

# The green certificates: new prospects for Hydro Electricity in Italy

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## Introduction

The new legal frame is defined by the Law Decree of March 1999 enforcing in Italy the European Community Directive 96/92 relating to the electrical market liberalization and by the subsequent Operating Decree of November 1999.

They define the renewable energy sources, object of Green Certificates and some other advantages, and fix the amount of 2% of the whole fossil-fuel thermal energy, produced or imported after 2001, as "portfolio of renewable energy" that every producer and distributor shall own.

According to the Kyoto Protocol, Italy should reduce, before 2012, the carbon dioxide emission of 6.5% compared with the 1990 value, which means a reduction of about 110 Mt of the total carbon dioxide expected emission.

The contribution of Energy Production at the gas emission is of about 30%, so the hydraulic energy covering 18% of the total Energy Production should have an important role to fulfil the Kyoto objectives.

The first results coming from the analysis of more than 80 new and rehab power stations projects, profitable thanks to the Green Certificates, show a notable increase of the technical exploitable hydraulic potential for the immediate future, higher than 7%.

As examples of economic analysis, we report the outcomes of three different power stations projects:

- completely new realization of a high head power plant with existing basins;
  - new medium head power station with existing feeding civil works;
  - upgrading of an old low head power station without strong modification of the civil works;
- all of them with the hypothesis of 120 Lire /kWh for a Green Certificate as a mean value, and an economic life of 30 years respectively. These Projects are at phase of realization final decision.

Finally, we will make some considerations about the "Green Pricing market" made by the renewable Energy Certificates (RECS). They are also included in the new operating Law Decree according to which the Producers can ask the National Grid Administration to certify the origin of electric energy produced by renewable sources, as well as in use in some other western countries.

## 1. Background of Italy

Main Subjects	Total n° of plants	n° of Plants (P > 10 MW)	Efficient Power (MW)	Yearly producibility (GWh)
ENEL Group	652	429	16 638	36 936
Municipalities	122	97	1 335	4 449
Indip.Prod.	500	465	1 858	7 598
Others	665	597	315	1478
<b>Total</b>	<b>1 939</b>	<b>1 588</b>	<b>20 146</b>	<b>50 461</b>

Tab. 1 – Efficient power & producibility of hydroelectric plants in Italy

The hydraulic source exploited for energetic aims has marked the progress of the industrial civilization since its dawning. Italy, in particular, has got benefits from the presence on its territory of a double mountain chain: the Alps arch and the Apennine ridge that with their rivers and natural basins have allowed to manufacture a series of hydroelectric power plants provided with hydraulic machinery of any type. As a matter of fact, it is thanks to the installation of Pelton, Francis and Kaplan turbines and of pumps and reversible pump-turbines that till half of the sixties the main part of electric energy necessary to the country has been supplied by hydroelectricity by exploiting a natural potential.

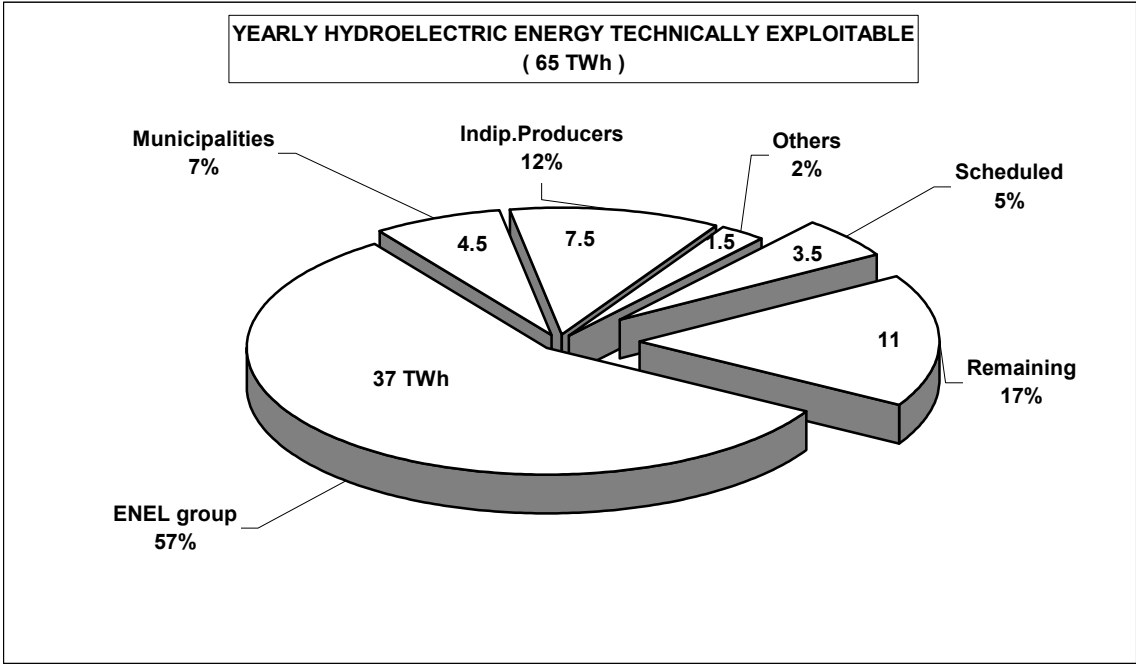
- The most significant power plants performed in the field of the pure generation are those relating to:
- the Pelton unit for the S. Giacomo sul Vomano power house in Central Apennine that with 282 MW of power output and a head of 630 m represents one of the largest machines of this type;
  - the Francis unit for the Rovina Piastra power house (Western Alps) that with more than 130 MW of power output and a head of 550 m is one of the most significant realizations among the power plants with high heads; the Isola Serafini (Middle Padana Valley) that is particularly noteworthy because of the fact that by exploiting a bend of the river Po by means of its 4 Kaplan units with head of 7.6 m, it is able to exploit the whole river discharge that amounts to more than 1200 m<sup>3</sup>/s.

The most prestigious realizations in the field of pumping and storing units are represented by the record power plants of Chiotas (Western Alps) and Edolo (Central Alps) producing 1000 MW each. Both these plants are equipped with reversible multi-stage pump turbines that, with heads over 1000 m, reach 150 MW per unit. The Presenzano power plant (Central Apennine) is also part of this type of realizations: with its reversible single-stage pump-turbines having heads of 500 m, it reaches 250 MW per unit.

A recent picture of the efficient power and the mean producibility of the hydroelectric power plants in Italy is given by the Tab 1.

**2. Yearly Hydraulic Potential Technically Exploitable**

All prudential evaluations fixed the amount of the yearly hydroelectric potential energy, technically exploitable at the time being in Italy, in at least 65 TWh. This value can be assumed as 100% (see Diag.1).



Diag.1 – Hydroelectric Energy Sharing & Exploitable Potential

**2.1 Today consumption**

Referring to that minimum potential value, it comes out that up to now about 78% of it has been utilized: roughly 50.5 TWh out of 65 TWh, it means that an amount of 14.5 TWh has remained to be still exploited (22%).

## 2.2 Scheduled

In the early years of the new century, the realizations of the planned interventions provided by the Law 9/91 and relevant actuating prescriptions (C.I.P. 6/92 and subsequent revisions) will increase the total installed hydroelectric power by 1200 MW (500 of which from ENEL) for a new producibility of 3.5 TWh (more than 5% of potential).

In this case, the total exploitation of hydroelectric source should reach 80% of the potential.

## 2.3 Remaining potential

The rough estimate of the remaining potential of 11 TWh, about 17% (see Tab. 2), is made by many contributions that can be summarized as follows:

<b>Exploitable Potential</b>	<b>Power ( MW )</b>	<b>Yearly producibility ( TWh )</b>	<b>Total ( % )</b>
a) New & Rehab Projects studied by Enel ( P > 10MW )	1500	5	7,7
b) Repowering of old Enel Hydroelectric park groups ( P > 10MW )	900	2,8	4,3
c) New & Repowering Projects of non Enel old hydroelectric park groups ( P > 10MW )	500	1,2	1,9
d) Mini Hydro new *& rehab projects ( P < 10 MW ) * <i>Thermie Action n° DIS-1556-97-IT</i>	500	2	3,1

**Tab. 2** – Remaining Yearly Exploitable Hydraulic Potential ( 11 TWh )

### a) New and Upgrading Projects studied by ENEL (P > 10 MW)

During the last twenty years, ENEL has developed a remarkable number of projects relating to the construction of new power plants or to the upgrading of the existing ones, and after the new law on the market liberalization, more than 80 projects have been re-examined, also under the "green certificate" prospects.

The results, considering the increase of the compulsory higher level of Minimum Vital Outflow of about 5% with respect to the previous value, estimates in more than 5 TWh the value of new producibility ,about 7.7% of the potential ( see Tab.3 )

### b) Repowering of old ENEL power plants (P > 10 MW)

More than 60% of the total hydroelectric power, for an amount of 12.4 GW, is over 40 years old, and 91, out of the 213 power plants manufactured before 1960, have been operating for more than 60 years.

A recent analysis showed that 1080 out of the 1240 ENEL groups entered into operation before 1965, that is more than 35 years ago.

Seeing that with its 160 power plants producing more than 20 MW each, ENEL covers 88% of its power and 77% of its producibility, a repowering program, with an increase of producibility of at least 15% dealing with merely 65% of the ENEL power stations, allows an increase of 2.8 TWh (about 4.3% of potential).

(All this assuming that the remaining 35% of power stations has been included in the new projects studied by ENEL, as mentioned at point a).

### c) New studies and repowering of non ENEL power plants (P > 10 MW)

The amount of 1.2 TWh (1.9% of the minimum potential) should come from the non-ENEL hydroelectric park repowering and from new power stations not studied yet.

#### d) Mini hydro power plants (P < 10 MW)

The whole contribution of mini-hydro (P < 10 MW) has been evaluated not to be able to produce more than 2 TWh for an amount of 500 MW of installed new power (about 3.1% of the minimum potential).

Type of plant	N°	Power ( MW )	Producibility ( GWh )	Investment ( Mio Euro )
New	40	970	3000	1300
Upgrading / Repowering	44	810	2550	500
<b>TOTAL</b>	<b>84</b>	<b>1780</b>	<b>5550</b>	<b>1800</b>

Tab. 3 – New/Upgrading Projects studied by ENEL

### 3. Kyoto Engagement

The engagement of December 1997 "Kyoto Protocol" is clear in its main terms: "Reducing the carbon dioxide (CO<sub>2</sub>) gas emissions in order to reduce the greenhouse effect".

The immediate consequence is that not even a plant of electrical energy production from renewable source would be renounced, provided its realization is consistent with the environment.

#### 3.1 White book 99 plan

The objective assumed by Italy is to reduce in 2012 the greenhouse gas emissions by 6.5% compared with the emissions of 1990: that means to pass from about 401 Mt to about 375 Mt of CO<sub>2</sub> in 2012 (see Tab. 4).

As the primary energy demand in 1990 was of 163.3 Mtep and the forecast by 2012 is of 194 Mtep, it is foreseen that, without any organic intervention on the productive mix, the emissions of CO<sub>2</sub> (with the average of 2.5 Mt of CO<sub>2</sub> for each 1 Mtep of fuel) would be equal to 485 Mt.

To reach the Kyoto goals, it is necessary to reduce the CO<sub>2</sub> emission by more than 110 Mt.

The yearly electrical energy demand from the Italian grid in 2012 will be 360 TWh, equivalent to 80 Mtep (1Mtep = 4.5 TWh), this value corresponds to 41% of the total primary energy demand, so it has been assigned to the electrical energy a contribution of emission reduction of 40% shared as follows:

22 Mt less, from the efficiency increase of the thermoelectric production park and  
18 Mt less, from the renewable sources production.

The 18 Mt less of CO<sub>2</sub> from the renewable sources (hydro, geo, aeolian, photovoltaic, biomass, trash...) are equivalent to 6.5 Mtep of primary energy, that means 29.25 TWh of more electrical energy from renewable sources.

It has been foreseen that the hydroelectric power could contribute to it with 1800 MW, both from new and from repowered plants, increasing the energy production from hydraulic source by about 5.4 TWh.

In this way, the CO<sub>2</sub> emission saving should amount to 1.2 Mtep of primary fuel energy not utilized, which means 3 Mt of CO<sub>2</sub>: roughly 17% of renewable sources contribution.

Energy Items		Year 1990	Year 2000	Year 2012
<b>Total Primary Energy</b>	<b>( Mtep )</b>	<b>163.3</b>	<b>185.4</b>	<b>194</b>
<i>Increase respect 1990</i>	<i>( % )</i>		13.5	18.8
<b>Electric Energy</b>	<b>( Mtep )</b>	<b>52,2</b>	<b>65.5</b>	<b>80</b>
<i>Percent on Primary Energy</i>	<i>( % )</i>	32	35	41
<b>* 1 Mtep = 4,5 TWh</b>	<b>( TWh)*</b>	<b>( 235 )</b>	<b>( 295 )</b>	<b>( 360 )</b>
<b>Hydraulic Energy</b>	<b>( TWh )</b>	<b>45</b>	<b>50.5</b>	<b>56.4</b>
<i>Percent on Electric Energy</i>	<i>( % )</i>	19	17.3	15,6
<b>CO<sub>2</sub> Emissions</b>	<b>( Mt )</b>	<b>401</b>	<b>434</b>	<b>485</b>

<b>Kyoto goals</b>	<b>( Mt )</b>	<b>375</b>
<b>Expected reduction</b>	<b>( Mt )</b>	<b>110</b>
<b>Reduction respect 1990</b>	<b>( % )</b>	<b>6.5</b>

**Tab. 4 – Italy Energy Prospect**

#### 4. Legal Framework

The new rule enforced in Italy by the Law Decree of March 1999 and subsequent Operating Decree of November 1999, implements the EEC Directive 96/92 regarding the liberalization of the electric energy market.

They both introduce some benefits for the renewable energy sources:

- First of all the electric energy produced by renewable sources and by cogeneration will have a "Dispatching" priority;
- Secondly, a bonus named "green certificate" shall be recognized for every 100 MWh coming from new and repowered power stations put into operation after April 1999 for a duration of 8 years after the Commissioning.

The "green certificate" can be asked to the National Grid Administration starting from the first of January 2001 for the production expected in 2002.

The "green certificates" shall be put in the stock market like shares of Producers and Importers that should be exchanged at the value fixed by the demand-offer mechanism.

The first scenery fixes the price value of "green certificates" around 120 Lire per kWh.

- Thirdly, after 2001, every Producer or Importer shall have in hands an amount of 2% of his whole fossil-thermal energy, exceeding 100 GWh a year, as portfolio of renewable new energy.
- Fourthly, the Authority resolution 82/99 recognizes a special purchase tariff, proportioned at the scale diseconomy, to the small hydroelectric plants (up to 3000 kW).

All these things should play an important role to rise faster the hydraulic potential exploitation.

#### 5. Practical examples about the effects of green certificates

The following examples, concerning feasibility studies for three recent cases, show how the law intervention relating to the green certificates may render economically advantageous a critical, or even to be rejected, investment that would have brought not to exploit a potential renewable natural resource.

For all three of these cases, we have assumed an economical life duration of 30 years, and a discount rate of 12%, taking also into consideration the various amortization rates of civil works, penstocks and of different types of electromechanical supplies.

##### Case a) NEW HIGH HEAD POWER PLANT (with existing basins)

Intervention providing for civil works, penstock and a new power house equipped with a 30 MW Pelton turbine, with an expected yearly producibility of 63 GWh.

The costs envisaged for EPC have been assessed in 28,4 Million Euro, shared as follows:

Civil works and Clerk of works	53%
Penstock (erected and tested)	13 %
Electro-Mechanical Supply (Erection, Commissioning and Tests)	34%

In this case all the energy produced for the first 8 years is subject to Green Certificates.

##### Case b) NEW MEDIUM HEAD POWER PLANT (with existing feeding dam)

Intervention providing for a new central building with installation of a 21 MW Francis turbine and expected yearly producibility of 35 GWh.

The costs envisaged for EPC, for a total of 13 Million Euro, are the following:

Civil Works and Clerk of works	24%
Penstock (with erection and tests)	11%
Electro-Mechanical Supply (Erection, Commissioning and Tests)	65%

Also in this case all the energy produced for the first 8 years is subject to Green Certificates.

##### Case c) OLD LOW HEAD MINI HYDROPLANT UPGRADING (with existing weir)

Electromechanical re-powering of an obsolete power plant, more than 60 years of life, with increase of the current yearly producibility of 7 GWh to 10 GWh obtained by introducing new single-regulating TAT units.

Expected cost of the investment equal to 2 Million Euro, shared as follows:

Civil Works and Clerk of works 17%  
 Electro-Mechanical Supply (Erection, Commissioning and Tests) 83%

In this case, only the increase of produced energy (3 GWh) would be subject to Green Certificates if the Authority accepts the concept to grant them for the amount of producibility increase caused by the mere replacement of the electromechanical machinery and by the limited interventions performed to the intake and outflow works.

The tab. encl. 5 summarizes the results of the three examples comparing the three main estimate rates of the investments: N.P.V. (net present value), P.B.P. (pay back period), I.R.R. (internal rate of return) without and with the application of the Green Certificates for the first 8 years of production.

As it can be seen in the table, the introduction of Green Certificates is certainly an incentive able to make economically interesting the investment and able to increase the value of the hydroelectric resource.

Project	Yearly Production ( GWh )	Medium Tariff (Cent. Euro/KWh )	Investment ( Mio Euro )	N.P.V. ( 30 years & discount rate 12%)	P.B.P. ( years )	I.R.R. ( % )
a )	64	3.6	28.4	-18.6	>30	4.8
<b>a ) with G.C.</b>	<b>64</b>	<b>3.6</b>	<b>28.4</b>	<b>3.4</b>	<b>13</b>	<b>13.5</b>
b )	35	4.6	13	-2.4	>30	9.9
<b>b ) with G.C.</b>	<b>35</b>	<b>4,6</b>	<b>13</b>	<b>9.7</b>	<b>5.4</b>	<b>22</b>
c )	10	3.6	2	0.67	12.4	15.5
<b>c ) with G.C. only for 3 GWh</b>	<b>10</b>	<b>3.6</b>	<b>2</b>	<b>1.7</b>	<b>5.9</b>	<b>22</b>

Tab. 5 – Examples of Projects Economic Analysis

## 6. Green pricing market

The new operating Law Decree allows the Renewable Sources Producers to ask the National Grid Administration to certify the origin of electric energy produced by renewable sources independently by the Green Certificates.

These new Renewable Energy Certificates (RECS) shall be a recognition of environmental value of the produced energy for feeding the “green pricing “market.

RECS should allow the producers to demonstrate to consumers that electric energy put in the market comes from RES.

So consumers can choose to address, completely or partly, their energy consumption to RES, showing to be available to pay a higher price than for every coming from fossil fuels.

Furthermore there is the possibility of creating a commercial mark to give prominence, beside of green energy, even the products coming from industries which consume renewable energy: the major cost born to purchase green energy should be compensate by a benefit of their public image.

An example of such a mark is “100% energia verde”. The mark has been created by ERGA (a company created by Enel for RES production) and APER (the Italian Association promoting production from RES) and managed by the CISE consortium.

In any case the issue of RECS represent an important incentive for new initiatives in the small hydro field which isn't linked to law obligations but only a free market choice.

## Conclusions

The white book states that only 1.9 TWh, more than the scheduled intervention of 3.5 TWh, among new, rehab and mini-hydro, could be implemented before 2012, for a total amount of 5.4 TWh.

That is to say putting into operation in ten years merely 600 MW more than the 1200 MW already scheduled for the early years of 2000.

It seems a prudential evaluation: as we have seen in this paper, the hydraulic energy could give a higher contribution, especially after the liberalization law and the Green policy introduction, which might light again the investment in this field : for instance starting from the realization of the New and Upgrading Projects already studied by ENEL (abt. 5 TWh).

This means to start with a program of realization of new/upgrading power for 1600 MW in ten/twelve years for an investment of abt. 1 800 Million Euro.

It is surely necessary to verify the actual value of the Green Certificates and wait for the expected positive effect of the Green Label on the Energy Market, but it is also necessary to create all the contour conditions to fasten all the authoritative procedures, which are in many cases the real handicap for the hydropower station realization.

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