Hydropower in Enel and implementation of WFD in Italy

29/05/2017

Andrea Casolaro

Head of Safety and Water Management at Business Unit Hydro Piemonte

Green Power

Enel today[1]

Global and diversified operator

~**40** €bn Regulated Asset Base
~**62** mn distribution end users

#1 in Italy, Spain, Chile, Peru
#2 in Argentina, Colombia

~**38** GW renewable capacity[2]

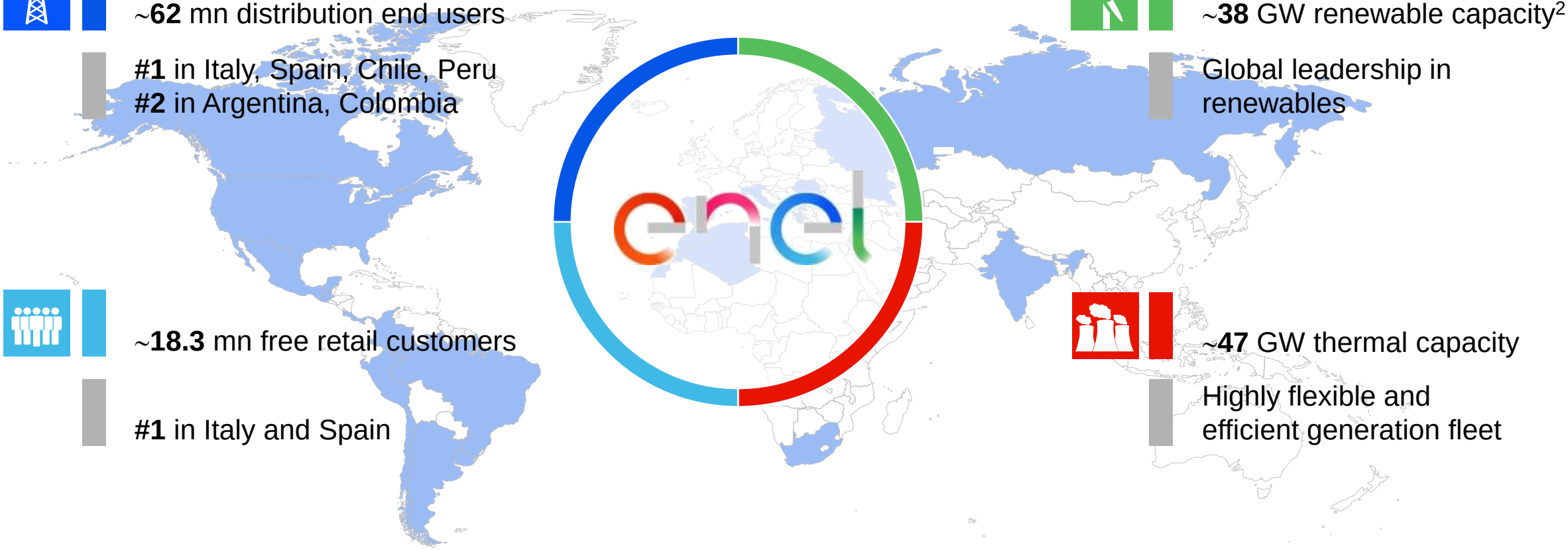
Global leadership in renewables

~**18.3** mn free retail customers

#1 in Italy and Spain

~**47** GW thermal capacity

Highly flexible and efficient generation fleet



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[1]

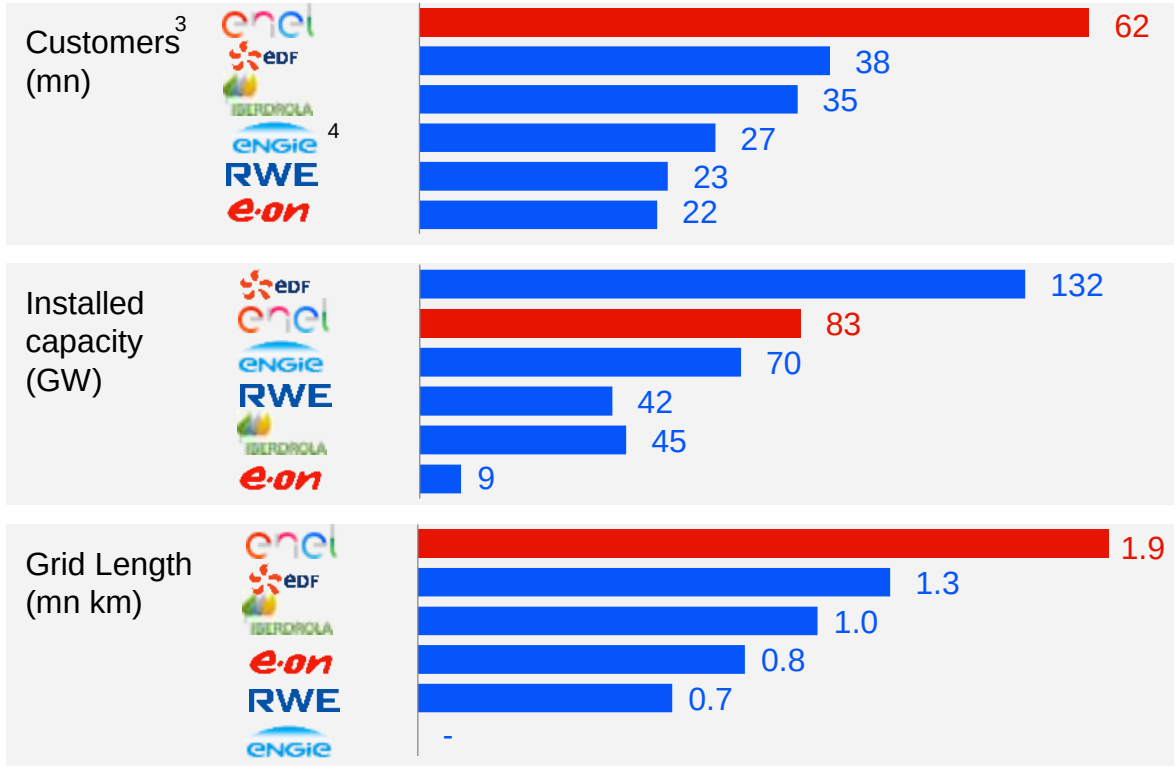
Infrastructure & Networks
62 mn end users
41.2 mn smart meters
1.9 mn km grids

Retail
56.4 mn power customers
5.5 mn gas customers

Renewables generation
35.9 GW of installed capacity[5]

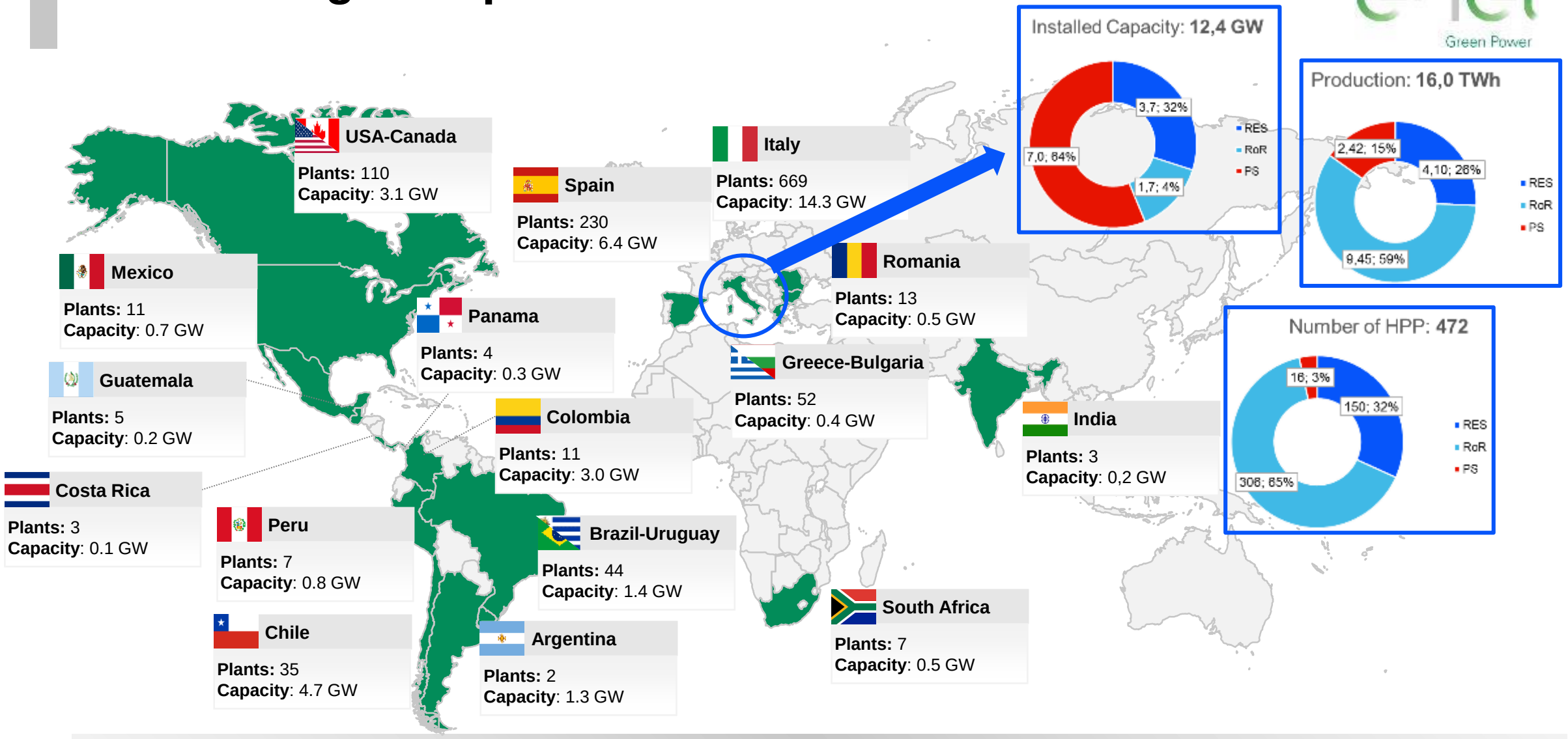
Thermal generation
46.8 GW of installed capacity

Enel and European peers[2]



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 disclosure total number of customers); 5. It doesn't include 1.9 GW of managed capacity*

GRE O&M global presence – Enel Green Power



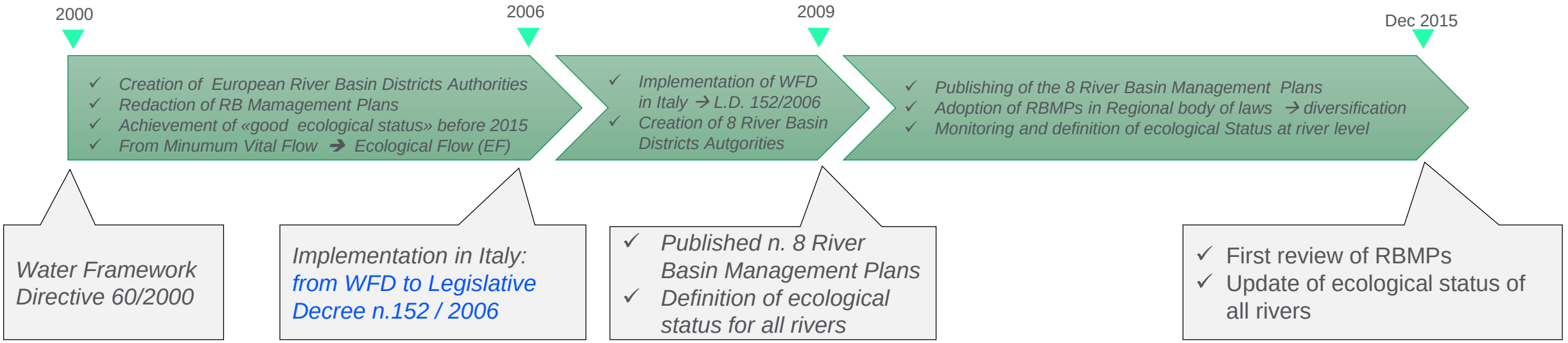
1,206 plants **37.6 GW installed** **84.6 TWh produced** **19 Countries** **4,400 O&M people**

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

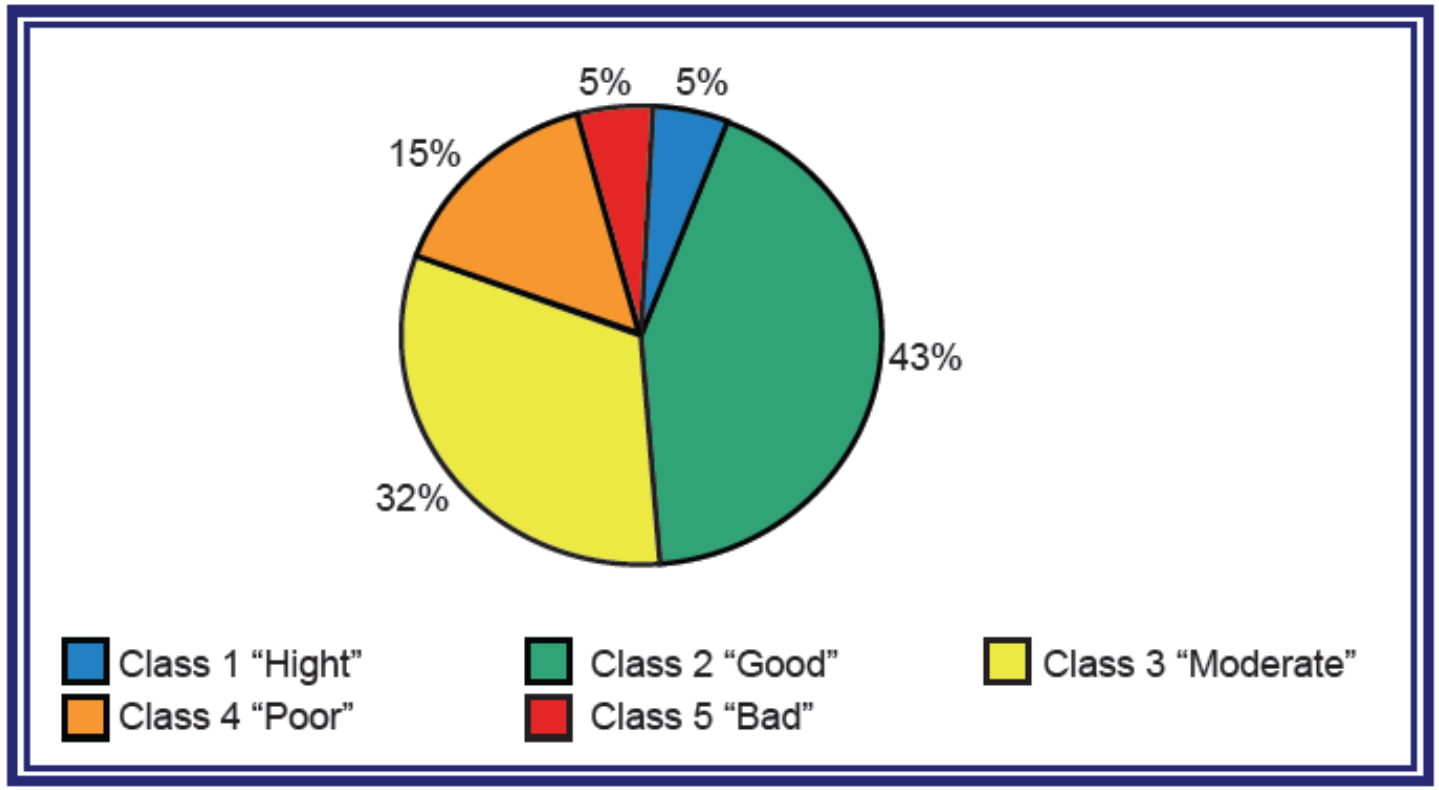
Legislative Decree n. 152/2006 → **United Text for Environment**



- ✓ Italy entirely implemented WFD in April 2006, by publication of Legislative Decree n. 152 (semplification 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:



The 8 italian River Basin Districts:

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

Ecological Flow

Formula to calculate Ecological Flow:

EF = k · qmed,a · S · M · Z · A · T (l/s)

where:

k = adimensional scaling factor, specific for the river considered and defined in RBMP
qmed,a = annual flow rate per unit of basin sufrace (l/s/km^2)
S = basin surface of the river section considered (km^2)
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.

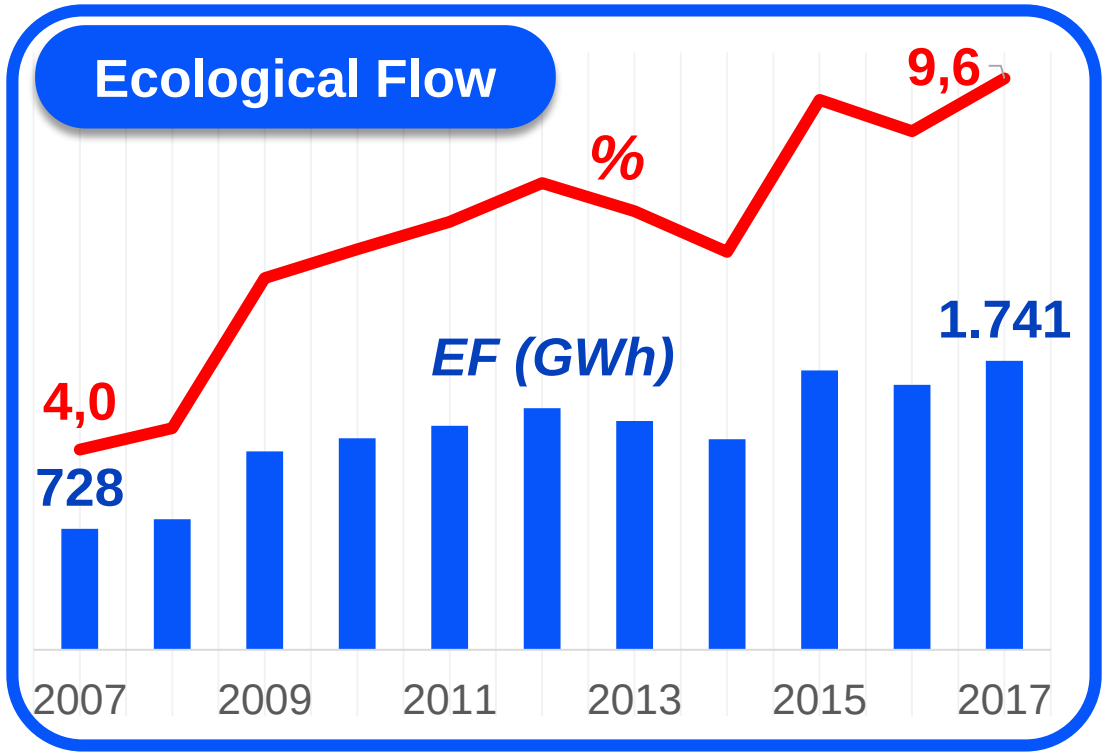
- The approval of EF for each river is **demanded to Regional Department**, through Water Safeguard Plans, and some Region established specific exceptions (case of Sicily) or temporal delays (case of trials, in most of the italian regions).

Opportunity of trials!

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

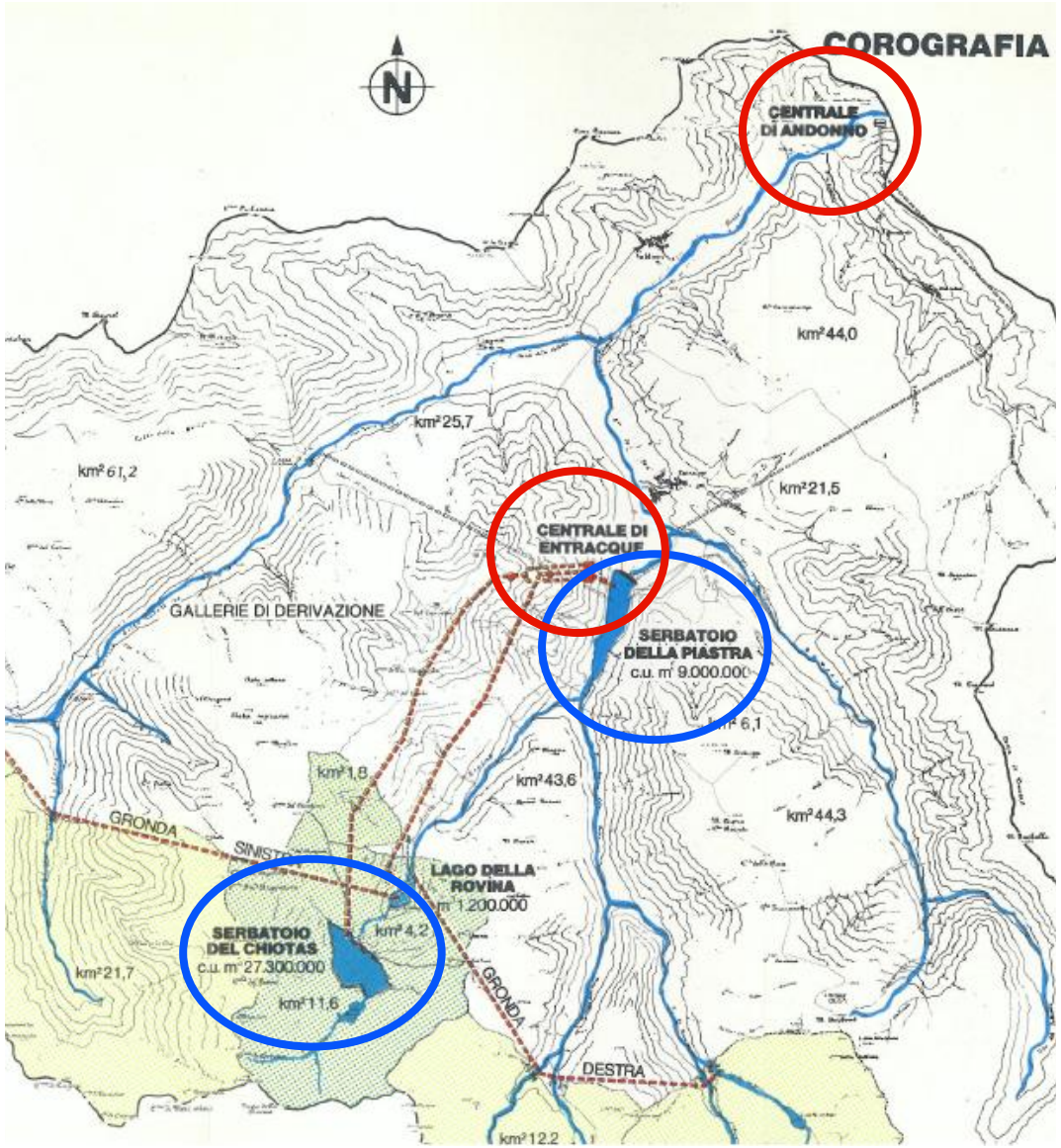


A cost-benefit evaluation, in our opinion, should be considered also in a regulatory context.

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:

HPP	Type	Unit	Capacity (kW)	Gross Head (m)	Max Flow (mc/s)	Anno
ANDONNO	Reservoir	2	65.000	273	30,000	1965
ENTRACQUE CHIOTAS	Pumping Storage	8	1.065.000	1.048	128,000	1982
ENTRACQUE ROVINA	Pumping Storage	1	125.000	598	26,950	1980

Large Dams on Gesso river:

Dam	HPP	Volume Mmc
Chiotas	Entracque Chiotas	27,3
Piastra	Andonno	12,0

Case study: EF on Gesso river

Trial on Gesso River:

July 2013

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

Kick off
trial on Gesso river

EF Approved → to be tested!

October 2013

Reporting of monitoring discussed in meetings with Local Administrations

Environmental Monitoring

Kick off

December 2014

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

Environmental Monitoring

1° year reporting

December 2015

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

Environmental Monitoring

2° year reporting

December 2016

- ➢ *Final Meeting*
- ➢ *Approval of EF*

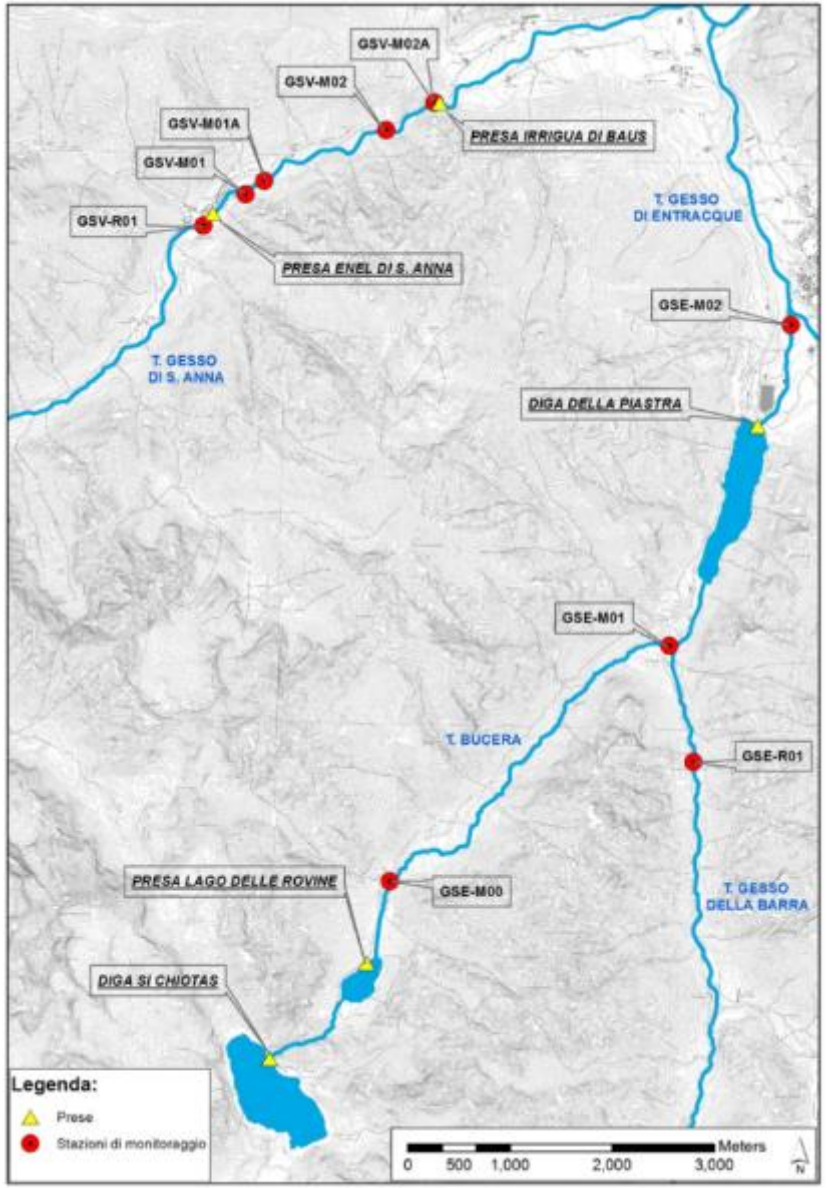
Environmental Monitoring

final reporting

TBD

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

Nome	Codice	Tipologia	Confini	Lunghezza (km)	Stato attuale	Obiettivo Ecologico	Obiettivo Chimico
Gesso della Valletta	04SS2N223PI	04SS2N	Sorgente - confluenza Gesso di Entracque	27	Buono	Buono al 2015	Buono al 2015
Gesso di Entracque	04SS2N224PI	04SS2N	Sorgente - confluenza Gesso della Valletta	42	Buono	Buono al 2015	Buono al 2015

Case study: EF on Gesso river

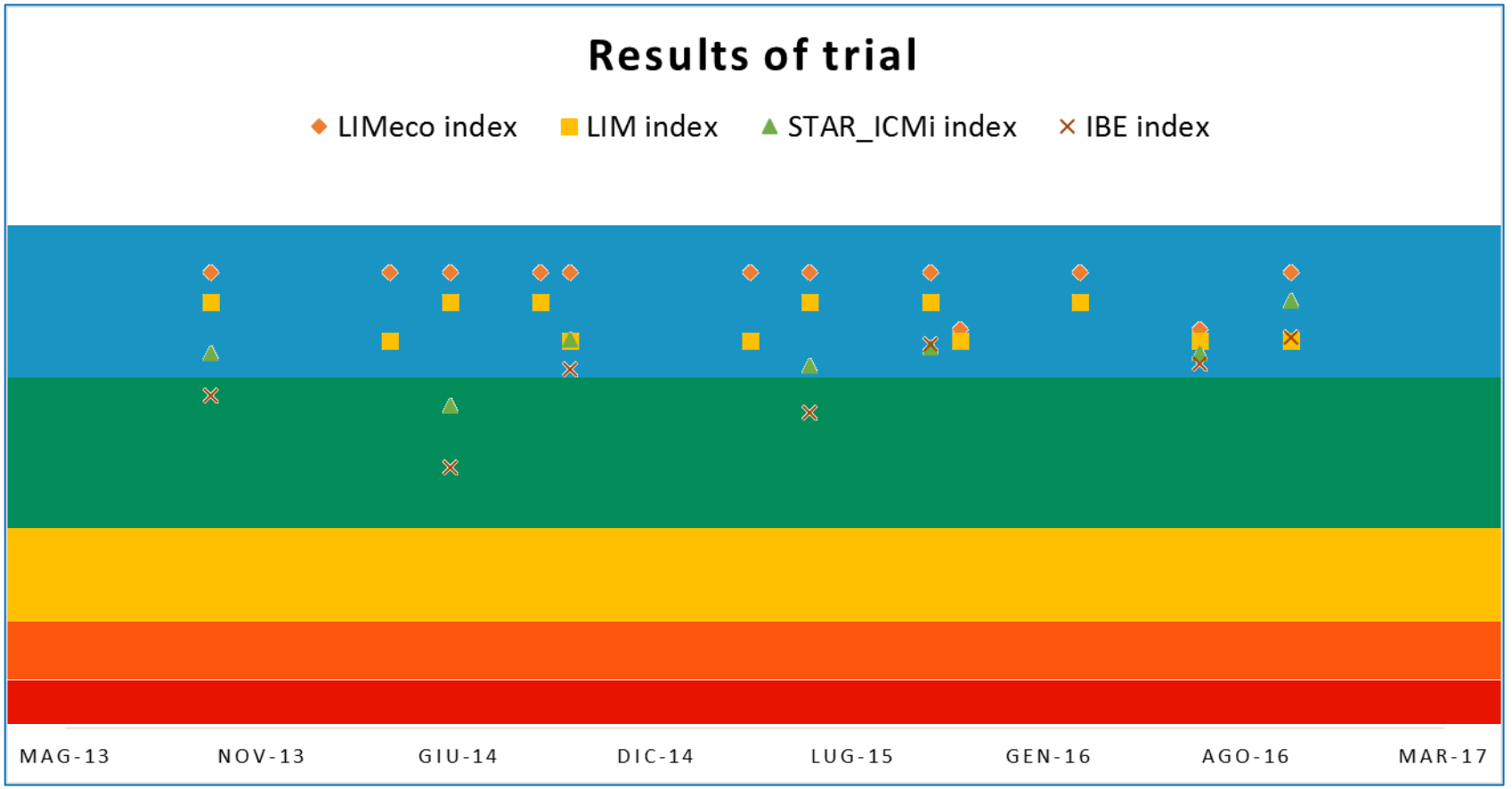
Scheduled monitoring activities:

- **Flow rate measurement** with determination of hydraulic-structural parameters (speed, wet area, etc..); 4 times per year
- Analisys 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 **diatomee bentoniche** with application of miltimetric 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!

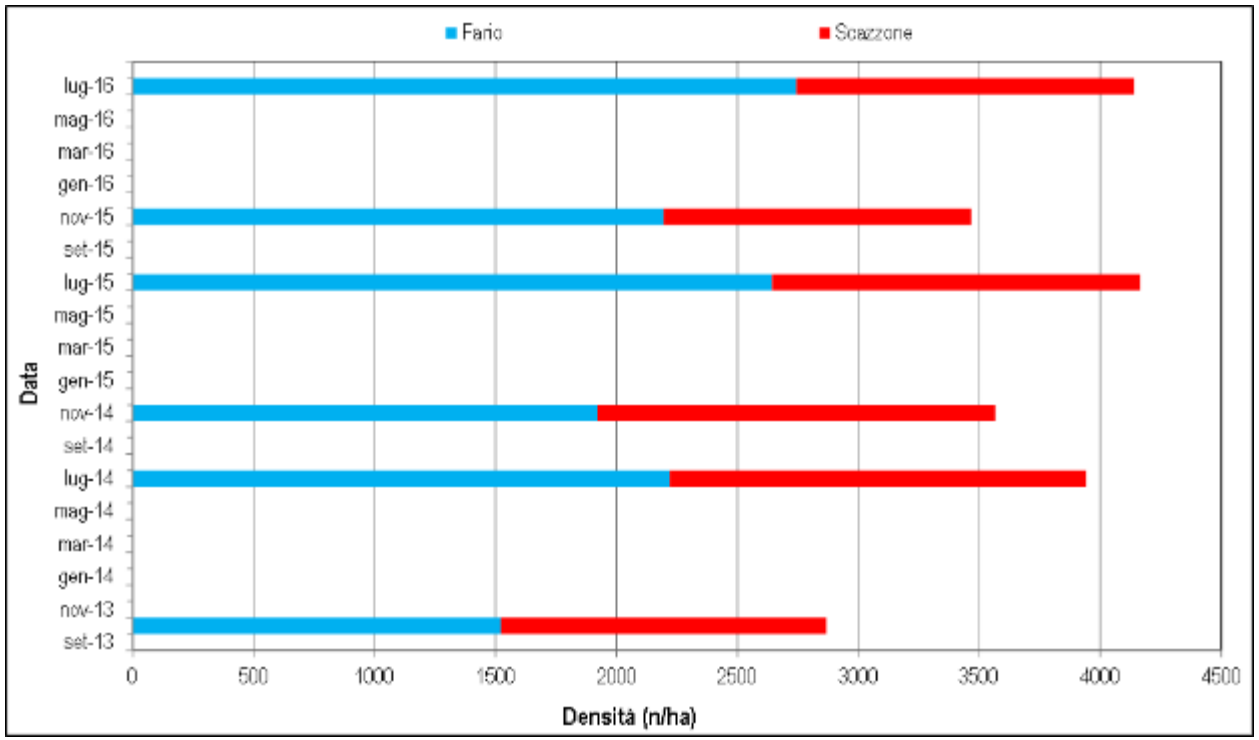
Clusterization, according to WFD and L.D. 152:

HIGH	GOOD	MODERATE	POOR	BAD

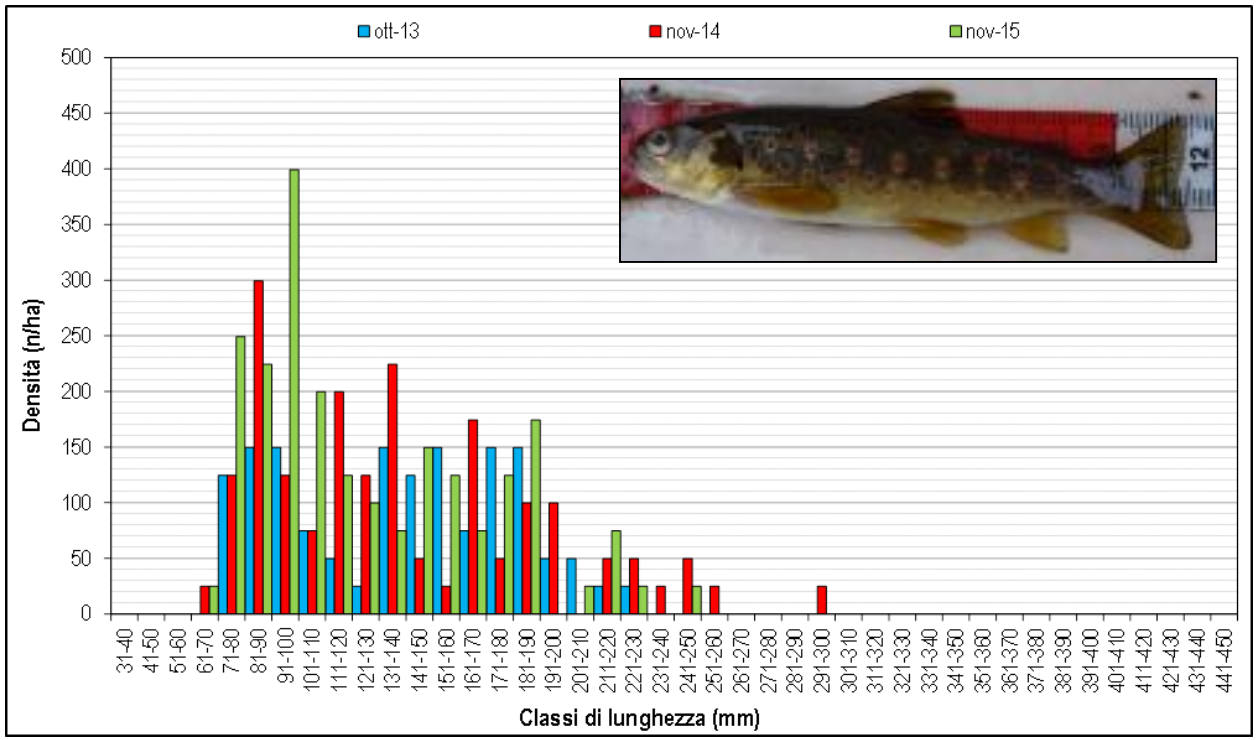
Case study: EF on Gesso river

Measurement of fish density

Density (n°/ha)



Type of trota fario in autumn

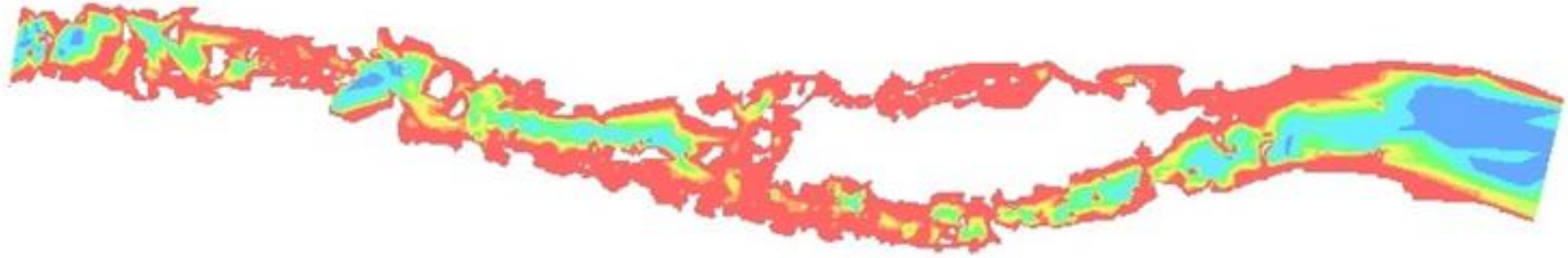


- ✓ On field measurements show a well structured presence of fish fauna in Gesso river, basically trota fario and scazzone
- ✓ Most of fishes have lenghts between 70 and 180 mm

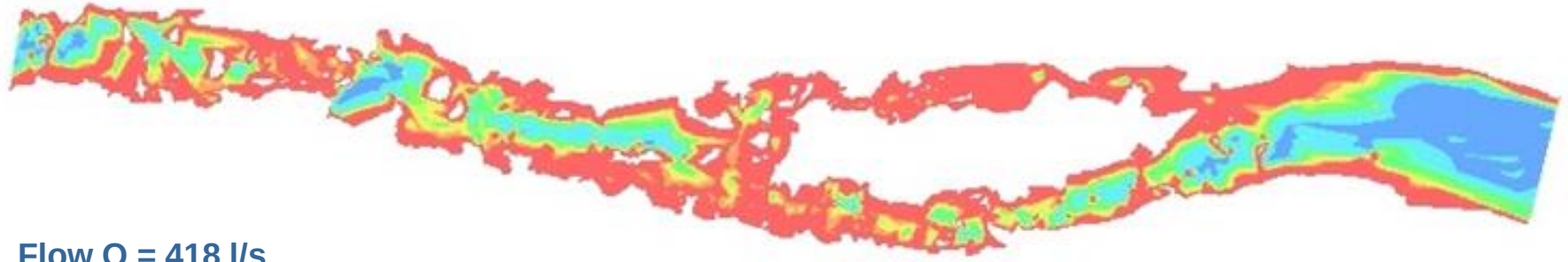
Case study: EF on Gesso river

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

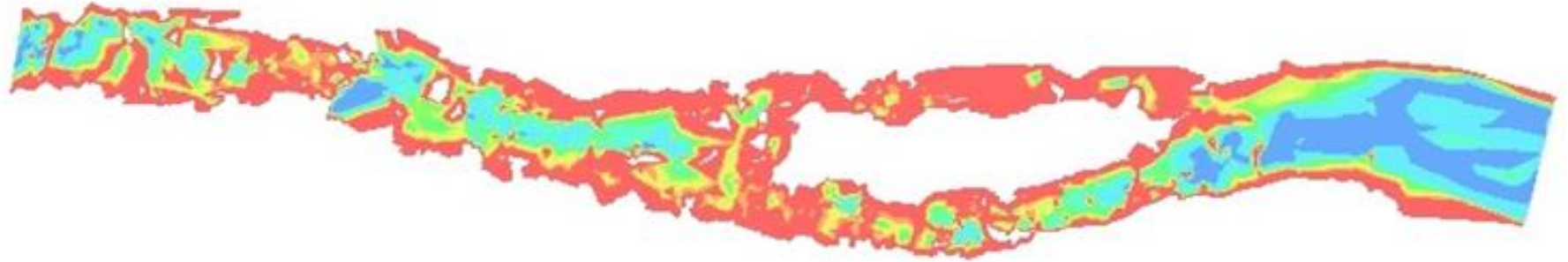
Flow Q = 139 l/s

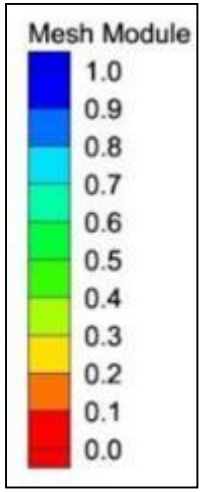


Flow Q = 209 l/s



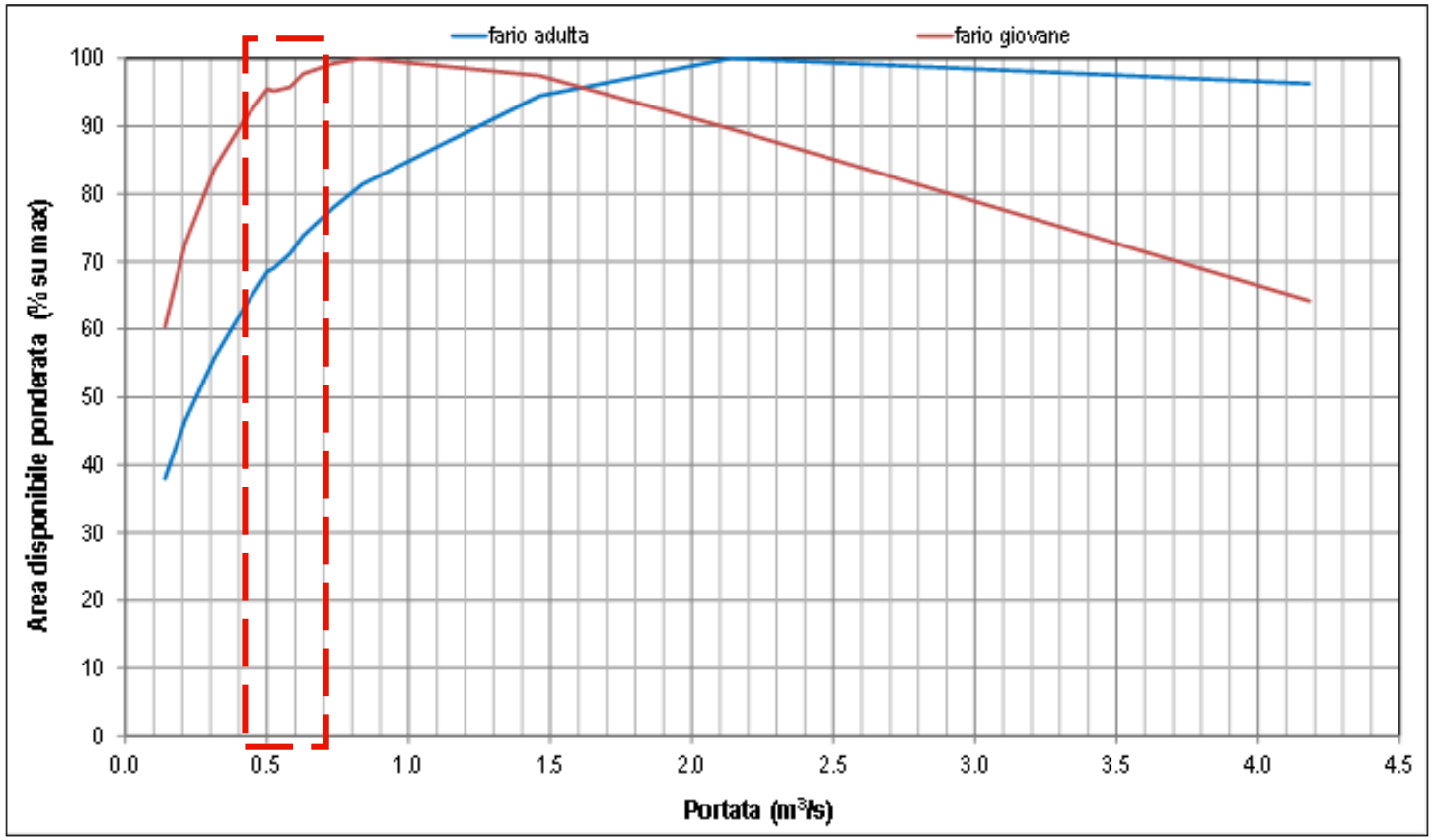
Flow Q = 418 l/s





Case study: EF on Gesso river

RESULTS: simulation of *Trota Fario*'s habitat



- ADP (%): parameter that represent 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 sepcific 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 exemples, 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!