Hydropower in Enel and implementation of WFD in Italy

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Enel today
Global and diversified operator

- ~40 €bn Regulated Asset Base
- ~62 mn distribution end users
- #1 in Italy, Spain, Chile, Peru
- #2 in Argentina, Colombia
- ~47 GW thermal capacity
- ~38 GW renewable capacity
- ~18.3 mn free retail customers
- #1 in Italy and Spain
- Presence with operating assets

1. As of 2016
2. Consolidated (35.9 GW) and managed (1.9 GW) capacity including 24.9 GW of large hydro.
3. Presence with operating assets
# Enel - Operational data

Leadership along the various segments of the value chain

## Key indicators

<table>
<thead>
<tr>
<th>Infrastructure &amp; Networks</th>
<th>62 mn end users</th>
<th>41.2 mn smart meters</th>
<th>1.9 mn km grids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail</td>
<td>56.4 mn power customers</td>
<td>5.5 mn gas customers</td>
<td></td>
</tr>
<tr>
<td>Renewables generation</td>
<td>35.9 GW of installed capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal generation</td>
<td>46.8 GW of installed capacity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Enel and European peers

<table>
<thead>
<tr>
<th>Customers (mn)</th>
<th>Enel</th>
<th>European peers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>38</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Installed capacity (GW)</th>
<th>Enel</th>
<th>European peers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>83</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

| Grid Length (mn km) | Enel | European peers |
|                    | 1.9  | 1.3            |
|                    | 1.0  | 0.8            |
|                    | 0.7  |                |

1. Data as of December 31st 2016; 2. Data as of December 31st 2016; 3. Retail Customer: Free + Regulated; 4. Figure refers to the European perimeter (Engie does not disclose total number of customers); 5. It doesn’t include 1.9 GW of managed capacity
Spain
Plants: 230
Capacity: 6.4 GW

Italy
Plants: 669
Capacity: 14.3 GW

Romania
Plants: 13
Capacity: 0.5 GW

India
Plants: 3
Capacity: 0.2 GW

Panama
Plants: 4
Capacity: 0.3 GW

Colombia
Plants: 11
Capacity: 3.0 GW

Guatemala
Plants: 5
Capacity: 0.2 GW

Mexico
Plants: 11
Capacity: 0.7 GW

USA-Canada
Plants: 110
Capacity: 3.1 GW

Argentina
Plants: 2
Capacity: 1.3 GW

Costa Rica
Plants: 3
Capacity: 0.1 GW

Peru
Plants: 7
Capacity: 0.8 GW

Chile
Plants: 35
Capacity: 4.7 GW

Brazil-Uruguay
Plants: 44
Capacity: 1.4 GW

South Africa
Plants: 7
Capacity: 0.5 GW

GRE O&M global presence – Enel Green Power

1,206 plants    37.6 GW installed    84.6 TWh produced    19 Countries    4,400 O&M people
**Water Framework Directive in Italy**

**WFD objectives**
- To prevent deterioration and enhance the status of the water environment
- To achieve the «good» ecological status of all rivers before 2015
- To reduce and prevent pollution in river basins

**Legislative Decree n. 152/2006**

- Creation of European River Basin Districts Authorities
- Redaction of RB Management Plans
- Achievement of «good ecological status» before 2015
- From Minimum Vital Flow ➔ Ecological Flow (EF)

**United Text for Environment**

- Implementation of WFD in Italy ➔ L.D. 152/2006
- Creation of 8 River Basin Districts Authorities
- Publishing of the 8 River Basin Management Plans
- Adoption of RBMPs in Regional body of laws ➔ diversification
- Monitoring and definition of ecological Status at river level

- Published n. 8 River Basin Management Plans
- Definition of ecological status for all rivers
- First review of RBMPs
- Update of ecological status of all rivers

- Italy entirely implemented WFD in April 2006, by publication of Legislative Decree n. 152 (simplification of the body of laws)
- Italy completed definition and «start up» of the 8 River Basin Districts Authorities, by publisching the first edition of RBMPs in 2009
- Each RBD updated its management plan within December of 2015
- According to L.D. 152, RBMPs have to be implemented at regional level, therefore each Region adopt a «Water Safeguard Plan»
WFD in Italy – Status of implementation

Distribution of the quality status of rivers in Italy, as defined in the 8 RBMPs:

![Pie chart showing the distribution of river quality status in Italy]

- **Class 1 “High”**: 5%
- **Class 2 “Good”**: 15%
- **Class 3 “Moderate”**: 43%
- **Class 4 “Poor”**: 32%
- **Class 5 “Bad”**: 5%

Ecological Flow → plays a key role in the enhancement of the status of river basins, in order to achieve the «good» status required by WFD

The 8 Italian River Basin Districts:
Ecological Flow

Formula to calculate Ecological Flow:

\[ EF = k \cdot q_{\text{med},a} \cdot S \cdot M \cdot Z \cdot A \cdot T \] (l/s)

where:
- \( k \) = adimensional scaling factor, specific for the river considered and defined in RBMP
- \( q_{\text{med},a} \) = annual flow rate per unit of basin surface (l/s/km²)
- \( S \) = basin surface of the river section considered (km²)
- \( M \) = morphologic parameter defined in the range 0.7 ÷ 1.3
- \( Z \) = the greatest among \( N, F, Q \), defined as follows:
  - \( N \) = naturalistic parameter ≥ 1
  - \( F \) = utilization parameter ≥ 1
  - \( Q \) = water quality parameter ≥ 1
- \( A \) = parameter related to the interaction between surface water and underground water defined in a range 0.5 ÷ 1.5
- \( T \) = parameter related to time modulation of the EF

- For current utilizations, such as Enel hydroelectric facilities, according to Legislative Decree n. 152, EF had to be defined within 31 of December 2016, except for the cases of ongoing trials.

- The approval of EF for each river is demanded to Regional Department, through Water Safeguard Plans, and some Region established specific exceptions (case of Sicily) or temporal delays (case of trials, in most of the Italian regions).
Ecological Flow

Many benefits, some drawback:

- Loss of production, with economic impact for hydropower operators
- Additional production from traditional Thermal Power Plants, in order to cover national demand of energy

A cost-benefit evaluation, in our opinion, should be considered also in a regulatory context.
Case study: Ecological Flow on Gesso river

- All activities on field commissioned by Enel SpA and performed by GRAIA srl
- Our path: a trial to define Ecological Flow
Case study: Ecological Flow on Gesso river

Hydro Power Plants on Gesso river:

<table>
<thead>
<tr>
<th>HPP</th>
<th>Type</th>
<th>Unit</th>
<th>Capacity (kW)</th>
<th>Gross Head (m)</th>
<th>Max Flow (mc/s)</th>
<th>Anno</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANDONNO</td>
<td>Reservoir</td>
<td>2</td>
<td>65,000</td>
<td>273</td>
<td>30,000</td>
<td>1965</td>
</tr>
<tr>
<td>ENTRACQUE CHIOTAS</td>
<td>Pumping Storage</td>
<td>8</td>
<td>1,065,000</td>
<td>1,048</td>
<td>128,000</td>
<td>1982</td>
</tr>
<tr>
<td>ENTRACQUE ROVINA</td>
<td>Pumping Storage</td>
<td>1</td>
<td>125,000</td>
<td>598,26,950</td>
<td>950</td>
<td>1980</td>
</tr>
</tbody>
</table>

Large Dams on Gesso river:

<table>
<thead>
<tr>
<th>Dam</th>
<th>HPP</th>
<th>Volume Mmc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiotas</td>
<td>Entracque Chiotas</td>
<td>27,3</td>
</tr>
<tr>
<td>Piastra</td>
<td>Andonno</td>
<td>12,0</td>
</tr>
</tbody>
</table>
Case study: EF on Gesso river

Trial on Gesso River:

- Kick off trial on Gesso river
  - EF Approved → to be tested!

- Environmental Monitoring
  - Kick off
  - 1° year reporting

- Environmental Monitoring
  - 2° year reporting

- Deeper analysis required by Local Administration (mesohabitat and 2D modeling of S.Anna river)

- Reporting of mesohabitat analysis and 2D modeling of S.Anna river during meetings with Local Administrations

- Reporting of monitoring discussed in meetings with Local Administrations

- D.D. n. 2220 del 22/07/2013
  - To define EF for Chiotas Dam and Piazza Dam
  - Environmental monitoring on ecological effects of EF (3 years)

- Final Meeting
  - Approval of EF

- Final definition of EF to be applied ongoing
Case study: EF on Gesso river

Monitoring site:
- 7 monitoring stations for scheduled activities
- 3 further monitoring stations for additional activities

Quality status of rivers as defined in RBMP of District Po

<table>
<thead>
<tr>
<th>Nome</th>
<th>Codice</th>
<th>Tipologia</th>
<th>Confini</th>
<th>Lunghezza (km)</th>
<th>Stato attuale</th>
<th>Obiettivo Ecologico</th>
<th>Obiettivo Chimico</th>
</tr>
</thead>
</table>
Case study: EF on Gesso river

Scheduled monitoring activities:

- Flow rate measurement with determination of hydraulic-structural parameters (speed, wet area, etc..); 4 times per year
- Analysis of main chemical-fisic water parameters in order to define LIM e LIMeco indexes according to L.D. 152/06; 4 times per year
- Multihabitat measurement of macrobenthos and evaluation of STAR_ICMi index; 2 times per year
- Characterization of diatomée bentoniche with application of multimetric index ICMi; 2 times per year
- Measurement of fish density; 2 times per year
- Determination of IFF index

Additional monitoring activities:

- Modelization of fish habitat with bidimensional hydraulic approach (in 3 sites).* Trota Fario and Scazzone have been selected as target species.*
Case study: EF on Gesso river

Results

LIM and LIMeco indexes are used for classification of chemical-fisic parameters

STAR_ICMi and IBE indexes are used for classification of macrobenthos population

Most of indexes show HIGH quality!
Case study: EF on Gesso river
Measurement of fish density

Density (n°/ha)

- On field measurements show a well structured presence of fish fauna in Gesso river, basically trota fario and scazzone
- Most of fishes have lengths between 70 and 180 mm
Case study: EF on Gesso river

Additional activities: bidimensional simulation of *Trota Fario*’s habitat in a specific section of Gesso river

Flow Q = 139 l/s

Flow Q = 209 l/s

Flow Q = 418 l/s
Case study: EF on Gesso river

RESULTS: simulation of *Trota Fario*’s habitat

- ADP (%): parameter that represents the attitude of the fish to live in a given river section (fish’s habitat)
- ADP > 60% is recognized as satisfactory
- ADP > 80% is recognized as optimum

**Adult trota fario: always optimum!**

**Young trota fario: always satisfactory!**
Conclusions and final remarks

Implementation of WFD in Italy:

✓ Italy implemented the WFD through the United Text for Environment (L.D. n. 152/2006)
✓ Distribution of the quality status of rivers in Italy, as defined in the 8 RBMPs, show a majority of «good» and «moderate» status
✓ According to L.D. 152, RBMPs are implemented at regional level by adoption of Water Safeguard Plans for each Region
✓ Therefore the new opportunity of trials in order to define the Ecological Flow for existing hydro facilities is born
✓ The application of EF has many benefits, but also some drawback, such as loss of production and additional capacity required

Trial on Gesso river:

✓ Ecological flow (as a result of the trial) define a «good» status on Gesso river, «high» for many parameters
✓ With specific respect to trota fario’s habitat, it is not possible to establish a single value of flow rate that is optimal for both adult and young examples, therefore a compromise is necessary
✓ Bidimensional simulation shows that increasing the EF up to the values determined in the trial has no benefits for environment and fishes’ habitat
Thanks!