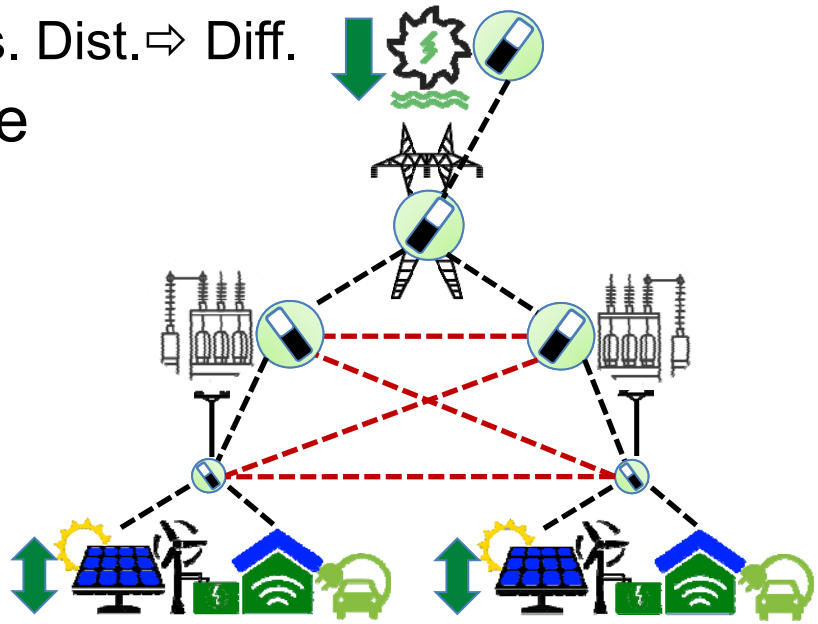
NTNU Status

- Projects;
  - ProSmart
  - SPANDEx
  - CINELDI
- PhD students
  - Konstantin Pandakov; Protection of distribution systems with DG
  - Charles Adrah; Communication for protection purposes
  - Maciej Gręb la; Protection system performance
- PostDocs
  - Dinh Thuc Duong; Application of PMUs
  - Zhou Liu; Adaptive relaying and HIL testing
- MSc students
  - Frida Berg; Application of Smart meters for fault location
  - Mari Lauglo; Transmission line protection with variable grounding condition
  - Hamza Kazmi; Pilot protection in distribution systems
  - Synne Garnås; Fault current contributions from converters
  - Bendik Fossen; Small-hydro protection practice
- New Master Course starting up January 2018. TET4215

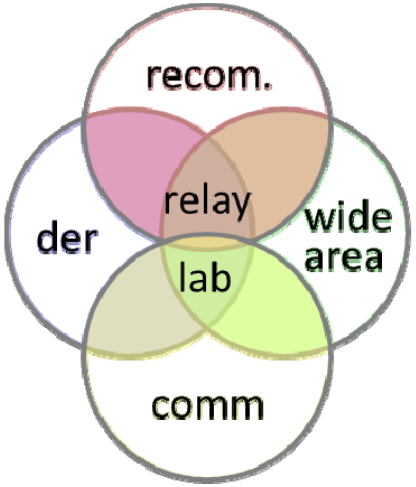
ProSmart - Project motivation

- Higher penetration of Distributed Energy Resources
  - Classical upstream/downstream concepts break down. Fault current direction unknown.
  - Changed fault current levels.
    - Islanding
    - Adaptive relaying
  - Distribution: Over-current ⇨ Distance protection
  - Transmission: Starting-zone settings. Dist.⇨ Diff.
- Roll-out of smartgrid infrastructure
  - Communication channels available
  - IT-revolution in the electro business
  - System protection (wide-area)
    - Power swing blocking
    - Voltage stability tracking
    - Load shedding etc.



ProSmart - Project content

- PhD 1: *Protection of power systems with DER*
- PhD 2: *Wide-area protection and control*
- PhD 3: C*ommunication for protection purposes*
- PhD 4: *System integration and performance*
- *Protection requirements for integration of DER*
- *Power system protection demonstration laboratory*



- Recommendations
- Distributed energy resources
- Wide-area protection
- Relay laboratory
- Communication

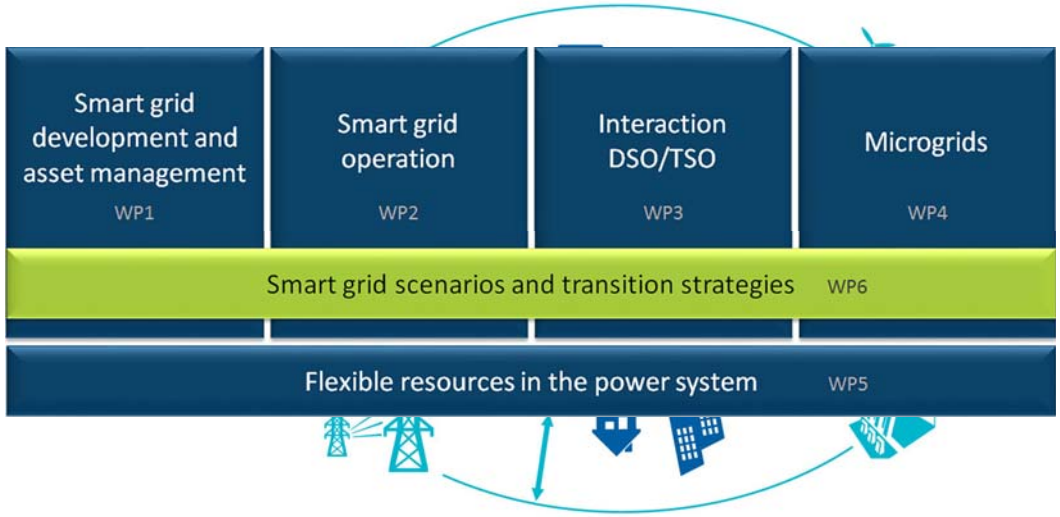
SPANDEx – Project content

- SPANDEx; **S**ynchrophasor/**P**MU **A**pplication **I**ntegration and **D**ata **Ex**change
- Project content:
  - Implement interface to test the usability of PMU-data in operation and control centers.
  - Develop, implement and test new applications.
  - Collect experience and knowledge through testing and performance analysis.
  - Develop a roadmap for future PMU initiatives at Statnett.
- Use PMUs to (31 stations equipped to date)
  - Monitor frequency, abnormal phase angles and changes
  - Detect voltage collapse and islanding

Forskningsrådet

CINELDI

Centre for Intelligent Electricity Distribution



- One of Norway's Centres for Environment-friendly Energy Research(FME) co-funded by the Research Council of Norway and Industry.
- Headed by SINTEF Energy Research in cooperation with NTNU and will operate for between five and eight years with a budget of about NOK 360 million.
- CINELDI will contribute to designing the future's flexible and robust electrical distribution grid at an acceptable cost.
- CINELDI will facilitate renewable energy, electrification of transport and more efficient use of energy.

Relay lab

In place:

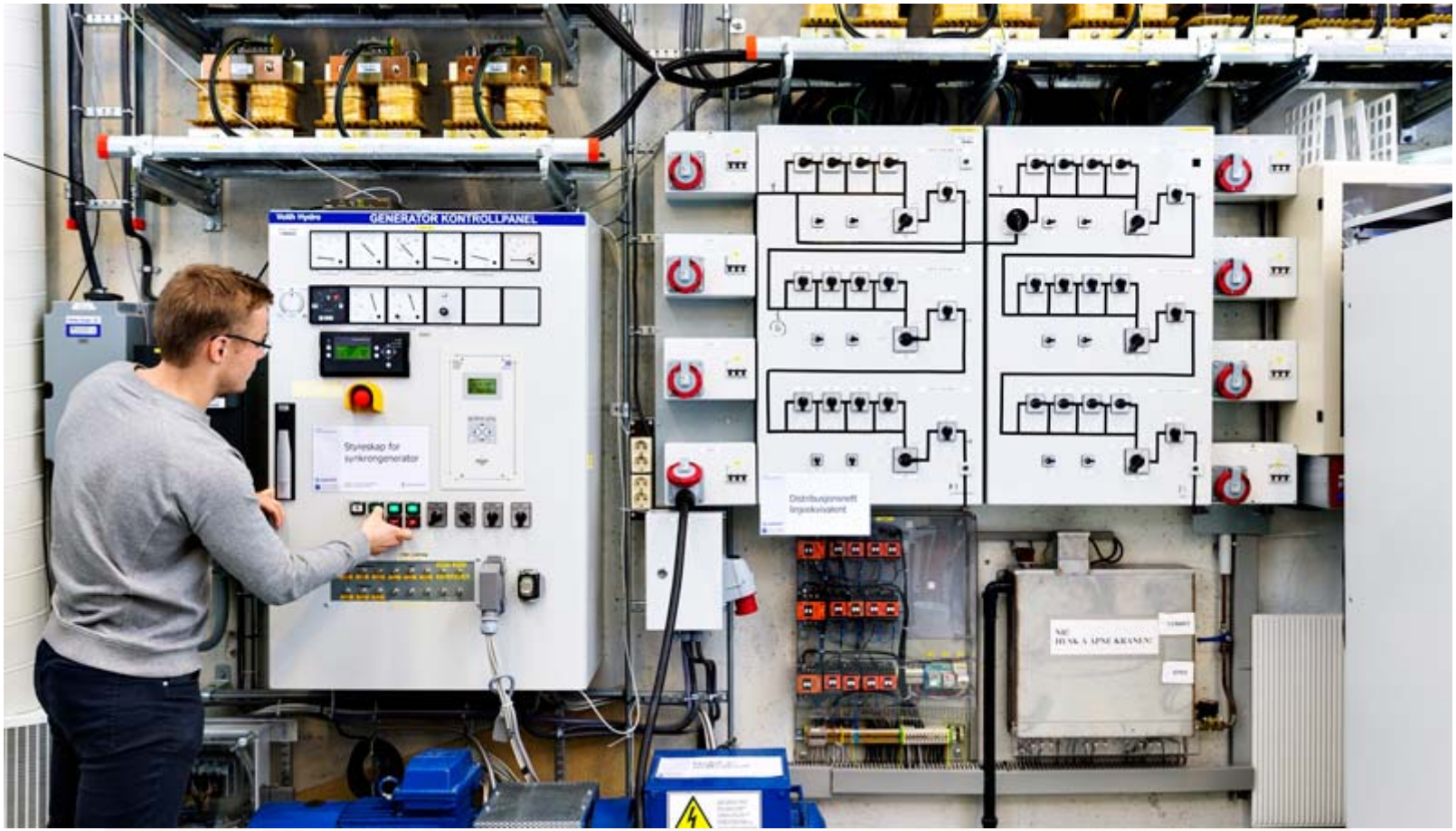
- OPAL-RT with full IEC 61850 capabilities
- 4 x 670 Relion relays
- Omicron CMC356
- Click switch emulator
- Station clock SEL2488

In queue:

- Merging unit SAM600
- Distrib.system relays

National smartgrid laboratory

Grand opening in September 2016



Testing PMU is the Smartgrid lab

- Education and emergency simulations
- Application development platform