Flexible hydropower providing value to renewable energy integration

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Presentation of White Paper no 1 - October 2019
Growing variable renewable energy (VRE) generation

- Coal: 38%
- Gas: 23%
- Nuclear: 10%
- Oil: 4%
- Renewables: 25%

Bar chart showing the growth in variable renewable energy (VRE) generation from 2010 to 2018:
- Bio
- Solar
- Wind
- Hydro
Balancing generation vs consumption

**Energy storage**
- Electrochemical
- Thermal storage
- Chemical storage
- Hydropower and PHS
- Flywheels
- Liquid and compressed air
- Superconductors
- Future technologies?

**Other sources of flexibility**
- Demand response
- Generation flexibility
- Flexible transmission
- Curtailment
Flexible hydropower
1. Preparation period
2. Ramping period
3. Min and max quantity
4. Min and max delivery period
5. Deactivation period
6. Min duration before next activation
What kinds of flexibility are needed?

• Power system size
• Power plant flexibility
• Demand-side flexibility and storage
• Correlation of VRE and demand
• Geographical distribution
• Interconnection and bottlenecks
• Regional correlation of VRE generation
### Timescales of power system flexibility

<table>
<thead>
<tr>
<th>Flexibility type</th>
<th>Short-term</th>
<th>Medium term</th>
<th>Long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time scale</td>
<td>Sub-seconds to seconds</td>
<td>Hours to days</td>
<td>Days to months</td>
</tr>
<tr>
<td>Issue</td>
<td>Ensure system stability</td>
<td>Short-term frequency control</td>
<td>Determining operation schedule in hour- and day-ahead</td>
</tr>
<tr>
<td>Relevance for system operation and planning</td>
<td>Dynamic stability (inertia, voltage, frequency)</td>
<td>Primary and secondary frequency response</td>
<td>Balancing real time market (power)</td>
</tr>
</tbody>
</table>

**Flexibility type**
- **Short-term**: Sub-seconds to seconds
- **Medium term**: Hours to days
- **Long-term**: Days to months, Months to years

**Time scale**
- **Sub-seconds to seconds**: Flexibility type
- **Seconds to minutes**: Time scale
- **Minutes to hours**: Issue
- **Hours to days**: Relevance for system operation and planning
## Phases of VRE integration [IEA 2017]

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>At initial stage of VRE deployment with no relevant effects in system operation</td>
<td>Still many countries</td>
</tr>
<tr>
<td>2</td>
<td>Additional flexibility needs can be met by minor adjustments in existing operations</td>
<td>Brazil, China, India, Sweden, Texas</td>
</tr>
<tr>
<td>3</td>
<td>VRE generation determines system operations in order to maintain stability</td>
<td>Italy, Germany, Portugal, Spain, UK, California</td>
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<tr>
<td>4</td>
<td>Additional investments in flexibility resources are needed to balance the system</td>
<td>Ireland, Denmark, South Australia</td>
</tr>
<tr>
<td>5</td>
<td>Structural surpluses of VRE generation from weeks to months may lead to curtailment</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Structural over- or under-supply over seasons to years validates the need for sector coupling</td>
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</tbody>
</table>

*from IEA 2017*
How can hydropower contribute?

Phases of VRE

1. Business as usual
   - Short-term flexibility, ancillary services

2. Short-term flexibility, ancillary services
   - More frequent ramping, start/stops, partial load, producing and consuming (pumping)

3. Long-term flexibility, pumping and storage (duration) when needed

4. Large scale capacity driven short term flexibility, capacity plus energy-driven medium-term and long-term flexibility (power and energy)

How can hydropower contribute?

Phases of VRE

1. Energy supplier (base load)
2. Short-term flexibility
3. 
4. 
5. Renewable flexibility supplier
6. Long-term flexibility

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What is the value of flexibility?

• Providing ancillary services, power and energy
• Highest value when the system is at the extremes
• Avoid deficit and limit surplus
• The value depends on available solutions
• Plant characteristics are important
The value of providing flexibility in market-based systems

• Price impact of changing systems
  • Lower average power price
  • Increase variations in price
  • Higher price peaks?

• Increasing importance?
  • Magnitude and frequency of extremes
  • Trading in several markets
  • New markets? What about long-term flexibility?

Marginal cost of the last unit sets the price
Conclusions

→ Increasing shares of VRE + decommissioning of fossil-based plants = increasing needs for flexibility at all time scales

→ Hydropower offers a unique range of possible flexibility capabilities

→ The market value of flexibility-related products should reflect the value these products provide to the electricity system and to the society
Recommendations

Authorities should design markets that trigger investments in system infrastructure so that all the services required to ensure a secure, reliable and affordable supply of energy are delivered.

Existing and new hydropower plant owners should analyse the capability and possible investments after deciding which type(s) of flexibility are best suited for their assets.
Flood control and drought management provided by hydropower

• The value of the services that hydropower can provide in minimizing and mitigating the risks of floods and management of droughts in a changing climate
• The value of avoiding and reducing floods
  • Reduced damage by protection
  • Providing possibilities of land use
• The value of providing water management services
  • Water for irrigation, domestic and industrial use
  • Water for the environment
• How can different needs for water and energy security be met today and in the future?
• Kick-off workshop organized in Rio in December 2019
• Collection of case studies and examples of flood control and drought management
Further work

• Assessment of technological, market, policy and regulatory requirements to ensure appropriate investments

• Optimizing market mechanisms to ensure sufficient flexibility at the right scale and the right time

• Understanding the frequency and magnitude of extremes and the impact on power prices

• The investment dilemma – effective price signals to ensure sufficient system capacity – avoiding price shocks for consumers in the long run

• Workshop to discuss 2\textsuperscript{nd} white paper in Washington DC March/April