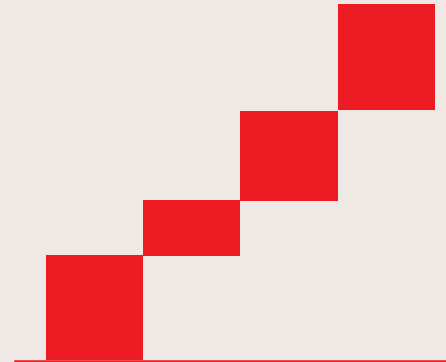
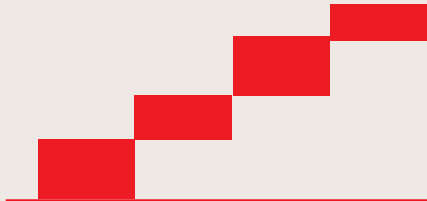
*Realising more  
of the potential*

## WAPS

... and can improve  
**automatic response**  
measures like system  
protection ...

## WACS

...control/regulation based  
on a complete set of  
synchronized measured  
and calculated state  
estimates

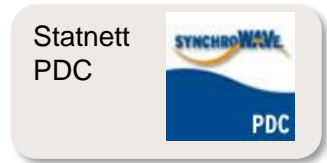


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**APPLICATIONS  
+ SCADA SYSTEMS  
FOR PROTECTION  
AND CONTROL**



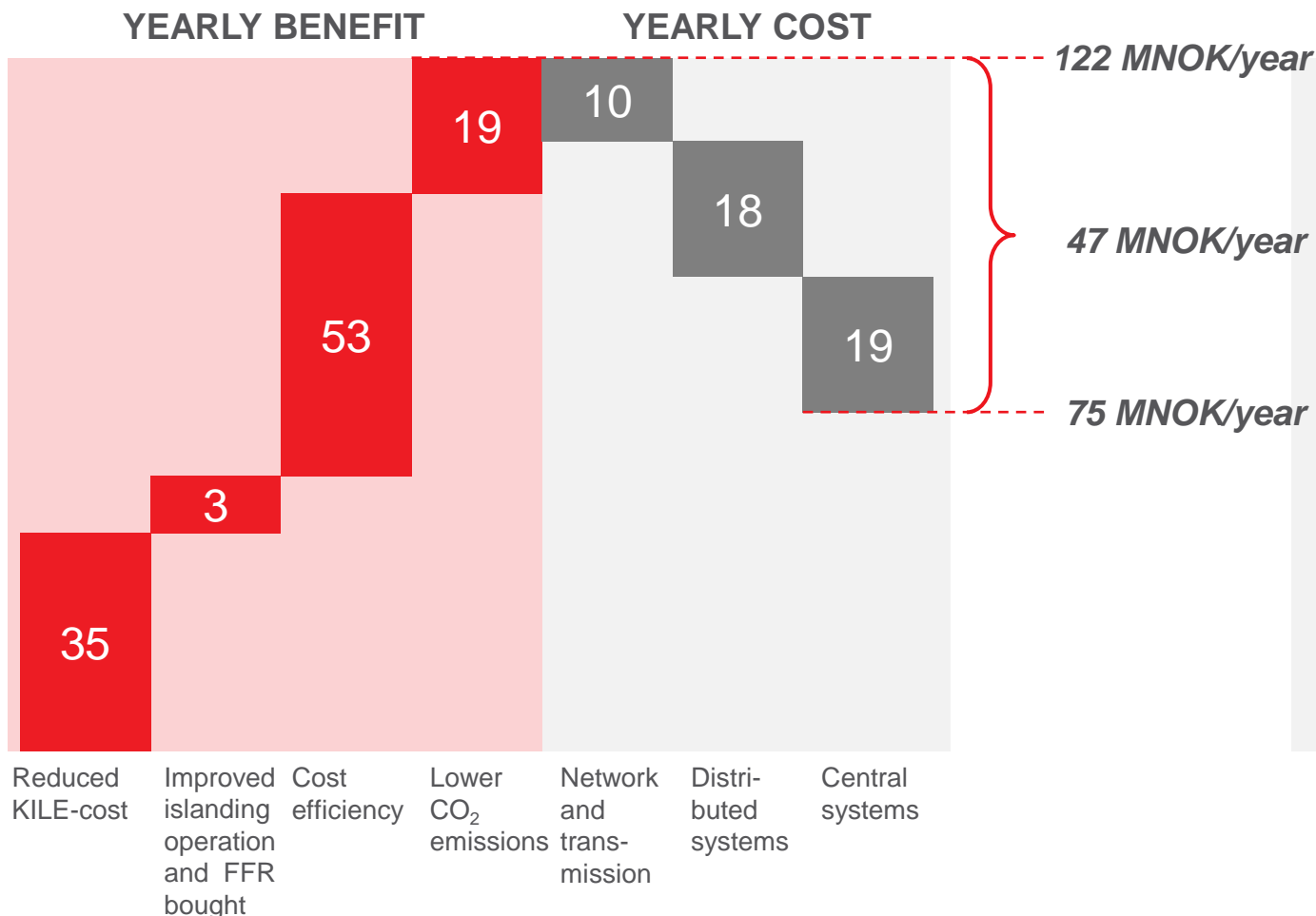
**PHASOR DATA  
CONCENTRATOR**



**PMUs DISTRIBUTED IN  
THE POWER SYSTEM**

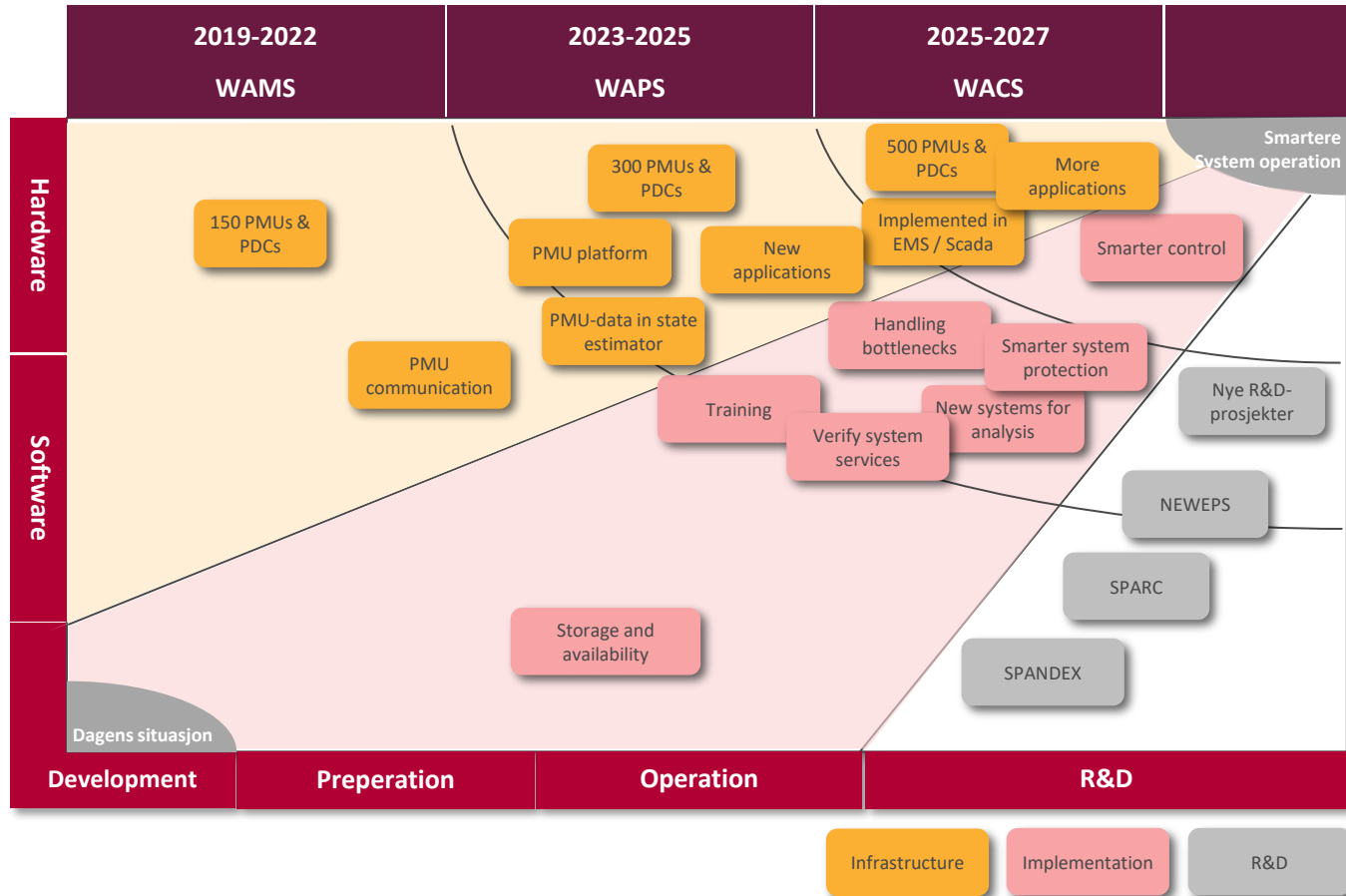






- *Estimates based on reports and interviews*
- *Numbers will be qualified in separate workshops*

# Overview of roadmap





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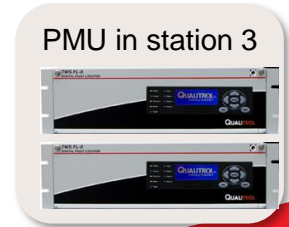
**PHASOR-POINT TO  
VIZUALIZE**



**PHASOR DATA  
CONCENTRATOR**



**PMUs DISTRIBUTED IN  
THE POWER SYSTEM**







**Thank you for your attention**