Renewable energy in Italy:
scenarios to 2030

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Abstract

The study represents an exploration of the Italian energy situation, which is characterised by huge energy imports, strong dependence on fossil fuels, and carbon emissions well above the Kyoto target. Certainly, in such a situation, given the nuclear energy ban of the Italian 1987 referendum, renewable energy could help the country. Nonetheless, its high costs could be an obstacle that strongly limits its expansion. One of the main results of the analysis performed with IRED (Italy's Renewable Energy Development) is that an increase of the renewables' share up to 20% in 2020 represents a striking change in the structure of the Italian electricity system, which, under certain conditions, is not feasible. Italy faces a sort of triangular challenge, involving fossil fuel prices, renewables production costs, and carbon prices. The trends in these variables will decide the destiny of renewables in the country.

The model

This paper gives a general overview of the IRED (Italy's Renewable Energy Development) model. IRED is a model primarily based on the system dynamics approach, which encompasses econometric forecasts, technical assessment, and cost estimation. IRED is able to generate a large number of scenarios and sensitivity analyses on a set of elements, the most important of which are primary energy demand, electricity demand, renewables mix, investment and operation costs, fossil fuel costs, and carbon prices. IRED base year is 2005, provided the latest official figures on a number of variables at the time of modeling. The simulation spans until 2030. The IRED's framework is showed in Fig.1. As can be seen at top of Figure 1, key drivers are economic growth, primary energy intensity, and electricity intensity. Combining electricity intensity and economic growth gives electricity consumption that, in turn, is instrumental to infer the projected electricity production. Parallel to that, over Total Primary Energy Supply maps into the renewable energy needed so to comply with the 2020 goal. Since in IRED we assume that all new renewable energy will be renewable electricity, electricity gross production and the renewable energy policy path determine residually how much electricity will be generated from non-renewable sources. Provided with simulations on electricity generation by source, one can consequently compute the two major output at stake, that is costs and emissions. Overall costs depends on the intensity each energy source contribute to total power generation and on fuel prices as well. Detailed cost accounting then translate into a synthetic €/kwh reference estimate. On the environmental side, the expansion of renewables brings about CO_2 emission containment. The CO_2 market value consequently indicate the monetary savings accrued from having reduced the dependence on fossil fuel.

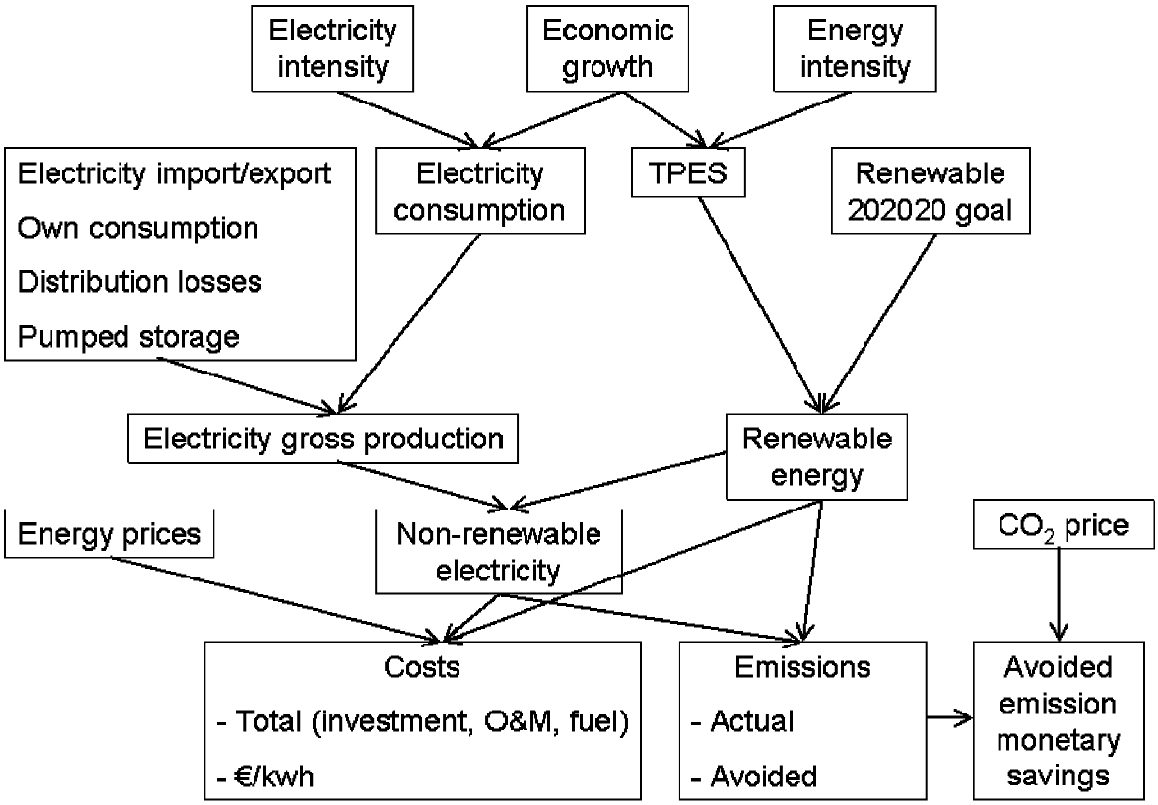

Figure 1. IRED's model framework.

Economic development is set to take exogenous paths at 1%, 1.5%, and 2%, in line with Italy's disappointing macroeconomic performances over the last 10 years. Italian primary energy intensity time series has shown a upside-down-U-shaped curve peaking in the mid-Seventies. This indicator has then asymptotically reached its steady state, hovering 0.09 Mtoe per 2000 USD at Purchasing Power Parity1. 0.09 is, hence, projected to be to future Italian primary energy intensity. Electricity intensity is interpolated econometrically, provided its satisfactory linear fit. The model thus adopts three electricity intensity scenarios. The more

[1] International Energy Agengy data.

energy-intensive one projects the linear regression. The other two assume more moderate expansions, having respectively 2/3 and 1/3 increase rates of the energy-intensive forecast.

Electricity intensity is defined as electricity consumption over real income, one needs to infer gross production to analyze on the generation side of the electrical system. In order to do that, the model assumes electricity import, export, distribution losses, own consumption, and pumped storage as shares of overall electricity consumption. Calibrations of such shares is corroborated by their historical stability, therefore reassuring the modeler of embodying realistic assumptions. Gross electricity production is consequently broken down in the energy sources generating it.

Official estimates report 78 Twh-equivalent energy for 2005 produced from renewable source (Italian Position Paper). Reporting the same documents a share of 5.2% renewable energy, one induces that Italian 2005 energy consumption was 1,496 Twh. Under the above-mentioned mild economic growth estimates combined with stagnant primary energy intensity, 2020 simulations indicate 1870 Twh primary energy-centered estimates, with little variation (extreme simulations set the limits of 1740 and 2000 Twh). Comparison of the 2020 primary energy forecasts with the Italian 17% renewable energy commitment gives a rough indication that absolute renewable energy production should linger around 310 TWh. Considering 75 Twh were already from renewable source in 2005, additional 235 Twh in 2020 are required to meet the European target.

As far as cost estimates are concerned, the model treats separately the existing capital stock from the one yet to be allocated . Such split should reflect the idea that policy makers have considerable room with respect to the capacity yet to be installed, while maneuver is stickier in changing the existing installed capacity. In addition to this, new capital stock expenditures benefits, in this model, from recent, Italy-specific, detailed cost estimates from Lorenzoni and Bano (2007), making it a reliable simulation of what the energy policy makers will actually face.

Power generating costs are divided into the usual categories – investment, operation and maintenance (O&M), and fuel costs, when present. Being these data expressed in €/kwh, investment costs underlie financing and depreciation assumptions as illustrated in Lorenzoni and Bano (2007). In order to account for future learning process stemming from cumulated renewable technology facility installation, yearly 2 % investment cost contraction for all renewable sources is adopted. Learning process is assumed to not affect O&M and fuel costs.

The overall renewable energy additional production is, under different scenarios, split into these 14 energy sources plus geothermal energy that is not assessed in Lorenzoni and Bano (2007).

Total generating cost has an historical component measured at 2005 energy production plus a post-2005 component. While the first one, minimal at the end of the simulation period, is based upon average generation costs, the additional renewable energy generate enjoy Table 1 thorough estimation. Summing up all costs related to generating energy brings to computing €/kwh, a valuable synthetic indicator.

Non-renewable energy sources in Italy are natural gas, coal, and oil. Much-rumored nuclear option, though part of many parties' 2008 election programs, has slim chances to play a role ar all. Energy from uranium has had the habit in Italy of losing and gaining stage, with no subsequent policy spill over whatsoever. Oil has been phased out and according to the Italian Government2 will no longer be part of the generation park in 2011. Coal remains a big question mark, since companies like Enel are lobbying towards its broader use, while Kyoto protocol rationale would in turn hinder solid fuels. Hence, it is not clear yet what will be coal's role in the Italian future. Natural gas, instead, will hold the lion's share in any case. The last years have witnessed booming CCGT capacity installation that with its high efficiency offsets skyrocketing hydrocarbon prices.

IRED's model is designed with great flexibility, so to deal with a great variety of simulated scenarios. In particular, the 2020 renewable energy target is set to either follow a 'business as usual' path, or the 17% goal, or, more optimistically, 22%. The additional renewable energy generated can be set to follow concave, linear, or convex growth paradigms. Concave development underlie a strong initial effort to expand renewable technologies, whereas convexity would mean a final boost in renewable energy so to comply with goals. The degree of concavity (convexity) is also at the modeller's disposal. The model allows also to allocate the renewable energy among its possible sources. One scenario considers the sources' shares emerging from the Italian Government Position Paper. The other five scenarios feature one dominant renewable energy source, the others taking proportional, residual shares as from the aforementioned Position Paper. One renewable energy source can dominate a scenario by degrees differing in intensity. This modelling choice rests on having a reference scenario, the Position Paper's one, and on testing how the expansion of each single source can affect total costs and emissions.

Although the potential combination stemming from this plastic model are many, we will only concentrate on few, significant ones. In the following paragraph there is a description of how the inputs were changed from time to time, as well as an illustration of the simulations outcomes.

[2] "Piano Nazionale d'Allocazione", pg.14, table 4.3

The model's aim is twofold: a) to provide a clear picture of the future Italian energy paths up to 2030, focusing both on energy consumption and carbon emissions and b) to analyse the future of the electricity system, taking into account the strong expansion in renewable energy that is assumed in the European Commission document “An Energy Policy For Europe”.

A quantitative, critical reflection is provided on Italian Government July, 2007 position paper in which was given a detailed picture of the renewables' share in 2020. In particular, through the IRED model, the economic meaning and feasibility of the Government's plan is evaluated by performing a careful cost analysis of the renewables' increaseand generating a number of possible future energy scenarios.

Conclusions

The main conclusions of this research can be summarised as follows:

- Renewables can help Italy, but do not solve the problem. The potential is lower than required and the implementation costs very high.
- The described simulations offer a bleak perspective on implementing the 202020 European policy. 17% of total primary energy in 2020 means setting an ambitious goal, implying a swift and dramatic change in the present trend.
- Two sets of employed cost generation estimates result in a similar outcome: we should expect average cost generation level to rise significantly. Such additional financial requirement could potentially be offset if the CO_2 market price was substantially higher than it is now. Alternatively, monetized CO_2 savings do not make the overall electricity bill look affordable. In addition, pricier sources, like solar, need to play a more marginal role, in order to avoid ballooning generation costs.

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