The unavoidable uncertainty of renewable energy and its management

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A Greek introduction

- Regulation of prices of renewable energy by law in Greece: 73 to 500 €/MWh.
- Retail price of night-time electric energy in 2006: ~50 €/MWh.
- Another provision of the same law: The hydraulic power generated by hydroelectric plants, which have a total installed capacity more than 15 MW, is excluded [from renewables].
- Several type-why questions arise which I will not discuss (but see Koutsoyiannis, 2011a)

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**ΕΦΗΜΕΡΙΣ ΤΗΣ ΚΥΒΕΡΝΗΣΕΩΣ**

**ΤΗΣ ΕΛΛΗΝΙΚΗΣ ΔΗΜΟΚΡΑΤΙΑΣ**

**ΤΕΥΧΟΣ ΠΡΩΤΟ**

<table>
<thead>
<tr>
<th>Παραγωγή Ηλεκτρικής Ενέργειας από:</th>
<th>Τιμή Ενέργειας (€/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Διασυνδεδεμένο Σύστημα</td>
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<tr>
<td>(α) Αιολική ενέργεια</td>
<td>73</td>
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<tr>
<td>(β) Αιολική ενέργεια από αιολικά πάρκα στη θάλασσα</td>
<td>90</td>
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<tr>
<td>(γ) Υδραυλική ενέργεια που αξιοποιείται με μικρούς υδροηλεκτρικούς σταθμούς με Εγκατεστημένη Ισχύ έως δεκαπέντε (15) MW</td>
<td>73</td>
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<td>(δ) Ηλιακή ενέργεια που αξιοποιείται από φωτοβολταϊκές μονάδες, με Εγκατεστημένη Ισχύ μικρότερη ή ίση των εκατό (100) kWpeak, οι οποίες εγκαθίστανται σε άκρες ιδιοκτησίας ή νόμιμες κατοχής ή άμεσα ή ιδιοκτήτη ή νομίμου κατόχου</td>
<td>450</td>
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<tr>
<td>(ε) Ηλιακή ενέργεια που αξιοποιείται από φωτοβολταϊκές μονάδες, με Εγκατεστημένη Ισχύ μεγαλύτερη των εκατό (100) kWpeak</td>
<td>400</td>
</tr>
</tbody>
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D. Koutsoyiannis, The unavoidable uncertainty of renewable energy and its management
What is the percentage of subsidy of solar energy? – Answer 1

- \((500 - 50) / 50 = 9 = 900\%\)
  
  (But one may object that the solar energy is mostly* produced during the day-time, while the price of 50 €/MWh is for night-time energy.)

* For amusing stories of night-time solar energy see e.g. http://www.theecologist.org/News/news_round_up/465409/spanish_night_time_solar_energy_fraud_unlikely_in_uk.html

(Even though this example refers to Spain, Italians may have anticipated but this has not been confirmed yet.)
What is the percentage of subsidy of solar energy? – Answer 2

- However the real incompatibility of the values 500 and 50 €/MWh is that the former is commercial price, while the latter is retail price. The commercial price varies markedly.
- The solar energy is uncertain and uncontrollable, which has a negative impact on its real price: it should equal the lowest commercial price.
- Based on the data of that period the subsidy is \((500 - 20) / 20 = 24\) = 2400% !!!
  (But one may correctly object that these data are daily values and if hourly values were used the percentage would be >3000%).
Does this mean that we should oppose renewables?

Merkel's Switch to Renewables: Rising Energy Prices Endanger German Industry

By Frank Dohmen and Alexander Neubacher

Last spring, Chancellor Angela Merkel set Germany on course to eliminate nuclear power in favor of renewable energy sources. Now, though, several industries are suffering as electricity prices rapidly rise. Many companies are having to close factories or move abroad.
No! BUT we should:

- Avoid scandals;
- Be honest;
- Back by *science* (not *sophistry*);
- Study the peculiarities of renewables and in particular *uncertainty and risk*;
- Be able to *manage* uncertainty and risk.

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**Principal Investigator:** Demetris Koutsoyiannis  
**Institution:** National Technical University of Athens

**Proposal title**

*Climate, Hydrology, Energy, Water: the Conversion of Uncertainty Domination and Risk Into Sustainable Evolution*

**Acronym**

**CHEWtheCUDANDRISE**

A research proposal submitted for the ERC Advanced Grant  
February 2008

**See reviewers’ comments of rejections in Koutsoyiannis (2011b)**
The summary of the rejected proposal in full

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**HESS Opinions:**

“Climate, hydrology, energy, water: recognizing uncertainty and seeking sustainability”

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Special thanks to the then Executive Chief Editor Hubert Savenije for publishing it. The many, interesting and mostly negative reviewers’ comments are online in HESSD.
Results of the sophistry-backed policy for renewables in Europe (1)

Energy Revolution Hiccups: Grid Instability Has Industry Scrambling for Solutions

By Catalina Schröder

Sudden fluctuations in Germany's power grid are causing major damage to a number of industrial companies. While many of them have responded by getting their own power generators and regulators to help minimize the risks, they warn that companies might be forced to leave if the government doesn't deal with the issues fast.

http://www.spiegel.de/international/germany/instability-in-power-grid-comes-at-high-cost-for-german-industry-a-850419.html
Results of the sophistry-backed policy for renewables in Europe (2)

Reality Check: Germany's Defective Green Energy Game Plan

A Commentary By Alexander Neubacher

All of the wind turbines, rooftop solar panels, hydroelectric and biogas plants in Germany have not reduced CO2 emissions in Europe by a single gram.

Results of the sophistry-backed policy for renewables in Europe (3)

Energy Charter Treaty: The umbrella for international arbitration against Spanish energy renewal

By King & Wood Mallesons on July 21, 2015
Posted in Global Network

The last step of the reform of the electricity sector carried the final straw. That step was the enactment of a Ministerial Order which reduced remuneration for different renewable energy technologies. This unprecedented retreatment of the profitability has been the reason for fresh private equity funds in the sector.

Solar investors lose out in Spanish Energy Charter Treaty decision


Results of the sophistry-backed policy for renewables in Europe (4)

European clean tech industry falls into rapid decline

Investment in low-carbon energy in Europe last year plummeted by more than half to $58bn, the lowest level in a decade, analysis shows

http://www.theguardian.com/environment/2016/mar/23/european-clean-tech-industry-falls-into-rapid-decline
Consequences of the sophistry-backed policy for renewables in Greece

- They are too many to describe.
- However, the legislation change shown gives an indication for one of them in quantified terms.
Continuing unfunded research on renewables

- **Reviewer #2 first review**: ... statistical analysis as in the present study (like LTP) to determine very small variations of meteorological data (such as wind speed and sunshine duration) can hardly be used in this design and management of systems ... Accordingly, in the feasibility and management studies of these systems (which the life times are shorter than 100 years), very small long term variations (100 years or more) of solar energy and wind energy seem irrelevant ...

- **Reviewer #2 second review**: I do not agree that long term evaluations of solar and wind data (more than 20 years) is a must (and is important) for the short term feasibility studies (design and management) of solar and wind energy system (as they are important renewable energy systems).
Is persistence irrelevant to renewable energy?

Wind turbines with almost **3,000 megawatts** are now in the North Sea in operation, the hope of reliable electricity supplies but not fulfilled: On **Tuesday morning** before last the entire feed-Installed there is offshore installations **dropped to up to one megawatt**. The giant windmills **worth more than ten billion euros** would in this period just to provide a few hundred households. There was not the first time in the past three months lull in the North Sea. **At a total of 25 of 91 days, the wind power production slipped sometimes several times in the two-digit or single-digit megawatt range.** With 2631 megawatts of power on November 11, late at night, fed most. The sometimes extreme fluctuations must compensate by switching on or off of conventional power stations...

[http://www.spiegel.de/spiegel/print/d-140604204.html](http://www.spiegel.de/spiegel/print/d-140604204.html)
So, what quantifies uncertainty in renewables?

- The distribution tails are useful, but not important (except for wind loads).
- Persistence means *enhanced uncertainty*.
- Persistence is expressed by the Hurst coefficient, $H$.
- $H$ equals the *entropy production* (Koutsoyiannis, 2011c, 2014; nb. *entropy* $\equiv$ *uncertainty*).
- Analysis of global data in Tsekouras and Koutsoyiannis (2011) suggest a nearly universal value $H = 0.84$ (both for wind and sunshine).

![Comparison of Hurst coefficient frequency histograms of historical and synthetic, with a theoretical $H = 0.84$, time series for wind speed (above) and sunshine duration (below).](image)

D. Koutsoyiannis, *The unavoidable uncertainty of renewable energy and its management*
How can we manage uncertainty?

- By storing.
- This answer has been trivial since prehistorical times as illustrated in the biblical story of lean and fat cows. Enhanced uncertainty needs long-term storing.
- Can electric energy be stored? No, it can only be converted.
- Which is (and most probably will ever be) the most efficient way of mass conversion and storage of electric energy? Using hydropower with reversible turbines and big reservoirs with dams (Efficiencies > 85% for full cycle).
- Did European renewable energy policy include energy storing through hydropower? No, because this is capital intensive (it is difficult to earn money quickly ...).
- Do we want large scale hydropower projects? We do not, because they are evil (they destroy the environment).
In July 2013 the World Bank (2013) decided to re-engage in large-scale hydropower infrastructure after having withdrawn from it for the past two decades.

51. **The WBG is firmly committed to the responsible development of hydropower projects.** Despite its potential, nearly four-fifths of potential hydropower resources in the developing world are yet to be realized, including more than 90 percent in Sub-Saharan Africa and about 70 percent in South Asia. For many countries, hydropower is now the largest source of affordable renewable energy. The WBG will engage in hydropower projects of all sizes and types—run of the river, pumped storage, and reservoir—including off-grid projects meeting decentralized rural needs. In many cases reservoir projects will be multipurpose, incorporating integrated water resource management. In addition to climate change mitigation, reservoir hydropower projects can often provide climate change adaptation services by reducing risks associated with extreme hydrological events and shocks to the economy. Reservoir hydropower can also pave the way for the later introduction of other forms of renewable energy, due to its unique ability to instantly come on-line to offset variabilities elsewhere in the system, as well as the potential for pumped storage to store, for example, wind power during periods of surplus.
Back to Greece: The technological breakthrough of the empty Mesochora reservoir

- A new project, including reversible energy facilities, is being built in the upper course of the Acheloos River, the largest river in Greece.
- Part of the project is the Mesochora dam, reservoir and hydropower station.
- The dam and the hydropower plant have been constructed (an investment of 500 M€) and have been ready for use since 2001.
- However, they have not been put into operation, thus causing a loss of 25 M€/year to the national economy (see Koutsoyiannis, 2011a).
- This surreal situation has been the most representative example of a course that led and keeps Greece into the current financial crisis.
But Greece is more than this: Ancient legacies and their usefulness to solutions of modern problems

- Aristotle (384-328 BC), among other things, conceived the principle of Orthos Logos (Recta Ratio, or Right Reason) in guiding human decisions and actions:
  \[ τὸ μὲν οὖν κατὰ τὸν ὀρθὸν λόγον πράττειν κοινὸν καὶ ὑποκείσθω. \]
  \( \text{(It is a common principle which must be accepted that we must act in accord with orthos logos.)} \)
  Aristotle, Nicomachean Ethics 1103b

- Aristotle distinguished *science*, i.e., thoroughly explored knowledge that we seek for the satisfaction which it carries with itself, from *sophistry*, a kind of abusing reasoning making trade of unreal wisdom (cf. Taylor, 1919; Horrigan, 2007; Papastephanou, 2015):
  \[ ἔστι γὰρ ἡ σοφιστικὴ φαινομένη σοφία οὖσα δ’ οὖ, καὶ ὁ σοφιστὴς χρηματιστὴς ἀπὸ φαινομένης σοφίας ἀλλ’ οὐκ οὖσης \]
  \( \text{(sophistry is the semblance of wisdom without the reality, and the sophist is one who makes money from apparent but unreal wisdom)} \)
  Aristotle, On Sophistical Refutations, 165a21
Concluding remarks

- We need Orthos Logos more than ever.
- We need science more than ever.
- We need to distinguish science from sophistry more than ever.
- We need to reestablish the link of science with philosophy and isolate science from ideology.
- In particular, we need to annul the stereotypes and doctrines related to the environmentalist ideology, which have obstructed progress for decades.

καὶ τὴν σοφίαν ὡςαύτως τοὺς μὲν ἀργυρίου τῷ βουλομένῳ πωλοῦντας σοφιστὰς ὥσπερ πόρνους ἀποκαλοῦσιν

(So is it with wisdom. Those who offer it to all comers for money are known as sophists, prostitutors of wisdom)

Xenophon, Memorabilia, 1.6.13, quoting Socrates
References


- Koutsoyiannis, D., Scale of water resources development and sustainability: Small is beautiful, large is great, *Hydrological Sciences Journal*, 56 (4), 553–575, 2011a.


Acknowledgments: I thank Marianna Papastefanou of the University of Cyprus for her discussions about correctly understanding Aristotle’s works. I thank the EU research bodies for rejecting all my proposals and keeping me, thus, away from sophistry, as well as the Greek General Secretariat for Research and Technology for funding some of the “rejected” ideas through the research project “Combined REnewable Systems for Sustainable Energy DevelOpment” (CRESSENDO [grant number 5145]).