Overview Training Topics

Economic driver for the development of renewable energy
- Cost of renewable energy
- Main financial support systems

Basic of solar PV and wind energy and different types of technologies
- Potential around the world
- PV development
- Principle of solar energy
- PV module and inverter in practice
- Principle of wind energy
- Wind turbine technology

International lessons learned from integrating vRE into power system
- Development and status in Germany and Denmark
- International comparison
- Power system aspects
- Key issues integrating vRE into power system
- Case study in Costa Rica

Regulatory issues for PV integration
- PV installation and connection procedues
- PV system installer quality and liability
- Application form for PV module and inverter
- PV panel roof installation process and commissioning
- German approach
- Grid connection in low voltage: Case study of Germany

Electricity market and vRE
- Introduction
- Unbundling system
- Electricity markets
- Renewable energy intensive
- Electricity tariff

Challenges of integrating vRE on transmission system level
- Overview of relevant issues and studies
- vRE variability and forecast errors
- Generatation adequacy and example
- Challenge in frequency response - Regulation of interconnected network and frequency stability
- Electro-mechanical stability
- Transient voltage stability
- Congestion management
- Dispatch balancing

Examples of grid integration studies for transmission network: Step-by-step approach how to do it

- Grid Integration Studies – Step-by-Step
- Example 1: German Grid Development Plan
- Dynamic Network Simulations – Step-by-Step
- Example 2: Costa Rica Wind and Solar Integration Study
- Example 3: USA - Western Wind and Solar Integration Study

Challenges of integrating vRE on distribution system level

- Case study on wind integration in Germany
- Case study on PV integration in India

Example of grid integration studies for distribution network: Step-by-step approach how to do it

- German distribution system study in the state of Rhineland Palatinate
- Indian distribution system study for rooftop PV

vRE power forecast

- Introduction of wind and solar prediction
- Unit dispatching
- Basic forecasting approach
- Forecasting error
- Generation flexibility
- Congestion forecast
- Forecast for trader
- Balancing forecast
- Case study in Germany

Grid code

- Grid code principle
- Development of grid code
- Lessons learned
- Harmomization - EU Grid Code
- Network code - Requirement for generator, demand connection
- System operation: Emergency and restoration
- German certification approach
- Grid code gap analysis for selected countries in ASEAN

Ancillary services from vRE

- On-going challenges
- Ancillary services from vRE
- Inertia response from wind turbines

Smart grid

- Introduction and definition of smart grid
- Example smart grid projects in EU (INES, GRID4EU)
- Status and example of smart grid development in ASEAN
- Cell controller project

Future technologies

- Sector coupling: Power-to-x
- EV and grid impact
- Storage and grid impact
- Power-to-gas

- Benefit of storage in low voltage distribution system with high PV penetration
- Energy storage technology

Integration strategies

- IEA strategy of system transformation
- Agora grid toolbox

Grid forming inverter

- Motivation
- Grid feeding VS Grid following inverter
- Proof of concept
- Alternatives and supporting measures

Grid stability

- Power system stability: Definition, rotor angle stability, frequency stability and voltage stability
- Technical requirement for vRE
- Supporting Technologies: Energy storage and dynamic security assessment

Blackstarting a power system with high vRE penetration

- Case study of blackout events wordwide
- System restoration plan
- Black start technologies
- Impact and requirement of vRE
- Restoration exmaples with wind power plant

Operation of island grid with high vRE penetration

- Island grid characteristics
- Island grid system
- Frequency control in island system: Barbados
- Case study of low contribution system : South Tarwa (Republic of Kiribati), Madeira island (Portugal), Canary island, Faroe island
- Case study of medium contribution system
- Case study of high contribution system

Grid operation with RE

- Impacts of renewable energy to grid operation
- Increasing power system flexibility approach
- Congestion management
- Technologies for congestion management
- Grid operation measures
- Forecasting for system operation

Balancing and virtual power plant

- Balancing power system
- Virtual power plant

Protection issues with vRE

- Main challenges in inverter-based system
- Grid disturbance: Protection issues with high distribution generator
- Technical capacity of wind and PV systems during grid fault