The Power of Transformation
Wind, Sun and the
Economics of Flexible Power Systems

Press Conference, 26 February 2014, Paris
Main Results

Ms Maria van der Hoeven
Executive Director
International Energy Agency
Current VRE shares and mid-term forecasts

Source: IEA statistics; note ERCOT = Electricity Reliability Council of Texas, United States

Instantaneous shares reaching 60% and above
Current VRE shares and mid-term forecasts

Instantaneous shares reaching 60% and above

Current VRE shares and mid-term forecasts

Case studies

Three main results

1. Very high shares of variable renewables are technically possible

2. No problems at low shares, if ...

3. Reaching high shares cost-effectively calls for a system-wide transformation
Integration means transformation

- Classical view: VRE are forced into the rest without adaptation
Integration means transformation

- Classical view: VRE are forced into the rest without adaptation

- More accurate view: entire system is re-optimised

→ **Integration is actually about transformation**
Transformation depends on context

**Stable Power Systems**
- Sluggish demand growth
- Little general investment needed short term

*Example: Europe*

**Dynamic Power Systems**
- Dynamic demand growth
- Large general investment needed short term

*Example: Emerging economies*

*Compound annual average growth rate 2012-20, slow <2%, dynamic ≥2%; region average used where country data unavailable*
Focus on key findings

Dr. Paolo Frankl
Head, Renewable Energy Division
Third project phase

- 7 case studies covering 15 countries, >50 in-depth interviews
- Technical flexibility assessment with revised IEA FAST tool 2.0
- Detailed economic modelling at hourly resolution
The 6 VRE properties that matter

- **Variable**
  - Maximum output varies depending on wind and sunlight

- **Uncertain**
  - No perfect forecast for wind and sunlight available

- **Non-synchronous technologies**
  - VRE connect to grid via power electronics, have little or no rotating mass

- **Location constrained**
  - Resource is not equally good in all locations and cannot be transported

- **Modularity**
  - Wide range of sizes and may be much smaller than other options

- **Low short-run cost**
  - Once built, VRE generate power almost for free
## The GIVAR III case study regions

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<thead>
<tr>
<th>Region</th>
<th>Power area size (peak demand)</th>
<th>Grid strength</th>
<th>Inter-connection (actual &amp; potential)</th>
<th>No. of power markets</th>
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Three pillars of system transformation

1. Let wind and solar play their part

Technology spread
Geographic spread
Design of power plants
System friendly VRE
1) System friendly VRE deployment

Example: System friendly design of wind turbines reduces variability

Source: adapted from Agora, 2013
1) System friendly VRE deployment

- Wind and solar PV can contribute to grid integration
- But only if they are allowed and asked to do so!

→ Take a system perspective when deploying VRE

Example: System friendly design of wind turbines reduces variability

Source: adapted from Agora, 2013
Three pillars of system transformation

1. Technology spread
2. Geographic spread
3. Design of power plants

System friendly VRE

2. Make better use of what you have

Operations

Balancing areas and markets: cooperation & consolidation

Market and system operations
2) Better system & market operation

- VRE forecasting

- Better market operations:
  - Fast trading
    Best practice: 
    US (Texas) – 5 minutes
  - Price depending on location
    Best practice: US – Locational Marginal Prices
  - Better flexibility markets
    Example: Fully remunerated reserve provision

➡️ Make better use of what you have already!
2) Better system & market operation

- VRE forecasting

- Better market operations:
  - Fast trading
    *Best practice: US (Texas) – 5 minutes*
  - Price depending on location
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  - Better flexibility markets
    *Example: Fully remunerated reserve provision*

⇒ Make better use of what you have already!
Three pillars of system transformation

3.
Take a system wide-strategic approach to investments!

- Balancing areas and markets: cooperation & consolidation
- Market and system operations
3) Investment in additional flexibility

Four sources of flexibility ...

- Grid infrastructure
- Dispatchable generation
- Storage
- Demand side integration
Three pillars of system transformation

- **Stable system**: New investment required
  - Sufficient existing flexibility resources
- **Dynamic system**: New investment required
- **Operations**: Balancing areas and markets: cooperation & consolidation
  - Market and system operations

- **Technology spread**
- **Geographic spread**
- **Design of power plants**
- **System friendly VRE**
System costs and transformation

Total system cost (USD/MWh)

- Grid cost
- DSI
- Fixed VRE
- Emissions
- Fuel
- Startup
- Fixed non–VRE

- Legacy
  - low grid costs
  - 0% VRE
  - 45% VRE penetration
System costs and transformation

Large shares of VRE can be integrated cost-effectively
System costs and transformation

- Large shares of VRE can be integrated cost-effectively
- But adding VRE rapidly without adapting the system is bound to increase costs
Investments in system flexibility – Need for a suite of solutions

- No single resource does it all!
Investments in system flexibility – Need for a suite of solutions

- No single resource does it all!
- Example:
  - Abundance
    - Flexible generation ✗ ✗
    - DSI ✓
    - Storage ✓
    - Curtailment ✓

Data: Germany 2011, 3x actual wind and solar PV capacity
Investments in system flexibility – Need for a suite of solutions

- No single resource does it all!
- Example:
  - Abundance
    - Flexible generation × ×
    - DSI ✓
    - Storage ✓
    - Curtailment ✓
  - Multi-day scarcity
    - Flexible generation ✓ ✓
    - DSI o
    - Storage ✓
    - Curtailment × ×

Solar and wind can be abundant ...

... or scarce.

Data: Germany 2011, 3x actual wind and solar PV capacity

✓ ✓: very suitable, ✓ : suitable, o : neutral, × × : unsuitable
All countries where VRE is going mainstream should:
- Optimise system and market operations
- Deploy VRE in a system-friendly way to maximise their value to the overall system

Countries beginning to deploy VRE power plants (shares of up to 5% to 10% of annual generation) should:
- Avoid uncontrolled local concentrations of VRE power plants ("hot spots")
- Ensure that VRE power plants can contribute to stabilising the grid when needed
- Use state of the art VRE forecast techniques
Countries with stable power systems should seek to

- Maximise the contribution from existing **flexible** assets
- Consider accelerating system transformation by decommissioning or mothballing **inflexible** surplus capacity

Countries with dynamic power systems should

- Approach VRE integration as a question of holistic, long-term system transformation from the onset
- Use energy planning tools and strategies that appropriately represent VRE’s contribution at system level
Q & A