European Geosciences Union
General Assembly 2016
Vienna | Austria | 17–22 April 2016

Session ERE3.8/HS5.7
Renewable energy and environmental systems: modelling, control and management for a sustainable future

The unavoidable uncertainty of renewable energy and its management

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Presentation also available at: www.itia.ntua.gr/1611/

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)

ΕΦΗΜΕΡΙΣ ΤΗΣ ΚΥΒΕΡΝΗΣΕΩΣ

ΤΗΣ ΕΛΛΗΝΙΚΗΣ ΔΗΜΟΚΡΑΤΙΑΣ

ΤΕΥΧΟΣ ΠΡΩΤΟ **Αρ. Φύλλου 129**

27 Ιουνίου 2006

ΝΟΜΟΣ ΥΠ' ΑΡΙΘ. 3468

Παραγωγή Ηλεκτρικής Ενέργειας από Ανανεώσιμες Πηγές Ενέργειας και Συμπαραγωγή Ηλεκτρισμού και Θερμότητας Υψηλής Απόδοσης και λοιπές διατάξεις

4. Αυτόνομος Παραγωγός ηλεκτρικής ενέργειας από Α.Π.Ε:. Ο Παραγωγός που παράγει ηλεκτρική ενέργεια από Α.Π.Ε. και του οποίου ο σταθμός δεν είναι συνδεδεμένος με το Σύστημα ή το Δίκτυο.

5. Αυτόνομο Ηλεκτρικό Σύστημα Μη Διασυνδεδεμένων

Παραγωγή ηλεκτρικής ενέργειας από:	Τιμή Ενέργειας (€/MWh)	
	Διασυνδεδεμένο Σύστημα	Μη Διασυνδεδεμένα Νησιά
(α) Αιολική ενέργεια	73	84,6
(β) Αιολική ενέργεια από αιολικά πάρκα στη θάλασσα	90	
(γ) Υδραυλική ενέργεια που αξιοποιείται με μικρούς υδροηλεκτρικούς σταθμούς με Εγκατεστημένη Ισχύ έως δεκαπέντε (15) MWe	73	84,6
(δ) Ηλιακή ενέργεια που αξιοποιείται από φωτοβολταϊκές μονάδες, με Εγκατεστημένη Ισχύ μικρότερη ή ίση των εκατό (100) kWpeak, οι οποίες εγκαθίστανται σε ακίνη ιδιοκτησίας ή νόμιμης κατοχής ή όμορα ακίνητα του ίδιου ιδιοκτήτη ή νομίμου κατόχου	450	500
(ε) Ηλιακή ενέργεια που αξιοποιείται από φωτοβολταϊκές μονάδες, με Εγκατεστημένη Ισχύ μεγαλύτερη των εκατό (100) kWpeak	400	450

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.)

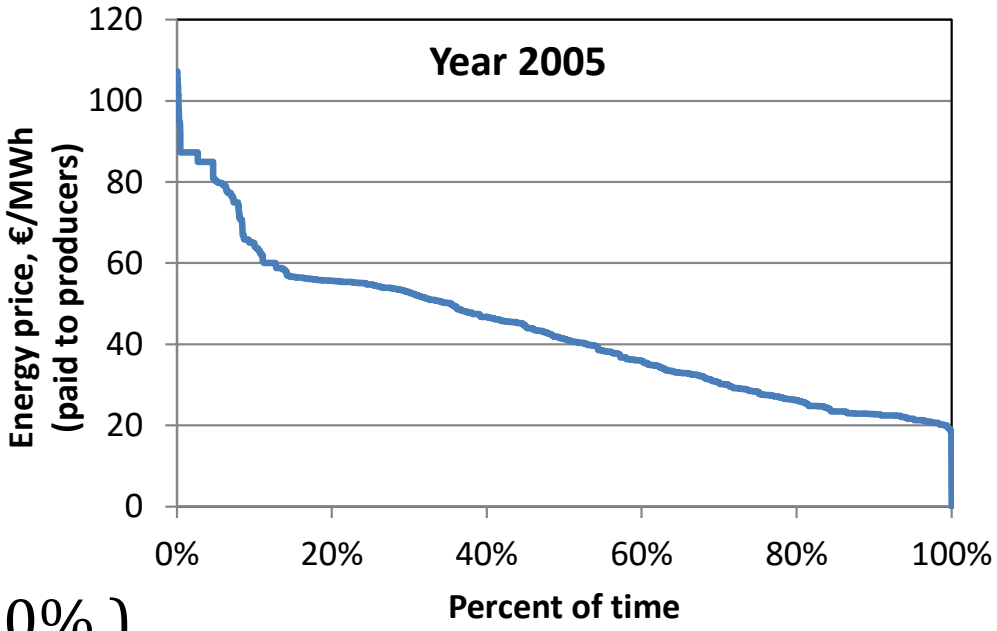
---

* 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?

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English Site > Business > German Energy Revolution > Merkel's Switch to Renewables: Rising Energy Prices Endanger German Industry

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.

February 24, 2012 – 11:07 AM

Print

Feedback

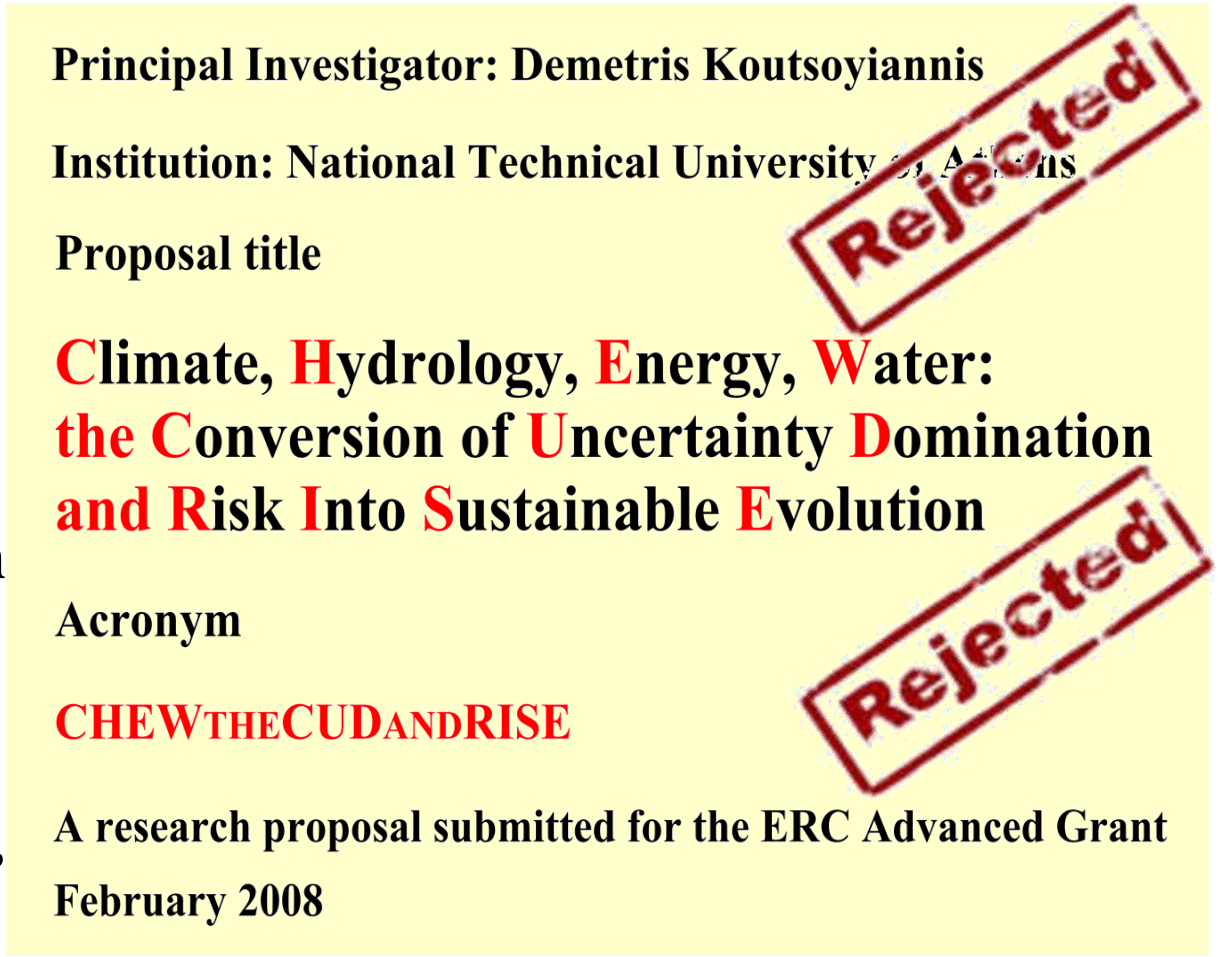
From DER SPIEGEL

http://www.spiegel.de/international/business/merkel-s-switch-to-renewables-rising-energy-prices-endanger-german-industry-a-816669.html

Does this mean that we should oppose renewables? (My answer)

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.



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

Hydrol. Earth Syst. Sci., 13, 247–257, 2009
www.hydrol-earth-syst-sci.net/13/247/2009/

Hydrology and Earth System Sciences

HESS Opinions:
"Climate, hydrology, energy, water: recognizing uncertainty and seeking sustainability"

D. Koutsoyiannis[1], C. Makropoulos[1], A. Langousis[2], S. Baki[1], A. Efstratiadis[1], A. Christofides[1], G. Karavokiros[1], and N. Mamassis[1]

[1]Dept. of Water Resources and Environment, School of Civil Engineering, National Technical University of Athens, Greece
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Received: 10 September 2008 – Published in Hydrol. Earth Syst. Sci. Discuss.: 27 October 2008
Revised: 9 February 2009 – Accepted: 9 February 2009 – Published: 23 February 2009

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)

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English Site > Germany > German Energy Revolution > Instability in Power Grid Comes at High Cost for German Industry

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.

August 16, 2012 – 06:00 PM

Print

Feedback

Comment | 1 Comment

From DER SPIEGEL

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)

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English Site > Germany > German Energy Revolution > Commentary: Why Germany Is Waging Its Green Revolution Wrong

Reality Check: Germany's Defective Green Energy Game Plan

A Commentary By Alexander Neubacher

http://www.spiegel.de/international/germany/commentary-why-germany-is-waging-its-green-revolution-wrong-a-929693.html

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

Home > Global Network > Energy Charter Treaty: The umbrella for international arbitration against Spanish energy renewal

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

By King & Wood Mallesons on July 21, 2015

Posted in Global Network

By Fernando Badenes, King & Wood Mallesons' Madrid C

The last step of the reform of the electricity sector carried
the final straw. That step was the enactment of a Ministeri
remuneration for different renewable energy technologies.
retrenchment of the profitability that the Spanish state had
been the reason for fresh private equity funds in the secto

http://www.chinalawinsight.com/2015/07/articles/global-network/energy-charter-treaty-the-umbrella-for-international-arbitration-against-spanish-energy-renewal/#page=1

http://www.cms-lawnow.com/ealerts/2016/02/solar-investors-lose-out-in-spanish-energy-charter-treaty-decision

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Solar investors lose out in Spanish Energy Charter Treaty decision

Global 11.02.2016

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

theguardian

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Renewable energy

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.

ΠΙΝΑΚΑΣ Α

ΦΩΤΟΒΟΛΤΑΪΚΟΙ ΣΤΑΘΜΟΙ															
		ΔΙΑΣΥΝΔΕΔΕΜΕΝΟ ΣΥΣΤΗΜΑ										ΜΗ ΔΙΑΣΥΝΔΕΔΕΜΕΝΟ ΣΥΣΤΗΜΑ			
Περίοδος Διασύνδεσης	Φ/Β Στεγών (<=10kW)	P≤100kW		100kW<P ≤500kW		500kW<P≤ 1MW		1MW<P ≤5MW		P>5MW		P≤100Kw		100kW<P	
		ΧΕ	ΜΕ	ΧΕ	ΜΕ	ΧΕ	ΜΕ	ΧΕ	ΜΕ	ΧΕ	ΜΕ	ΧΕ	ΜΕ	ΧΕ	ΜΕ
Πριν το 2009	-	-	445	-	390	-	385	-	385	-	385	-	480	-	440
Α Τριμ. 2009	-	-	440	-	375	-	365	-	365	-	355	-	480	-	380
Β Τριμ. 2009	-	-	435	-	370	-	345	-	345	-	325	-	460	-	370
Γ Τριμ. 2009	-	-	430	-	365	-	325	-	325	-	315	-	430	415	360
Δ Τριμ. 2009	-	-	425	-	350	-	315	-	300	400	300	-	410	415	350
Α Τριμ. 2010	-	-	400	-	335	-	315	-	290	390	280	-	385	415	330
Β Τριμ. 2010	-	-	380	-	315	-	315	400	285	390	270	500	370	410	310
Γ Τριμ. 2010	-	-	365	-	295	400	295	380	260	375	255	490	355	405	275
Δ Τριμ. 2010	-	-	345	395	280	395	280	355	245	360	240	470	335	400	275
Α Τριμ. 2011	-	-	335	390	270	375	260	340	235	335	225	455	330	360	245
Β Τριμ. 2011	-	-	320	375	260	365	250	330	225	320	220	440	315	360	245
Γ Τριμ. 2011	470	430	305	360	250	360	245	310	215	300	205	415	295	335	230
Δ Τριμ. 2011	470	405	285	330	230	325	225	290	200	280	190	390	280	305	210
Α Τριμ. 2012	415	375	265	305	215	295	205	260	180	260	180	365	265	280	195
Β Τριμ. 2012	385	360	240	280	195	265	185	235	165	230	155	330	240	270	190
Γ Τριμ. 2012	340	360	225	265	185	250	175	215	150	210	145	305	220	260	180
Δ Τριμ. 2012	295	340	215	255	180	240	165	205	145	195	135	290	215	240	170
Α Τριμ. 2013	295	285	205	240	170	240	145	195	140	190	130	280	205	220	155
Β Τριμ. 2013	270	270	195	185	160	185	145	185	140	180	130	270	195	185	150
Γ Τριμ. 2013	220	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Δ Τριμ. 2013	175	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1383

ΕΦΗΜΕΡΙΣ ΤΗΣ ΚΥΒΕΡΝΗΣΕΩΣ

ΤΗΣ ΕΛΛΗΝΙΚΗΣ ΔΗΜΟΚΡΑΤΙΑΣ

ΤΕΥΧΟΣ ΠΡΩΤΟ Αρ. Φύλλου 85

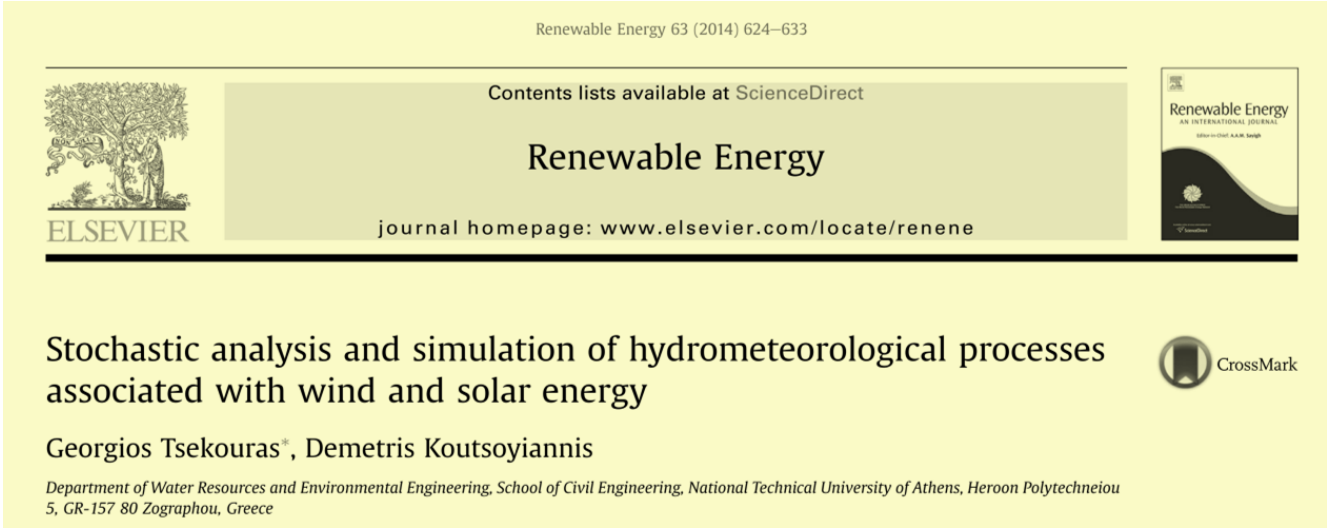
7 Απριλίου 2014

ΝΟΜΟΣ ΥΠ' ΑΡΙΘ. 4254

Μέτρα στήριξης και ανάπτυξης της ελληνικής οικονομίας στο πλαίσιο εφαρμογής του ν. 4046/2012 και άλλες διατάξεις.

ελέγχου των εισοδηματικών και περιουσιακών κριτηρίων για τη χορήγησή του ανά κατηγορία δικαιούχων και κάθε άλλη αναγκαία λεπτομέρεια για την εφαρμογή της παρούσας υποπαραγράφου.

Continuing unfunded research on renewables



Renewable Energy 63 (2014) 624–633

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Stochastic analysis and simulation of hydrometeorological processes associated with wind and solar energy

Georgios Tsekouras*, Demetris Koutsoyiannis

Department of Water Resources and Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Heroon Polytechneiou 5, GR-157 80 Zographou, Greece

- **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)*.

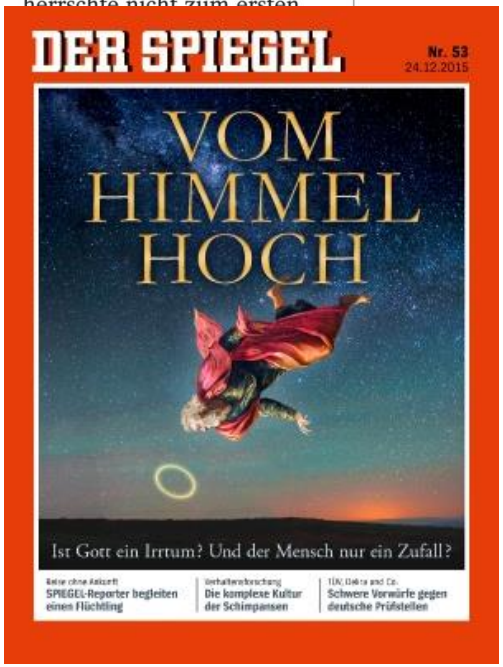
Is persistence irrelevant to renewable energy?

Windenergie

Flaute auf See

Windräder mit fast 3000 Megawatt Leistung sind inzwischen in der Nordsee in Betrieb, die Hoffnung auf verlässliche Stromlieferungen erfüllt sich allerdings nicht: Am vorvergangenen Dienstagvormittag sank die gesamte Einspeiseleistung der dort installierten Offshore-Anlagen auf bis zu ein Megawatt. Die riesigen Windmühlen im Wert von mehr als zehn Milliarden Euro hätten in diesem Zeitraum gerade einmal wenige Hundert Haushalte mit

Strom versorgen können. Es herrschte nicht zum ersten



Google translation

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

So, what quantifies uncertainty in renewables?

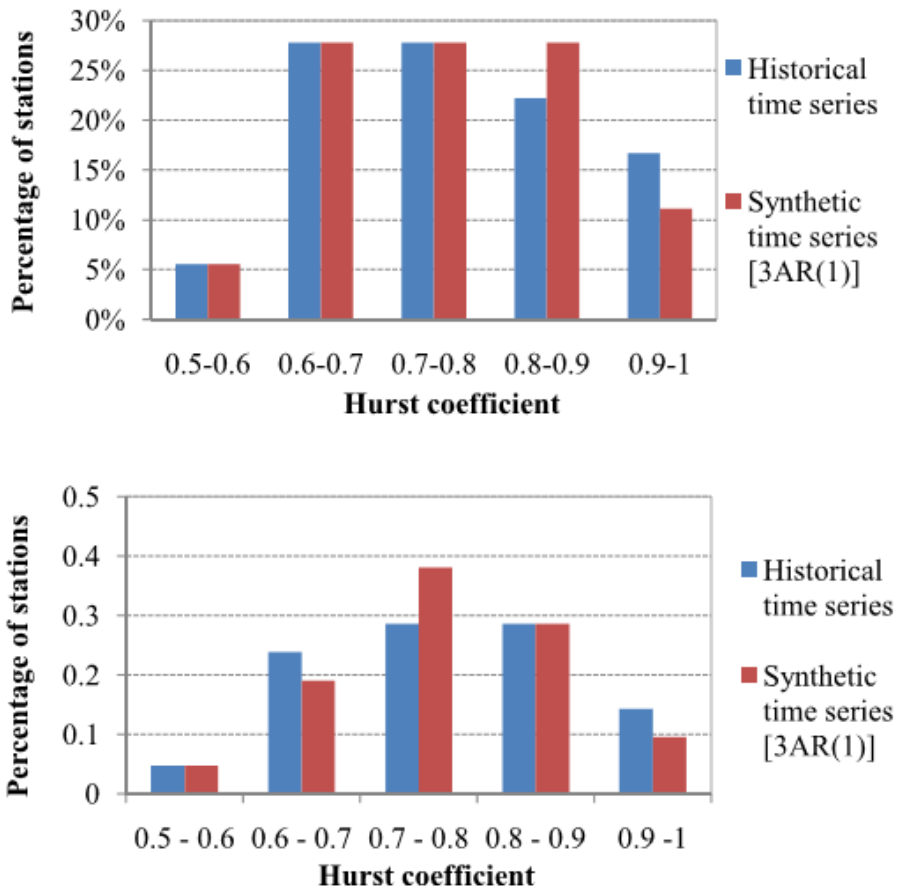


Fig. 6. Comparison of Hurst coefficient frequency histograms of historical and synthetic, with a theoretical $H = 0.84$, time series for wind speed (above) and sunshine duration (below).

- 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* ≡ *uncertainty*).
- Analysis of global data in Tsekouras and Koutsoyiannis (2011) suggest a nearly universal value $H = 0.84$ (both for wind and sunshine).

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).

Or do we?

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.

Toward a sustainable energy future for all : directions for the World Bank Groups energy sector (English)

ABSTRACT

As global energy markets evolve rapidly, producing and maintaining a reliable power supply for many countries in the developing world remains a significant issue. The World Bank Group will approach this energy crisis in partnership

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.

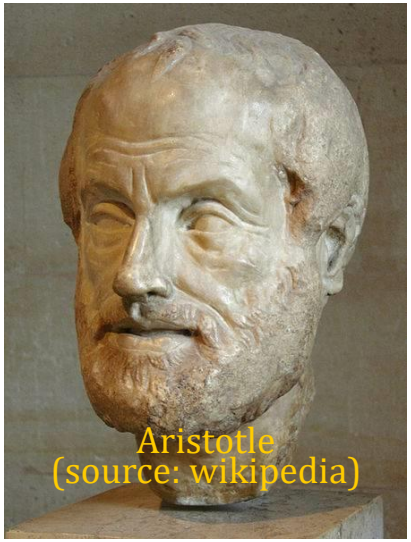
But Greece is more than this: Ancient legacies and their usefulness to solutions of modern problems

- 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.

  (*It is a common principle which must be accepted that we must act in accord with orthos logos*.)

  Aristotle, Nicomachean Ethics 1103b


Aristotle
(source: wikipedia)

- 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):

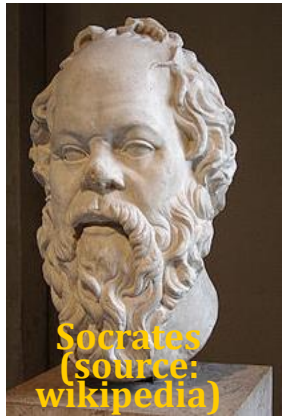
  ἔστι γὰρ ἡ σοφιστικὴ φαινομένη σοφία οὖσα δ᾽ οὔ, καὶ ὁ σοφιστὴς χρηματιστὴς ἀπὸ φαινομένης σοφίας ἀλλ᾽ οὐκ οὔσης

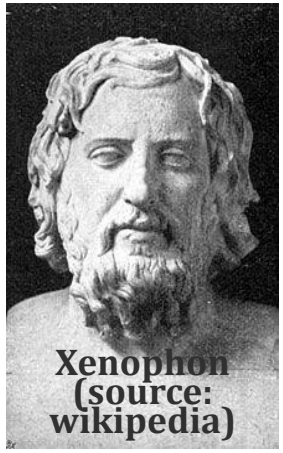
  (*sophistry is the semblance of wisdom without the reality, and the sophist is one who makes money from apparent but unreal wisdom*)

  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.


Socrates (source: wikipedia)


Xenophon (source: wikipedia)

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

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