The Electricity of France

RTE data

September 2010 – August 2011

Hubert Flocard

CSNSM/IN2P3/CNRS

flocard@csnsm.in2p3.fr

Presentation Layout

1) Two approximate laws on Social Electricity

2) RTE data.

3) France*, electricity consumption and production September 2010 -- August 2011.

4) France*, electricity wind production, September 2010 – August 2011

5) An anticipation scenario based on the « Grenelle » decisions.

6) Perspectives ; a role for the academic world ?

- Here France means “continental France”

  (Corse and DOM-TOM territories are excluded)

First approximate law

(domain of validity : European economy)

First approximate Lemna

Electric energy can't be stored at adequate levels

- Strictly speaking : condensator (marginal)
- Indirect storage (efficiency is at best 70%) :
  - Chemical (batteries; hydrogen ?),
  - Mechanical futuristic (flywheels, compressed gases, …),
  - Mechanical existing (hydraulic; Alps, Norway, Sweden).

First approximate theorem on social electricity

Consumption(t) = Production(t), at any t

Deviation -> frequency mismatch ; when not quickly corrected -> blackout

First Consequence

Permanent control of balance is required

Either consumption or production (or both) has (have) to be controlled

Second approximate law

(domain of validity : European economy)

Second approximate Lemna

Electricity can't be transferred at adequate levels

- AC, ~6% loss per 1000km (DC is better, SC is even better ,but …)
- Limited international connections
- ~5years to build for a power plant. ~10years for a long distance HV line
- Underground HV line is 5 to 10 more expensive than aerial HV line

Second approximate law on social electricity

Over the year, European consumption varies
by a factor two to three
nearly in phase in every country

Second consequence

Excess production capacity is necessary; it has a cost

RTE data
Réseau de Transport d'Electricité
(French national grid)

French electricity production ; recent evolution

Over the last ten years, no significant controllable power (hydraulic, oil, coal, gas, nuclear) has been built in France

In the mean time, electricity consumption has grown by about 10%

The safety margin :

sum of controllable production power – maximal consumption power

which existed at the turn of the century has disappeared.

During winter cold waves, France must now import electricity

Over the last ten years, 6.3GW of wind turbine have been erected (>1/10 of installed nuclear power) and about 1GWc of photovoltaic solar panels have been installed.

The « Grenelle de l'Environnement » (2008-2009) has decided the extension of the French wind park to 25GW (19+6) and the solar PV park to 5.4GWc

Organisation of the French Electric system

Past organized by «dull» engineers !

EDF

- Production
- Transport
- Distribution

National Entity

No competition

Consumers

Mrs Thatcher's philosophy :

- **Competition is always best**
- **Deregulation whenever possible**

- These two principles have been adopted by EU
- A new supposedly **"optimal"** system is developed
- It is approved by national governments (France: Jospin +Chirac)

Present organized by «fancy» economists !

Major Production Level (competition)
EDF
GDF, EON POWEO, …

Transport Level (no competition)
RTE
V> 63kV
In charge of balancing

Control Level
CRE
checks impartiality of RTE

Distributed production
+
Renewable Energies
Subsidized – forced injection
(Wind – Solar PV)

Distribution level (competition)
Today only ERDF

Consumers

Availability of data at « Grenelle »'s time

Since many years – RTE – « Réalisations Données de production »

Données de réalisation du 01/01/2009

Heures	Nucléaire	Charbon + Ga	Fioul + Pointe	Hydraulique	Autres	Total
00:00	59549	2012	275	4874	0	66710
01:00	59566	1785	279	5539	0	67169
02:00	59392	1765	176	4951	0	66284
03:00	59137	1769	17	4543	0	65466

Question to RTE le 1er january 2009: Why, with more than 2 GW of wind turbines, is « Autres » still **equal to zero** ?

Données de réalisation du 21/01/2009

Heures	Nucléaire	Charbon + Ga	Fioul + Pointe	Hydraulique	Autres	Total
00:00	59213	5186	137	5813	*	70349
01:00	58990	4323	19	5329	*	68661
02:00	58787	3852	0	4959	*	67598
03:00	58984	3833	0	4946	*	67763

No RTE answer
However …
on January 21st , zeros are replaced by **asterisks**!

Till March 2006 – French agency ADEME – « données horaires de production éolienne »

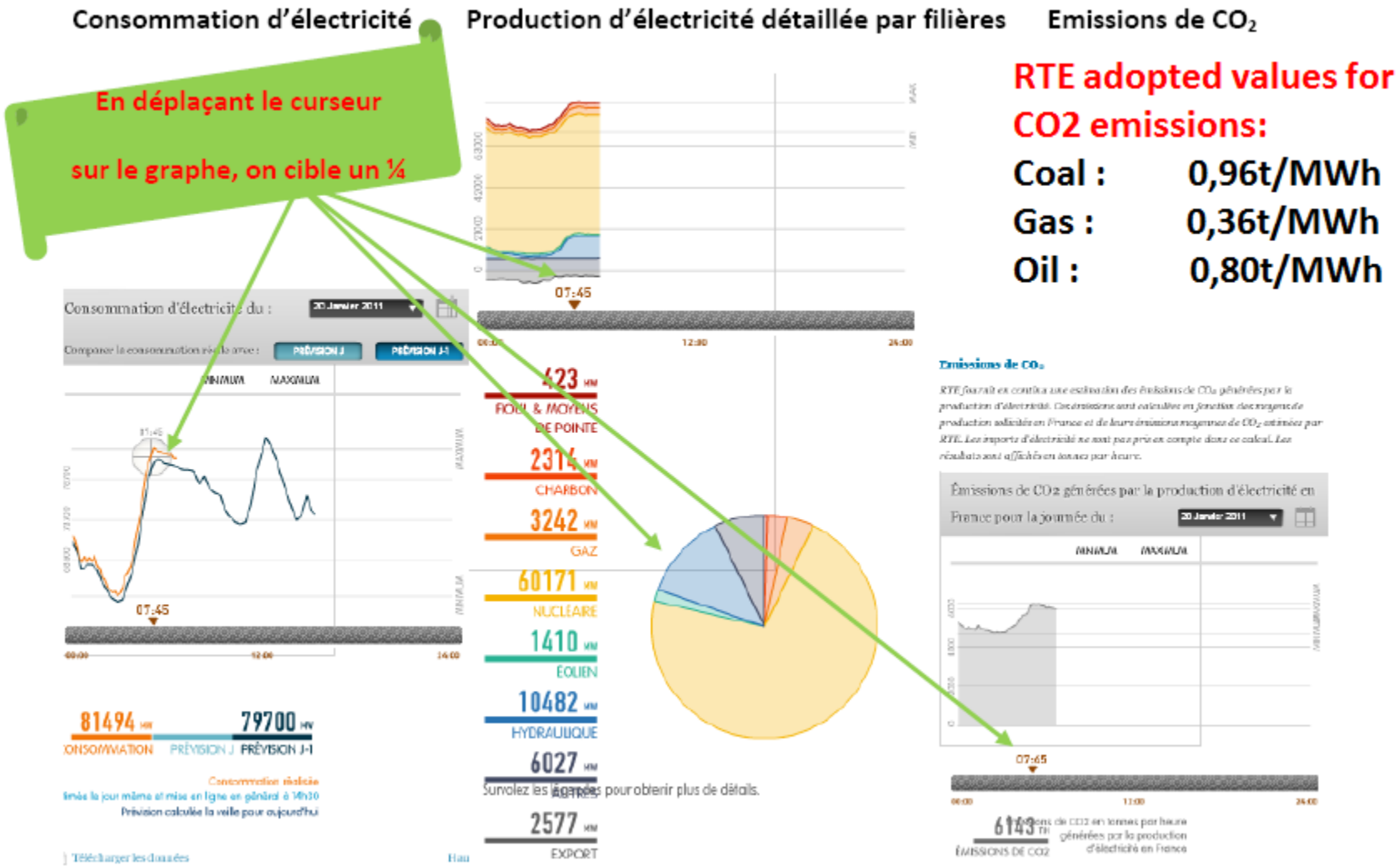
Just as the limit at 1500MW of the compulsory buy of wind electricity at a favorable tariff is lifted , **the wind production data "disappeared" from the ADEME web site.**

The discussions on renewable energies which were held during the « Grenelle de l'Environnement » (2008-09) took place while the French public and probably most participants had no or very little information on these "renewable" means of electricity production.

RTE data (today) to access, on Google, type : eco2mix

Since july 1st – RTE website eCO2mix

www.rte-france.com/fr/developpement-durable/maitriser-sa-consommation-electrique
/eco2mix-consommation-production-et-contenu-co2-de-l-electricite-francaise#mixEnergetique



RTE data (today) (complete file available to any interested students)

High quality information : **consumption, various productions and import-export balance** are given with **a high time granularity (every 1/4h)**

Journée du 01/05/2011

Heures	Consommatio	PrévisionJ-1	Fioul + pointe	Charbon	Gaz	Nucléaire	Eolien	Hydraulique	Autres	Solde	Co2	PrévisionJ
00:00	46229	45800	0	0	248	45791	1531	4537	2276	-8154	999	46200
00:15	45451	44900	0	0	237	45895	1528	3788	2198	-8196	963	45150
00:30	44224	44000	0	0	206	45663	1460	3295	2200	-8600	953	44100
00:45	42634	42900	0	0	254	44671	1439	2618	2199	-8547	970	42900
01:00	41802	41800	0	0	255	43671	1416	2582	2203	-8325	972	41700
01:15	42062	42000	0	0	237	43936	1386	2101	2208	-7806	967	42000
01:30	41385	42200	0	0	248	43261	1353	2098	2211	-7786	972	42300
01:45	41464	41950	0	0	252	43937	1364	1511	2210	-7810	974	42000

However still some misgivings :

- « Memory span » of eCO2mix website does not extend over 31days.
- Some missing data : blank lines no more than one hour typically (1 counter example)
- Some few inconsistencies (pumping ? Coal ?)
- Some disagreement with other RTE publications.
- No specific information on solar, biomass, tidal electricity, …
- Some strange behaviors not yet explained by RTE (questions asked, answers still awaited)
- No information on geographical distribution of productions-consumption

Still, one should not complain and be too picky!

Compared with the policy of restricted information so typical of the past, it is remarkable that RTE now accepts to provide such detailed and comprehensive information to the French general public

(Note : such data has been available for years in Spain, Germany and Denmark)

France
Electricity Consumption and Productions
September 2010 – August 2011

Electricity of France (September 2010-August 2011) (I)

Information on 35040 quarters hour on

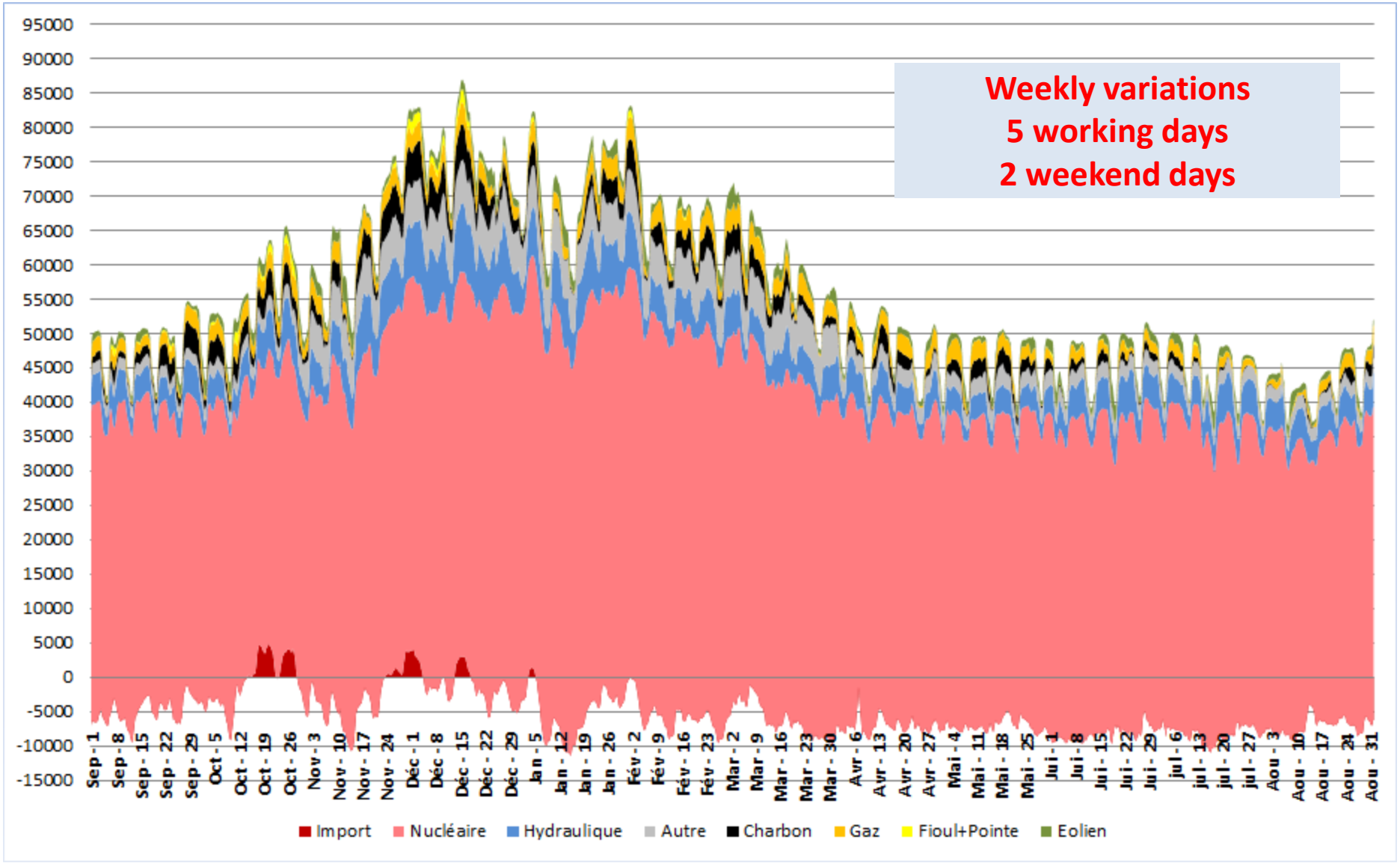
1) electric consumption
2) productions
2.A) fossil
2.A.1) coal
2.A.2) gas
2.A.3) oil + peak power
2.B) nuclear
2.C) hydraulic*
2.D) wind
2.E) « others »**
3) import – export balance
4) « electric CO2 » emissions

*the « hydraulic» column reports only « mountain dams hydroelectricity » (and pumping stations ?)
**contribution of river dams (Rhône, Rhine) is counted in « others »

Electric consumption over 12months : 491.8 TWh

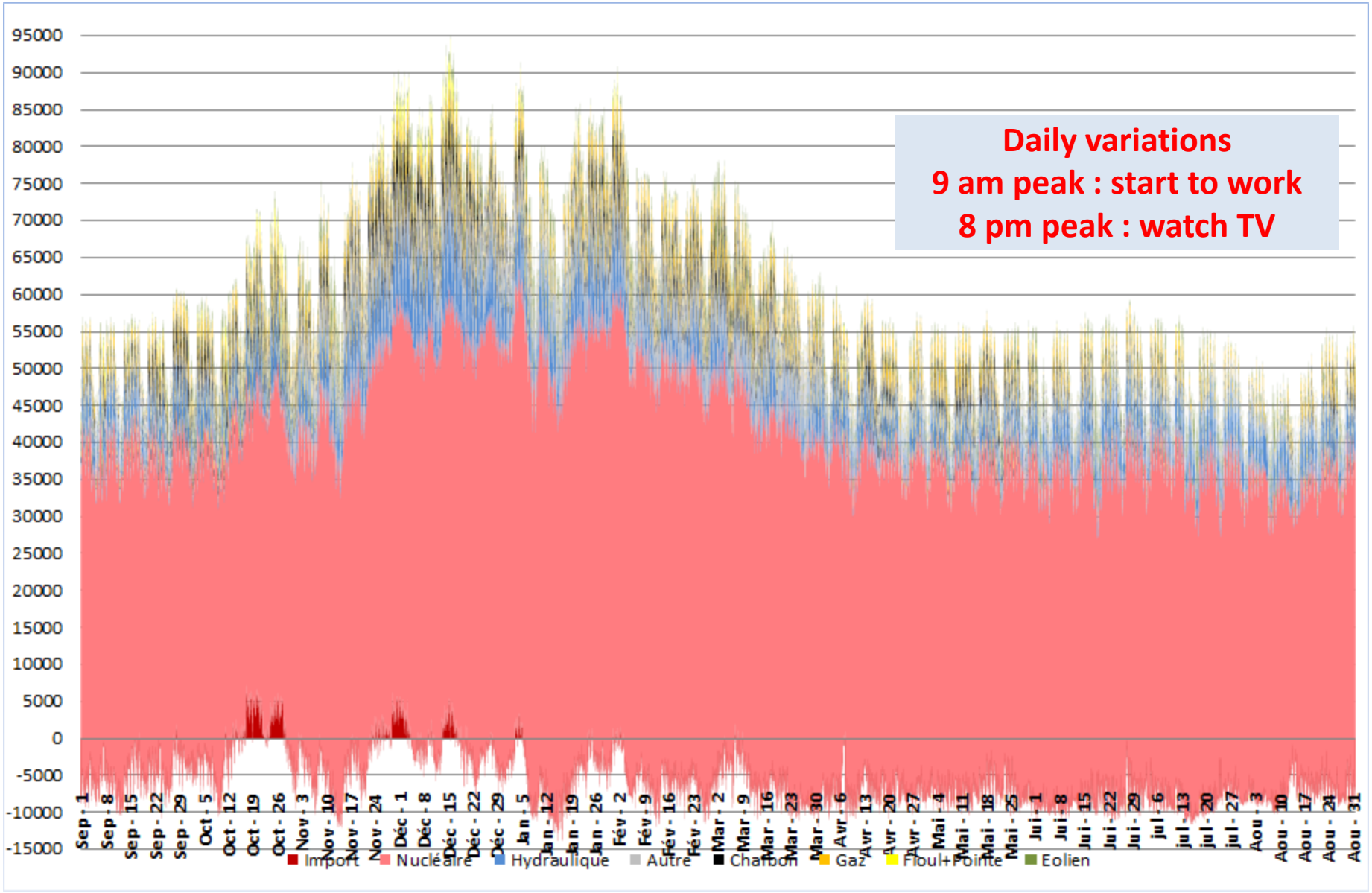
Coal %	Gas %	Oil + Peak %	Nuclear %	Hydraulic %	wind %	« Others » %	Consumption %	Import-Export %	Production %
3,09	3,20	0,25	86,01	8,48	2,08	6,48	100	-9,58	109,58
2,82	2,92	0,23	78,50	7,73	1,90	5,91	91,26	-8,74	100

Electricity of France (September 2010-August 2011) (II)



Ordinate MW; « sliding average over 96 quarters hour» (=1 day)

Electricity of France (September 2010-August 2011) (III)

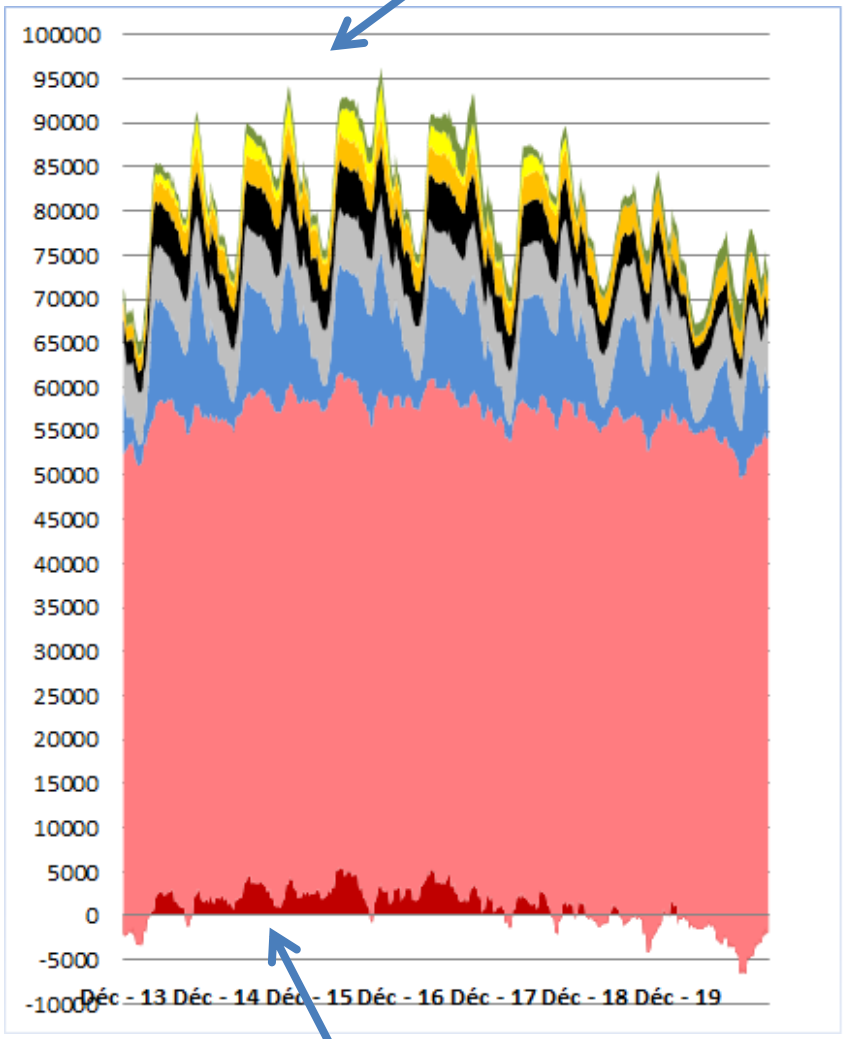


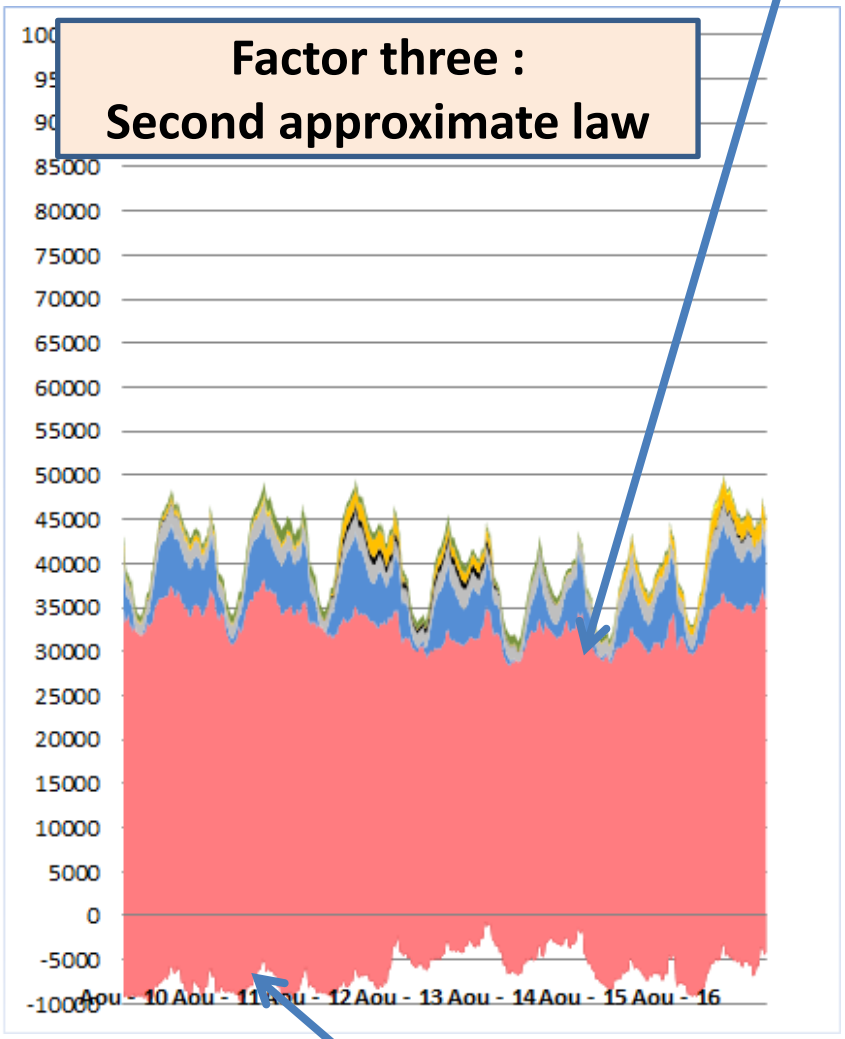
Ordinate MW

Electricity of France (Max and Min) (IV)

95 GW

31 GW





Factor three :
Second approximate law

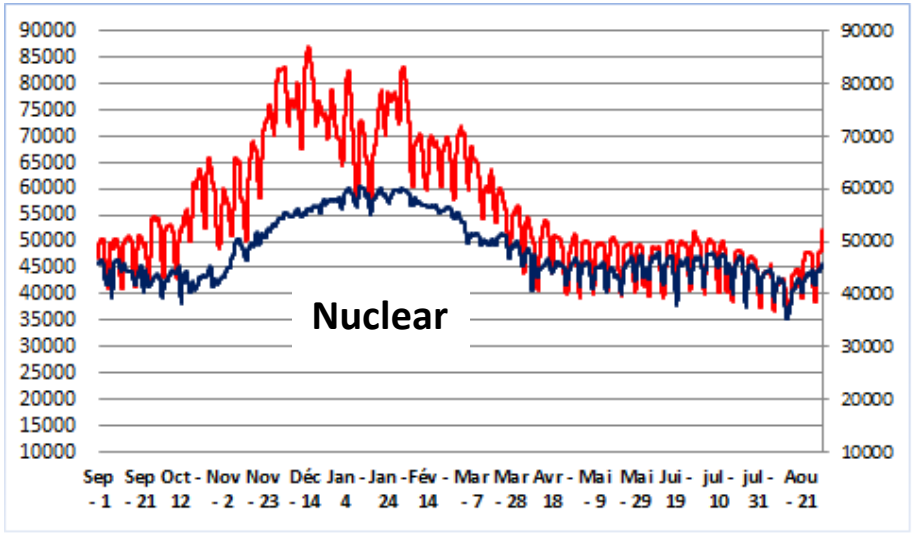
Importations

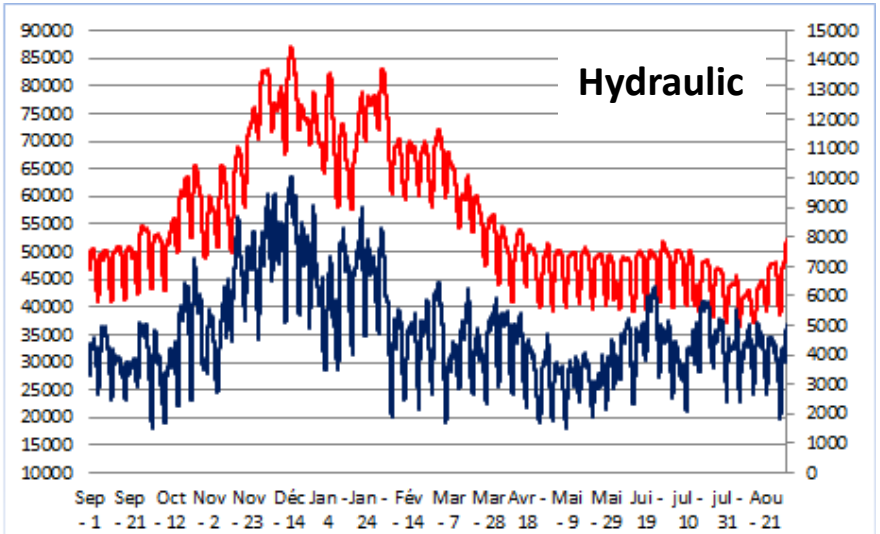
Exportations

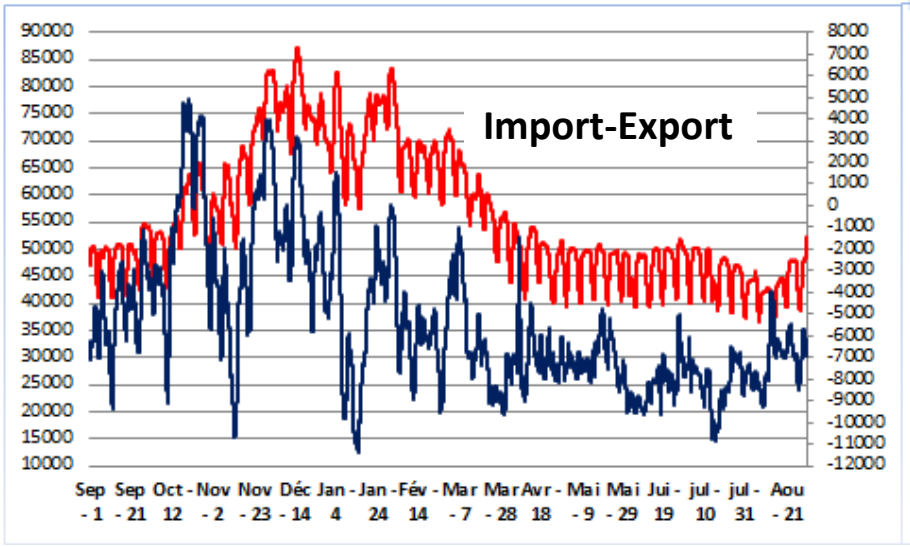
Electricity of France (September 2010 - August 2011) (V)

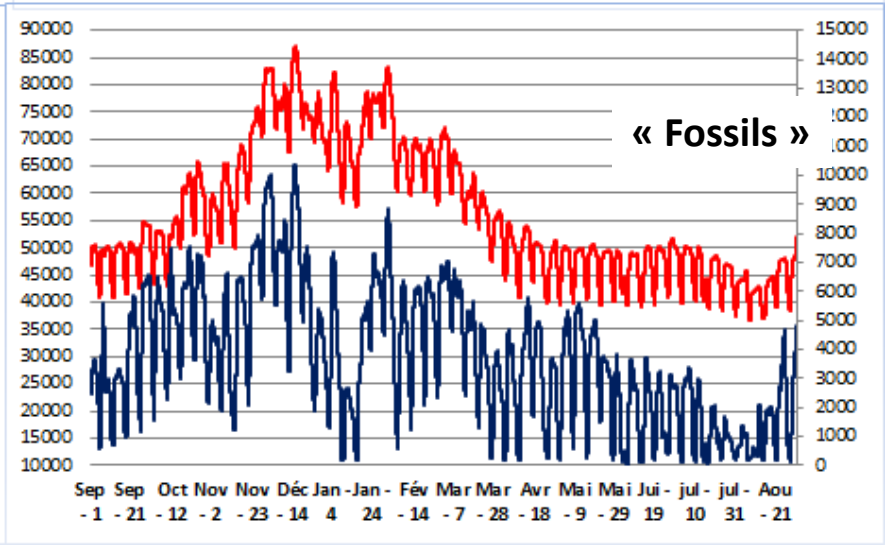
« dispatched » productions

Curves averaged over one full day





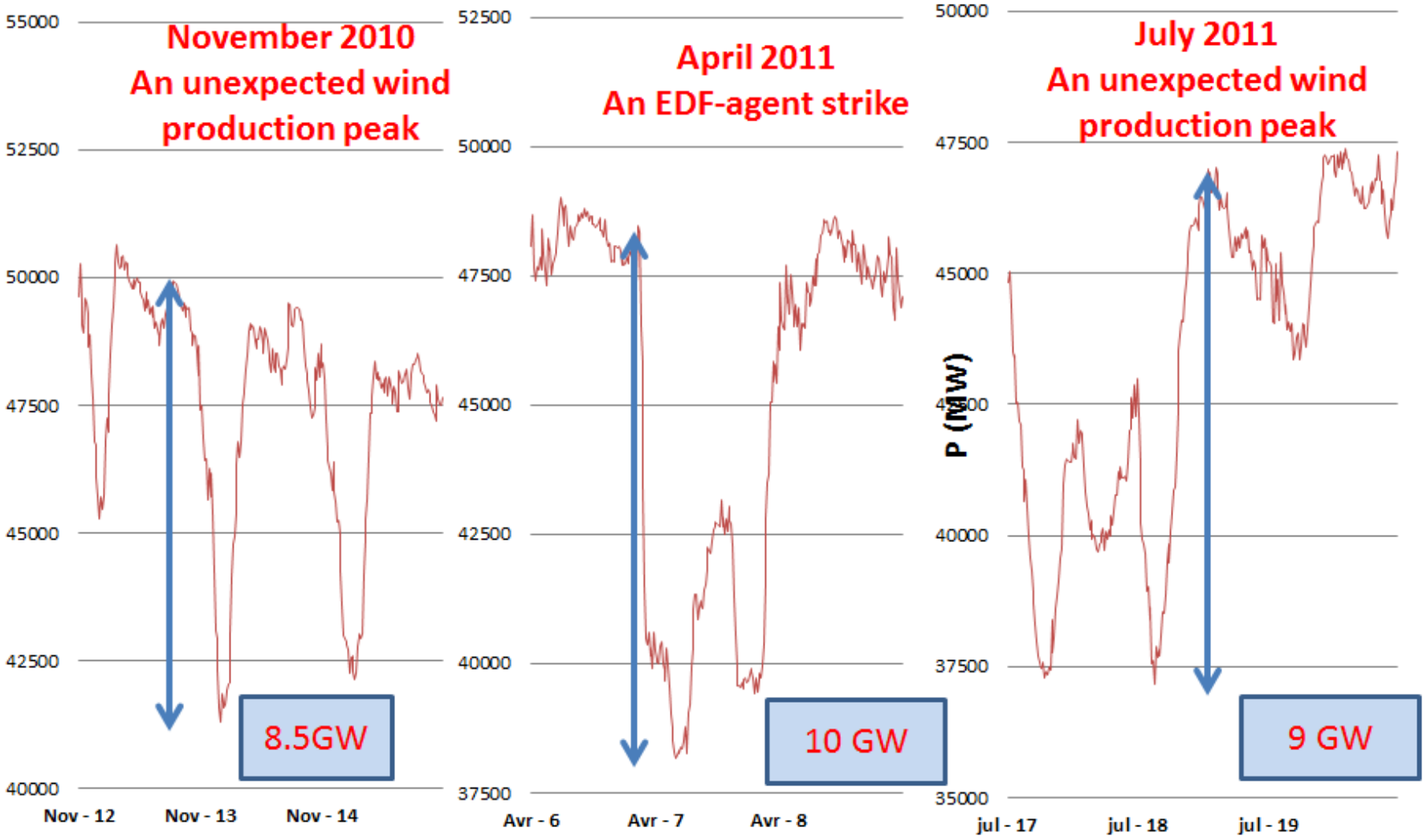




Red curve, left scale : Consumption; Blue curve, right scale : dispatched energies

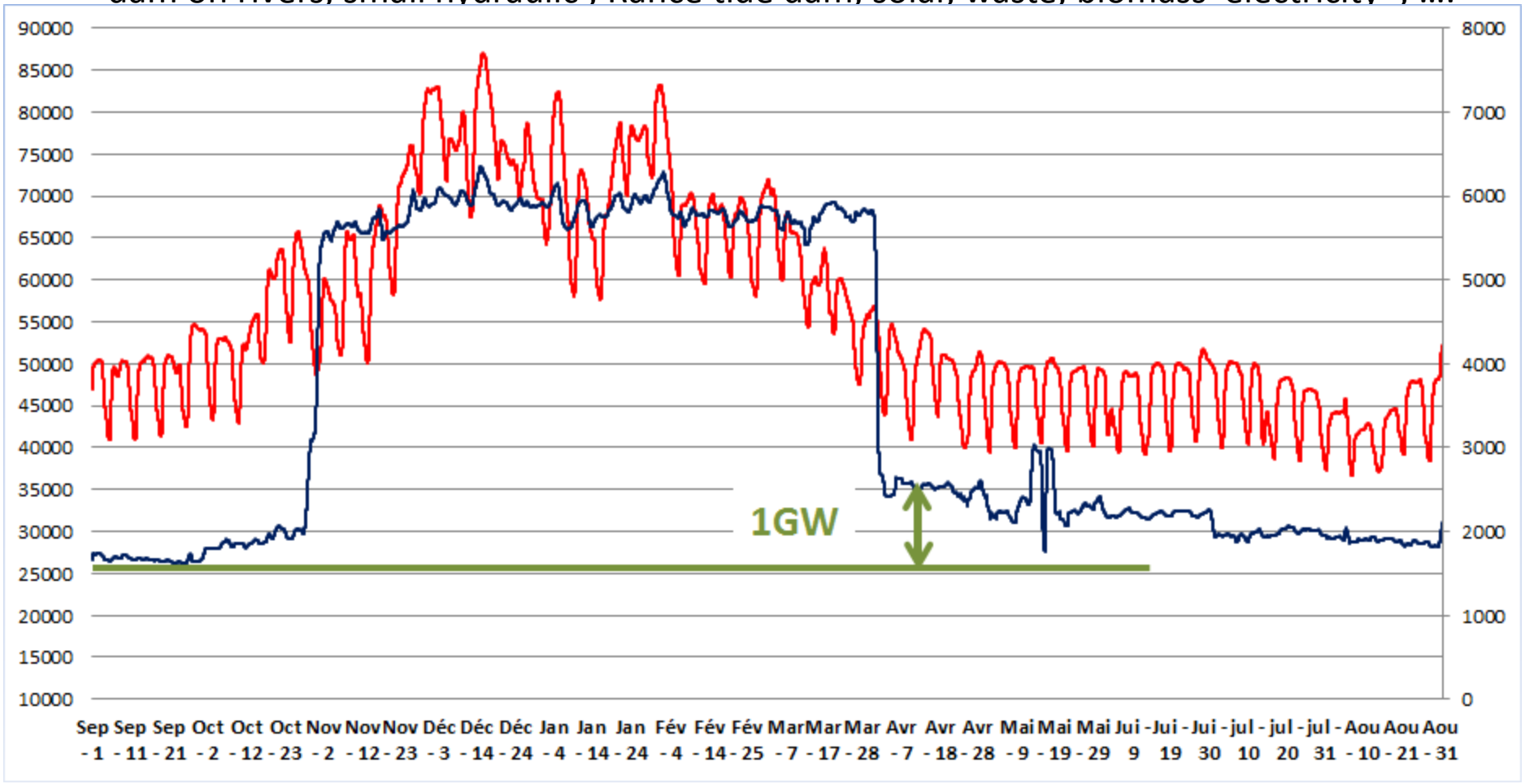
Electricity of France (Is Nuclear only Base-load ?) (VI)

When requested, nuclear power can handle rapid variations



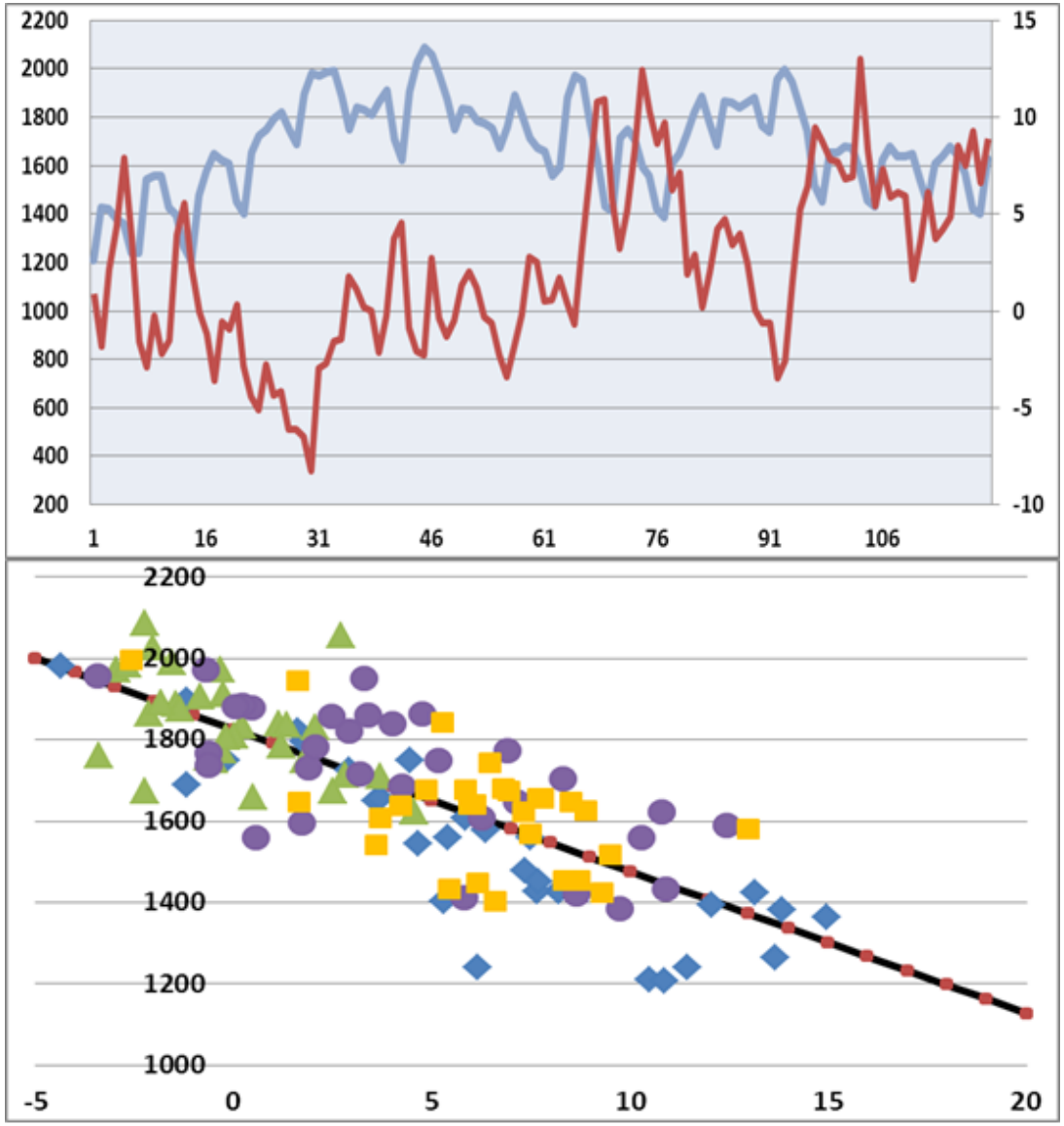
Electricity of France (September 2010- August 2011) (VII)

In the French system, there are two « FATAL » energies Wind and « Others » which includes dam on rivers, small hydraulic , Rance tide dam, solar, waste, biomass electricity*, ….



*** On January 1st 2011, according to ERDF small hydraulic 1,3GW, biogas-biofuel 196MW, waste 442MW, solar 808MW**

French consumption during the cold season
November – December – January - February



Daily electric consumption (GWh)

Blue curve, left scale

Average temperature at Toussus le Noble (°C)

Brown curve, right scale

Abcissae : days counted from November 1st (interval two weeks)

Ordinate : Daily electric Consumption (GWh)

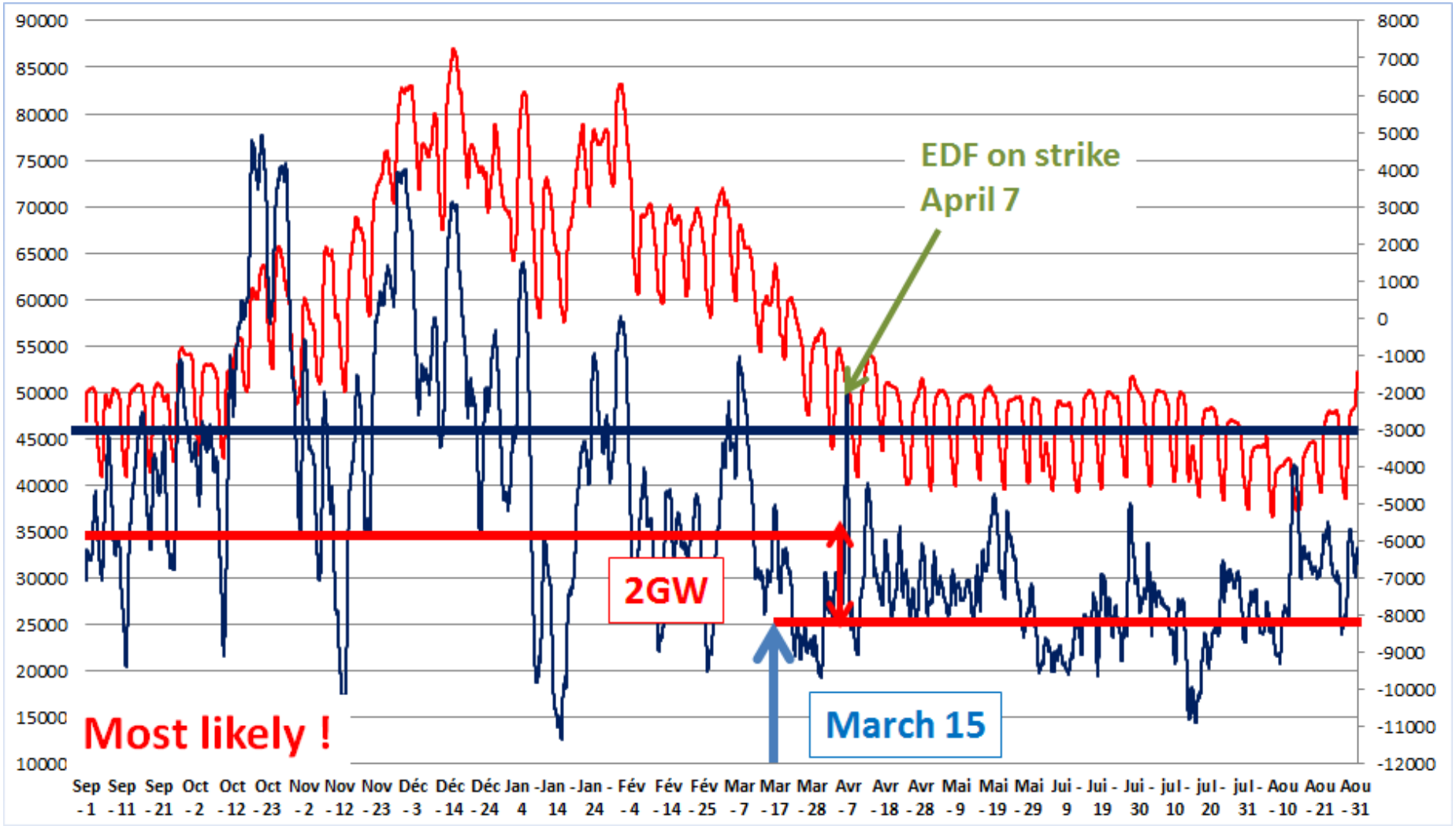
Abscissa : Avergage temperature at Toussus le Noble (°C)

Points blue (November) green (December) purple (January) yellow (February)

Linear Regression (negative) - 35GWh (~ - 1.5GW) per °C

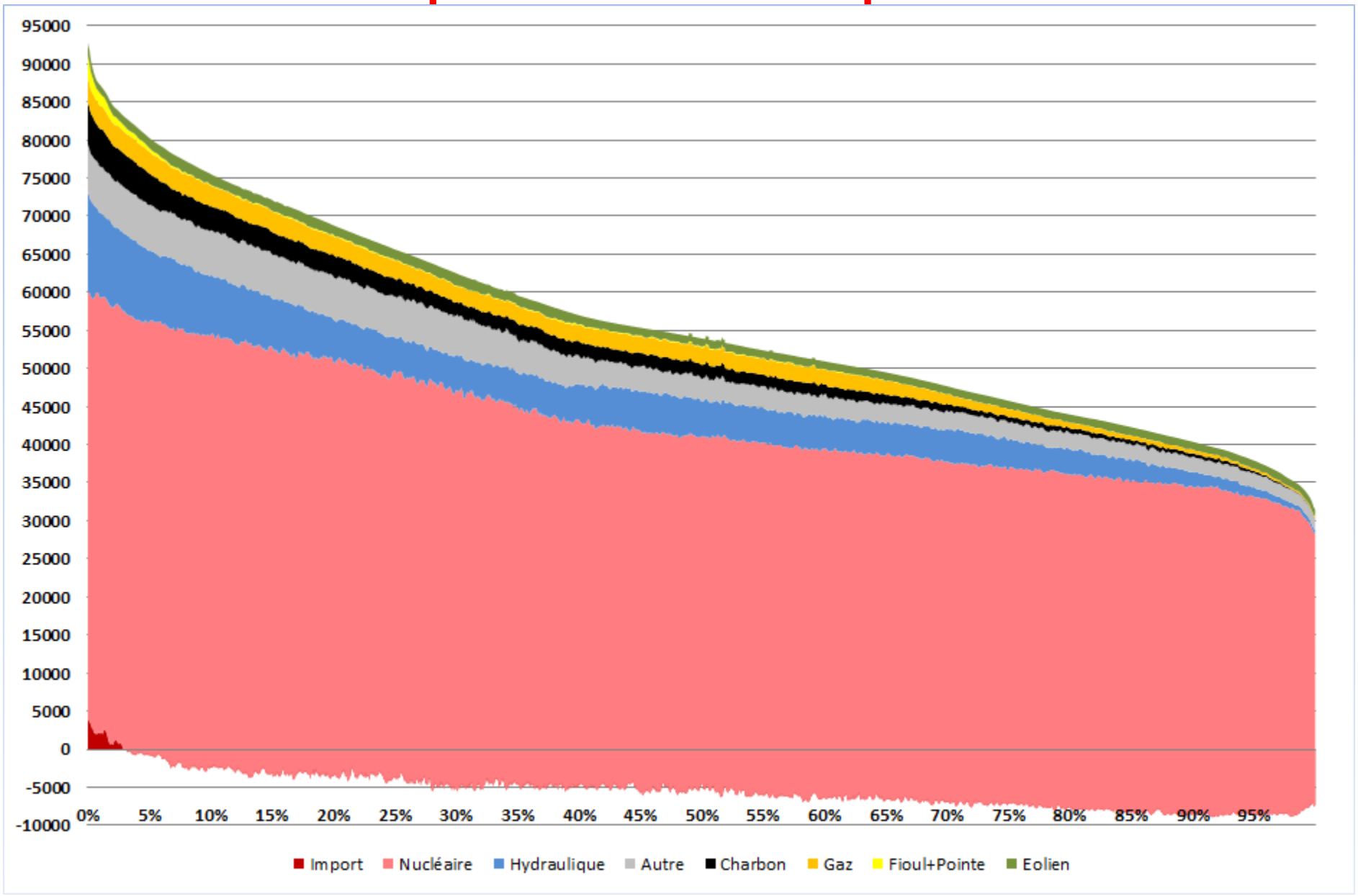
Is a « Merkel effect » visible in France ?

Following damages inflicted by a tsunami to the Japanese plant at Fukushima, by the middle March 2011, the Chancellor Mrs. Merkel asked that 8 German nuclear reactors be stopped



Red curve consumption ; blue curve Import- Export

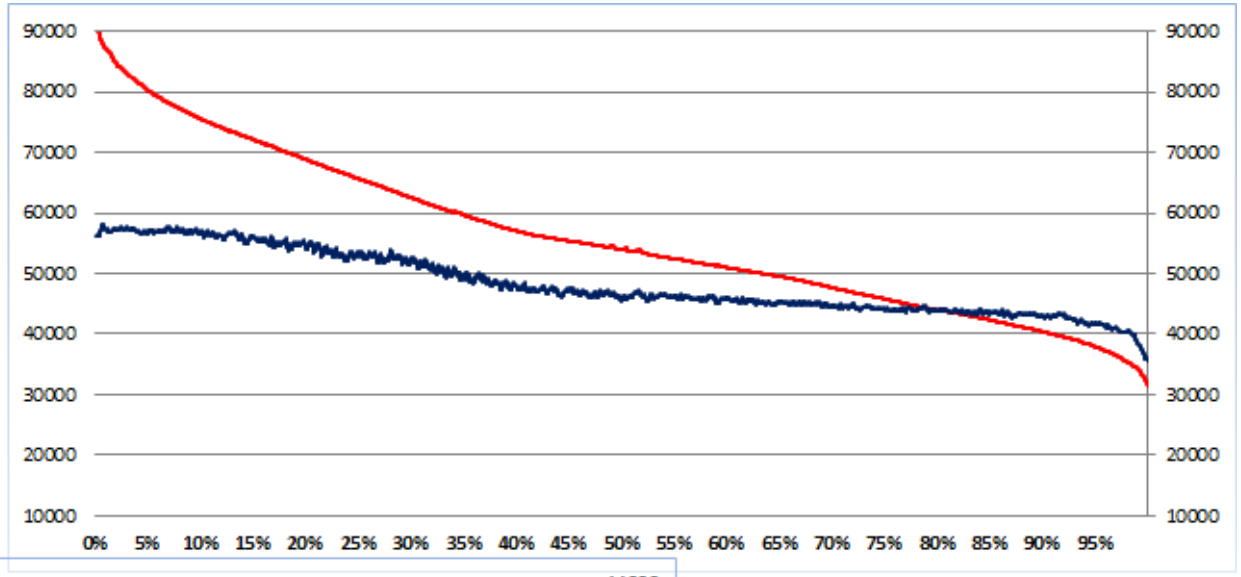
Consumption monotone vs productions

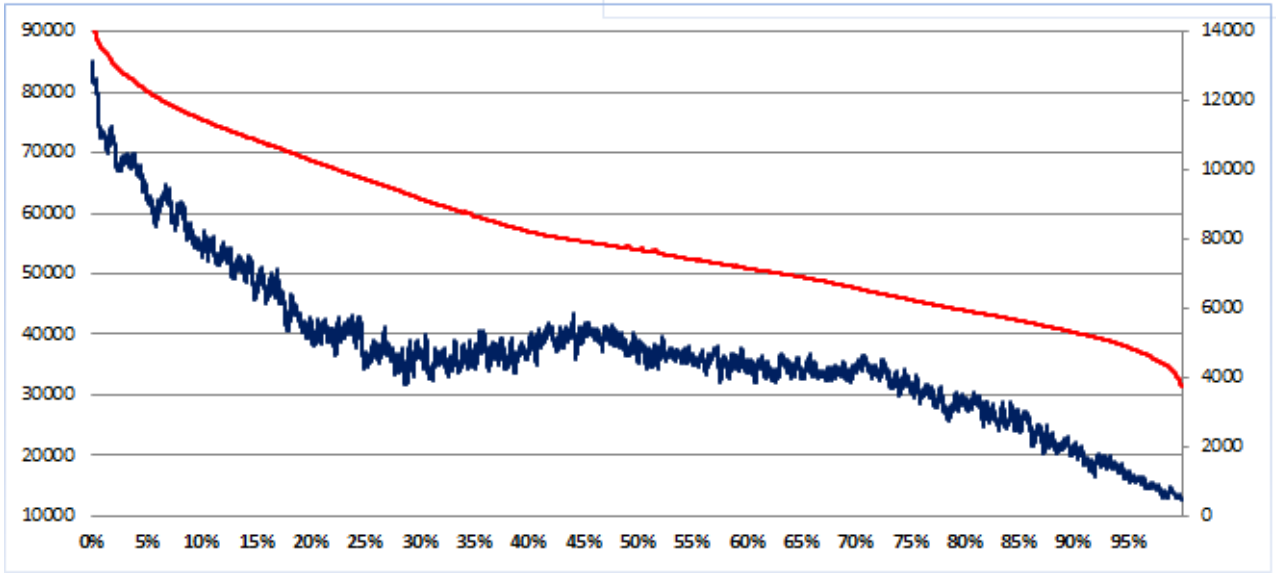


Consumption monotone
Nuclear and hydraulic productions

Nuclear

Consumption monotone
Red curve ; left scale
Nuclear production
Blue curve ; right scale
Same scales

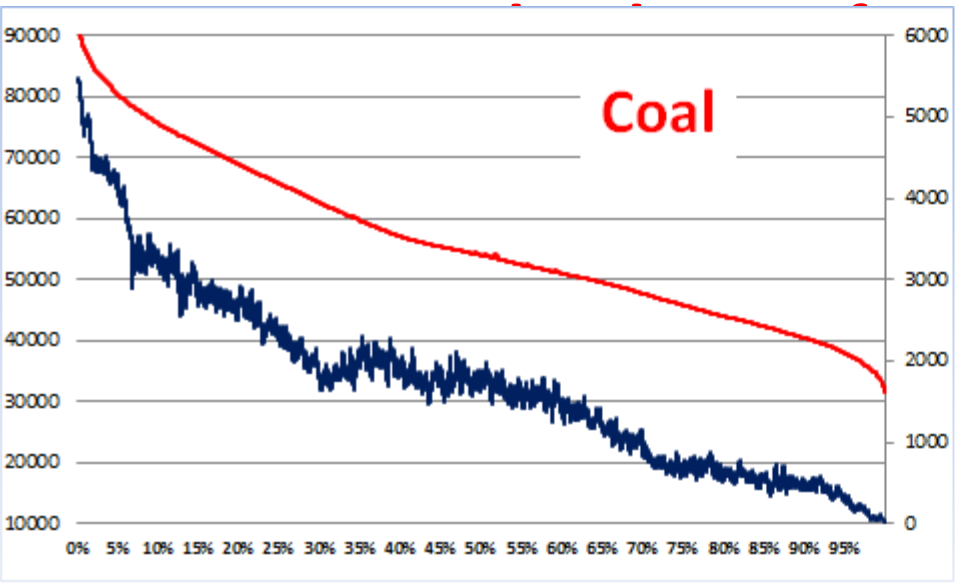


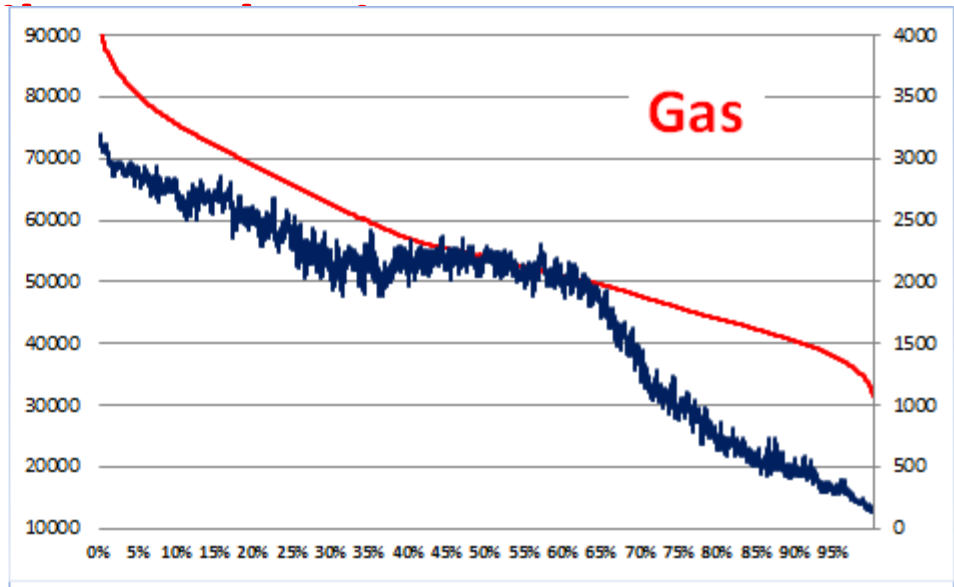


Hydraulic

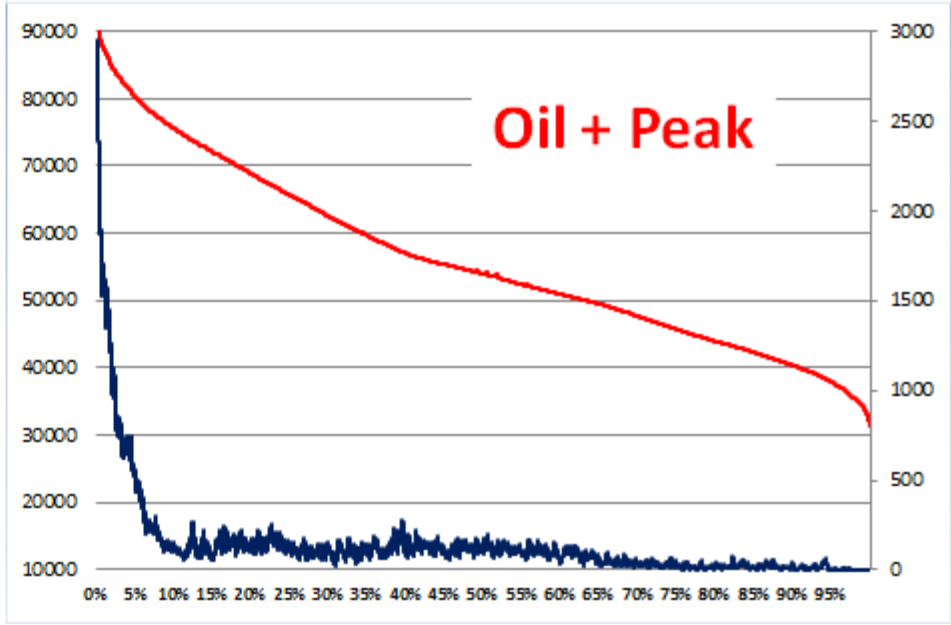
Consumption
Red curve ; left scale
Hydraulic production
Blue curve : right scale
Different scales

Consumption monotone





Consumption
Red curve ; left scale
"fossil" productions
Blue curve : right scale
Different scales

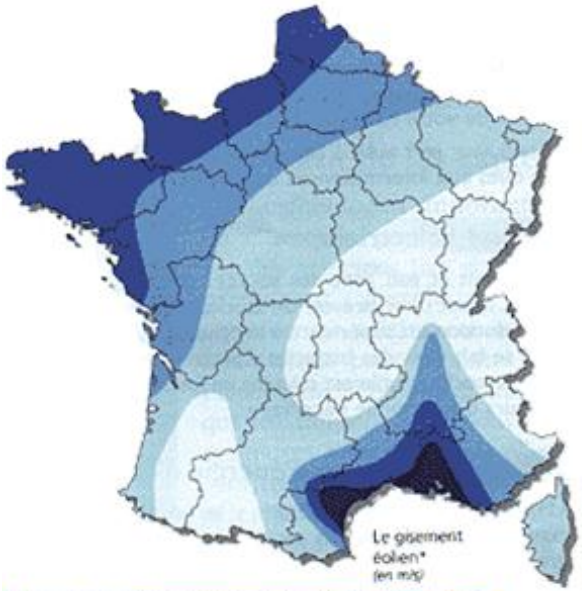


France
Wind production
September 2010 – August 2011

Wind – general data

- Installed power ~6.35GW (continental France) 1st September 2011
- Typical yearly growth 1.4 GW par an : 4,95GW on 1st September 2010.
- A geographical implantation which
  does NOT take into account very much the wind potential over France

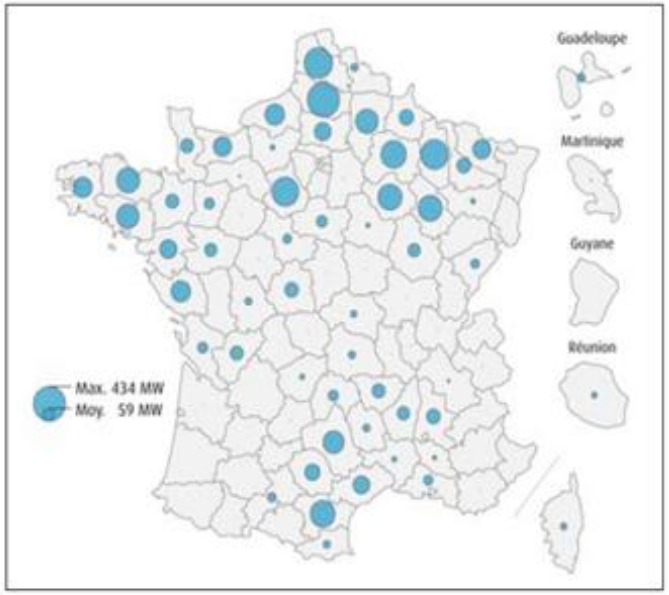
Wind potential (speeds m/s)



Bocage dense, bois, banlieue	Rase campagne, obstacles épars	Prairies plates, quelques buissons	Lacs, mer	Crêtes**, collines	
<3,5	<4,5	<5,0	<5,5	<7,0	Zone 1
3,5 - 4,5	4,5 - 5,5	5,0 - 6,0	5,5 - 7,0	7,0 - 8,5	Zone 2
4,5 - 5,0	5,5 - 6,5	6,0 - 7,0	7,0 - 8,0	8,5 - 10,0	Zone 3
5,0 - 6,0	6,5 - 7,5	7,0 - 8,5	8,0 - 9,0	10,0 - 11,5	Zone 4
>6,0	>7,5	>8,5	>9,0	>11,5	Zone 5

* Vitesse du vent à 50 mètres au-dessus du sol en fonction de la topographie
** Les zones montagneuses nécessitent une étude de gisement spécifique

Turbine implantation 31/03/2011



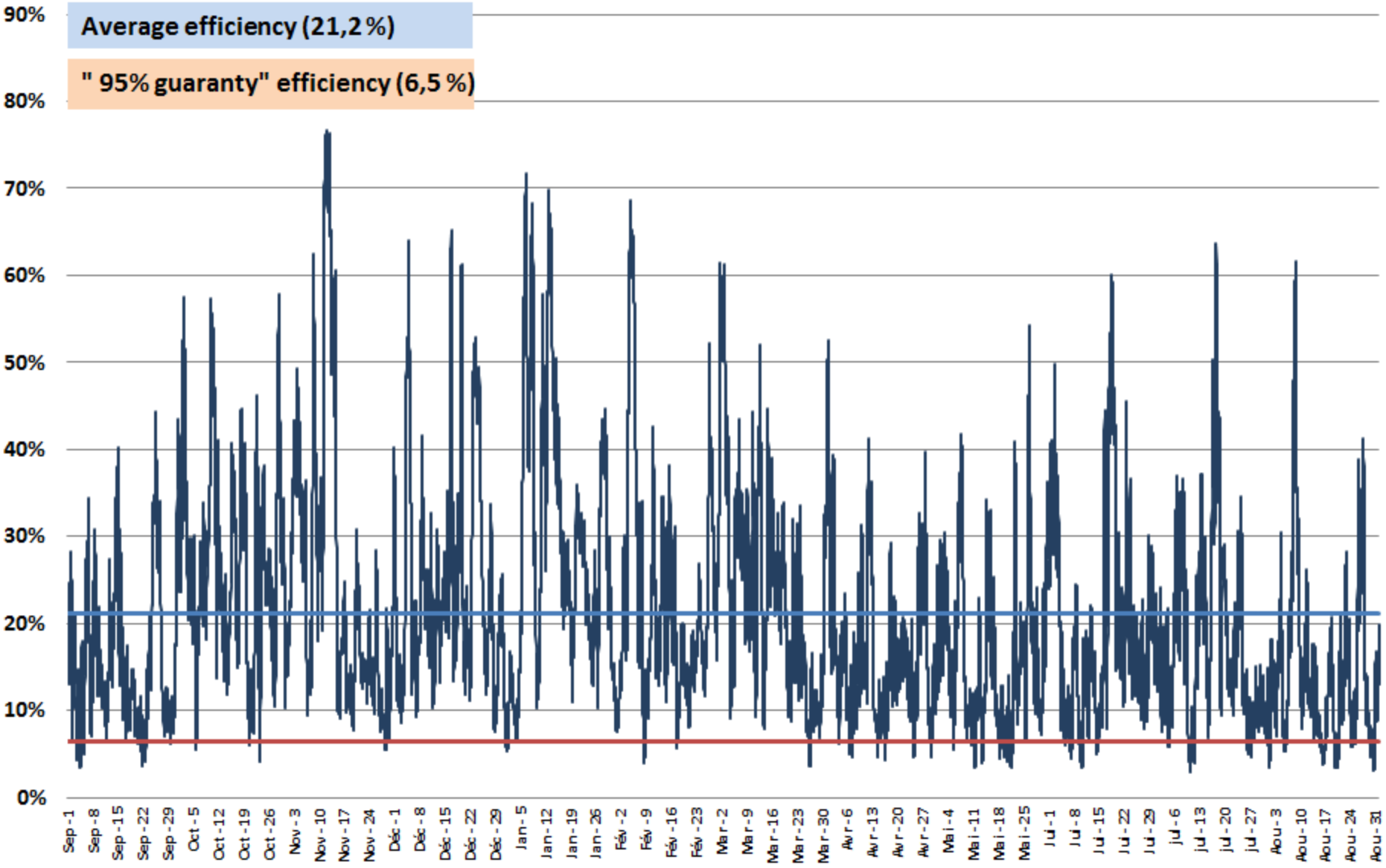
Source CGDR – ERDF-RTE

The major French Wind regions 1st September 2011
(source ADEME)

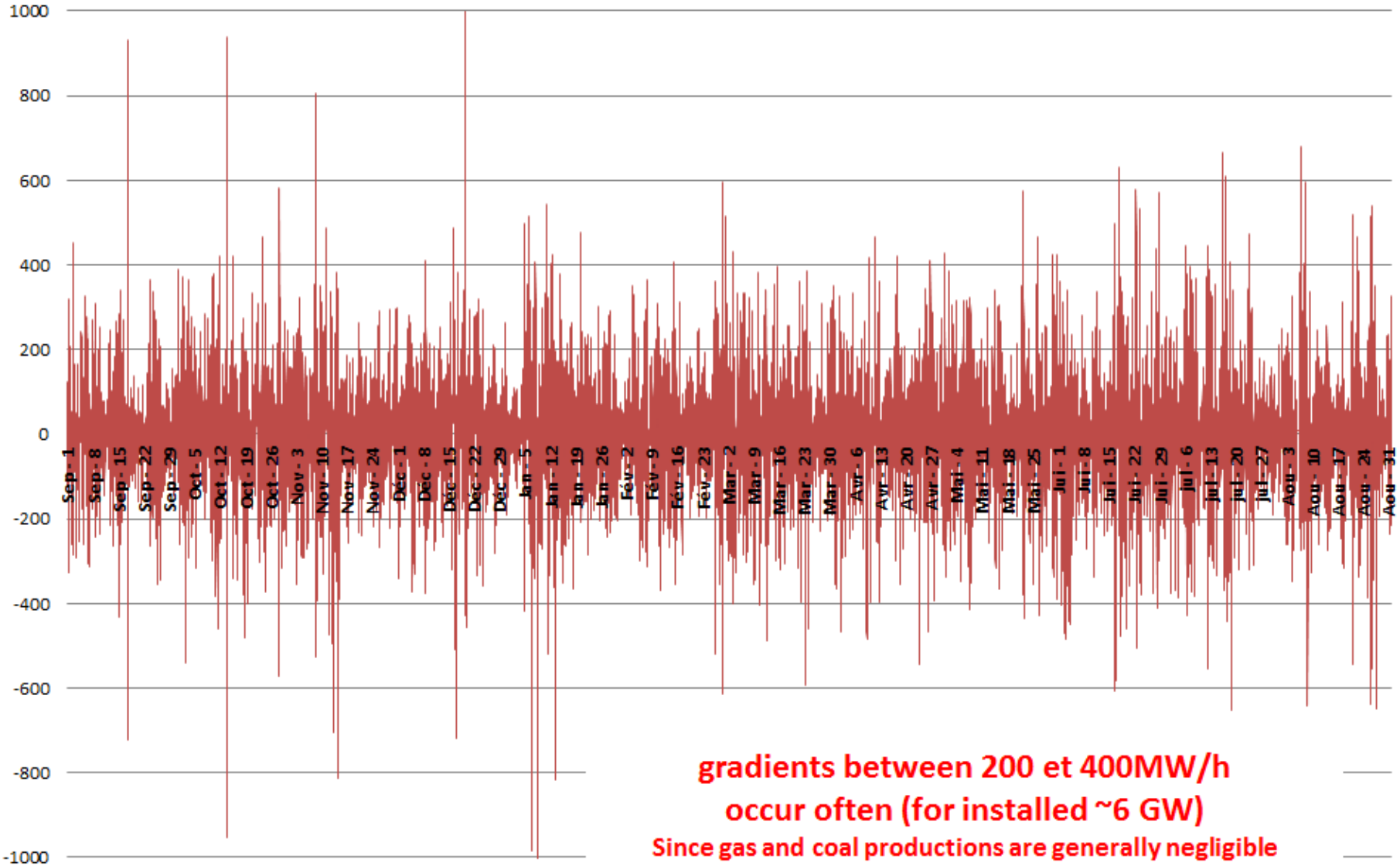
Champagne - Ardennes 744MW,
Picardie 709MW,
Bretagne 599MW,
Centre 566MW,
Lorraine 532 MW,
Languedoc – Roussillon 419MW,
Pays de Loire 392MW,
Nord - Pas de Calais 345MW,
Midi - Pyrénées 330MW,
… ,
Basse Normandie 198MW,
Haute Normandie 180MW,
…,
PACA 45MW

bold face : French windy regions

Wind – Production efficiency (MW)



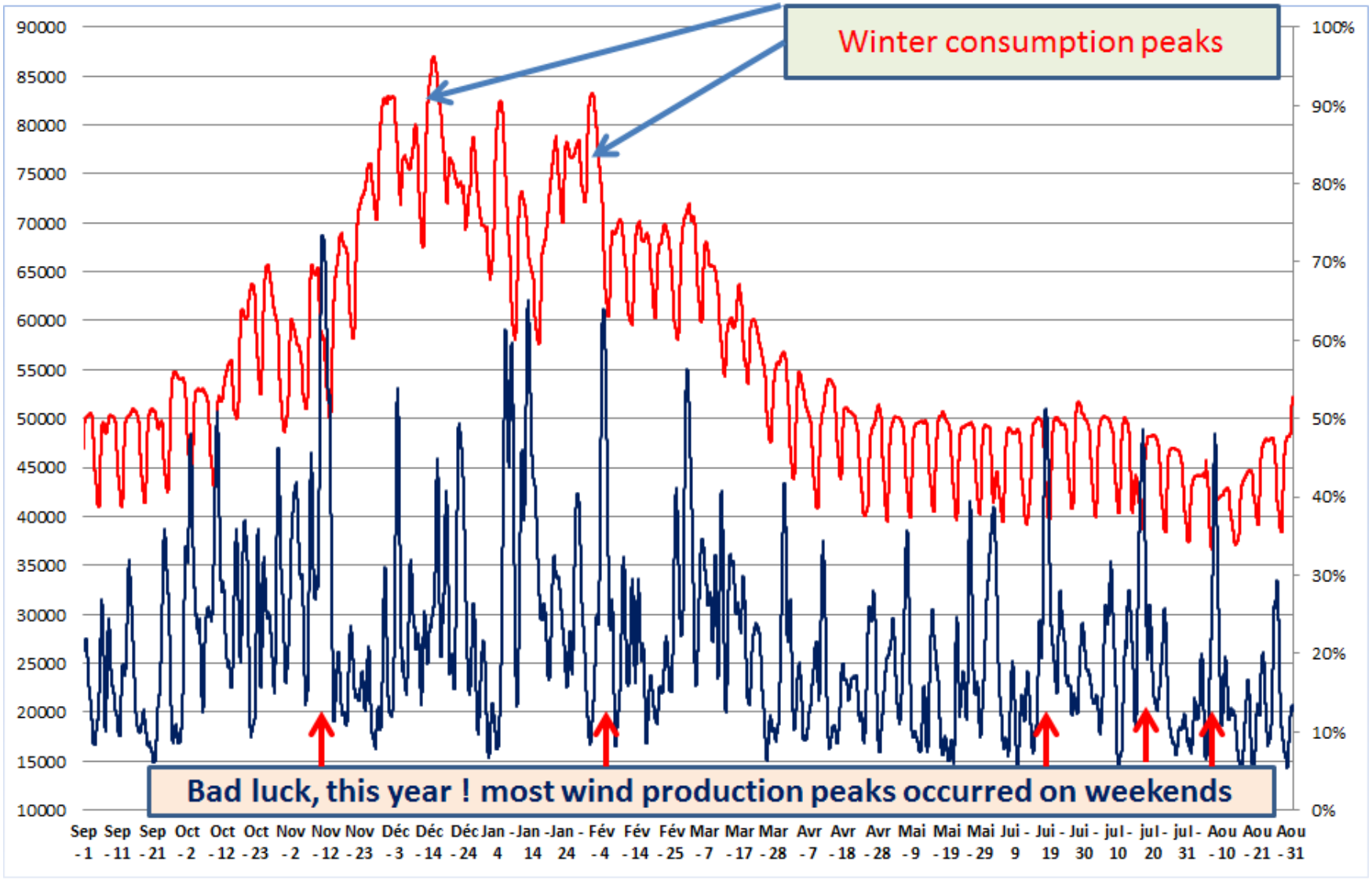
Wind - power gradients (MW/hour)



gradients between 200 et 400MW/h occur often (for installed ~6 GW)

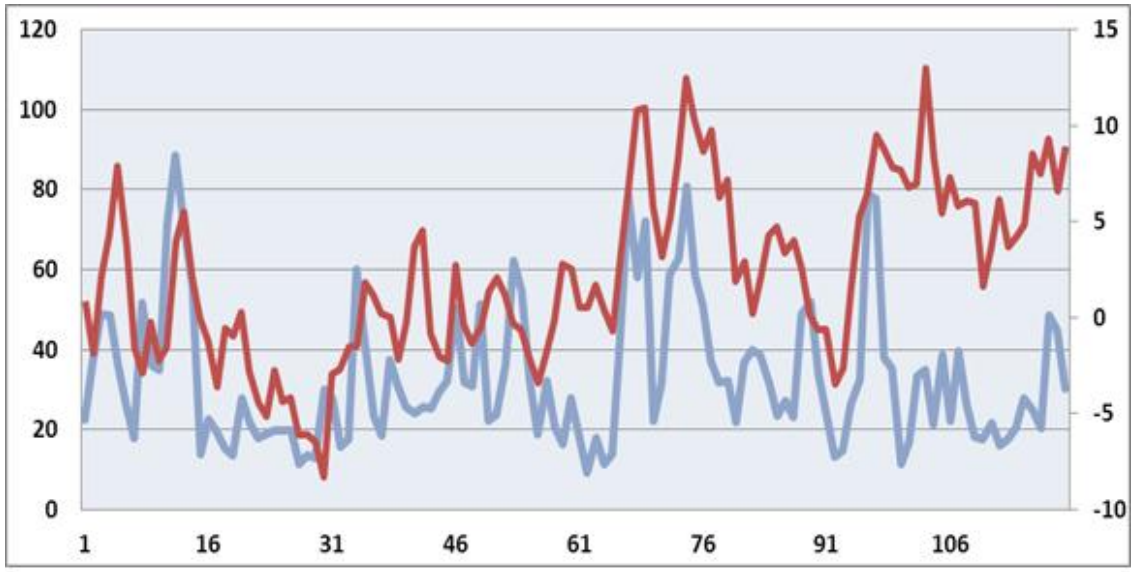
Since gas and coal productions are generally negligible at these moments, nuclear energy must handle the fluctuations

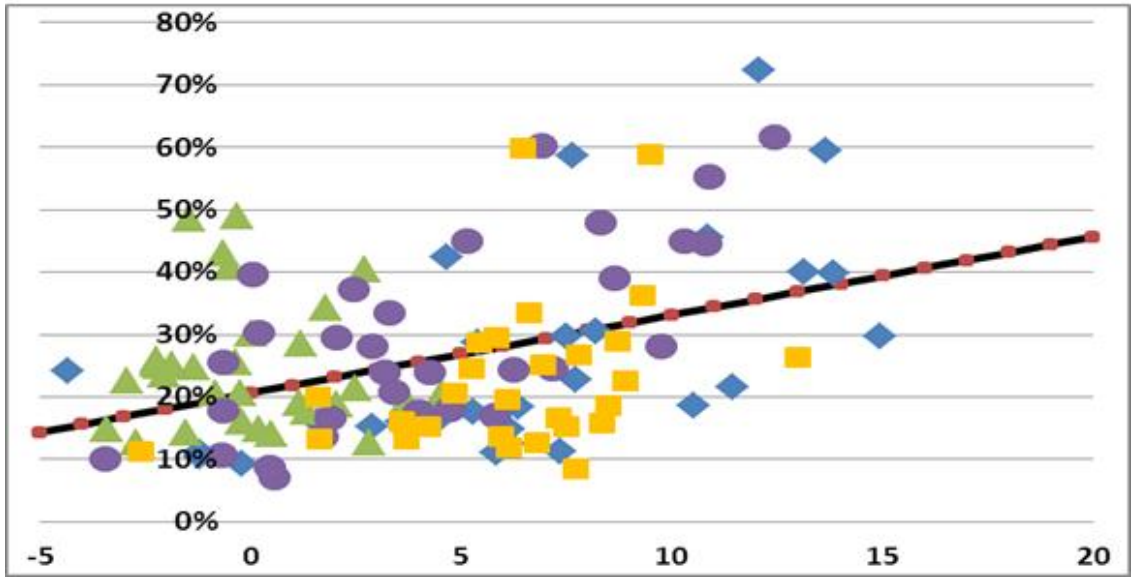
Electric consumption and wind production(MW)



Red curve ; left scale : consumption ; Blue curve ; right scale : Wind power

Wind production during the cold season
November – December – January - February





Daily electric wind production (GWh)

Blue curve, left scale

Average temperature at Toussus le Noble (°C)

Brown curve, right scale

Abcissae : days counted from November 1st (interval two weeks)

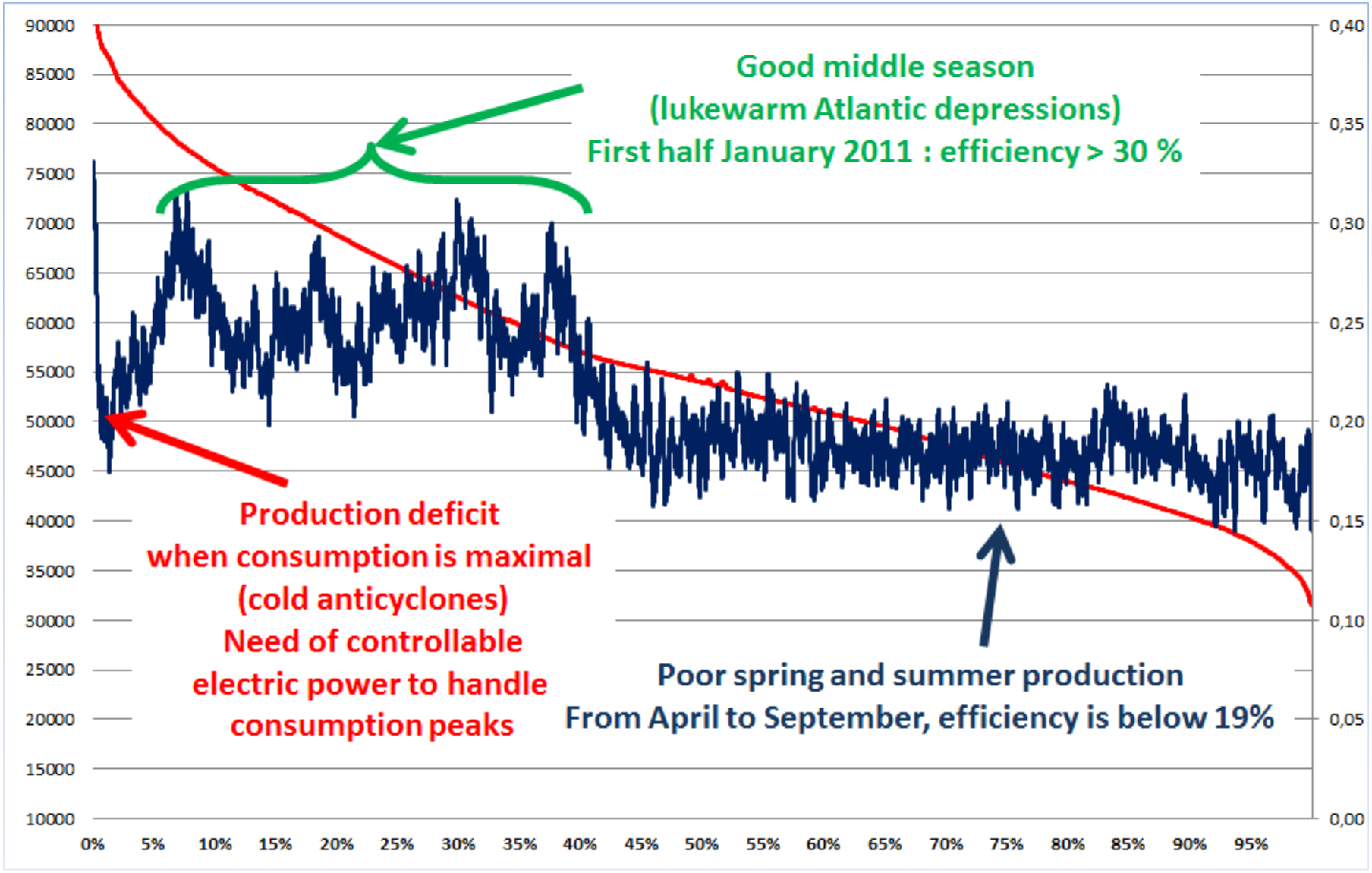
Ordinate : wind power efficiency (%)

Abscissa : Avergage temperature at Toussus le Noble (°C)

Points blue (November) green (December) purple (January) yellow (February)

Linear Regression (positive) + 1.3% per °C

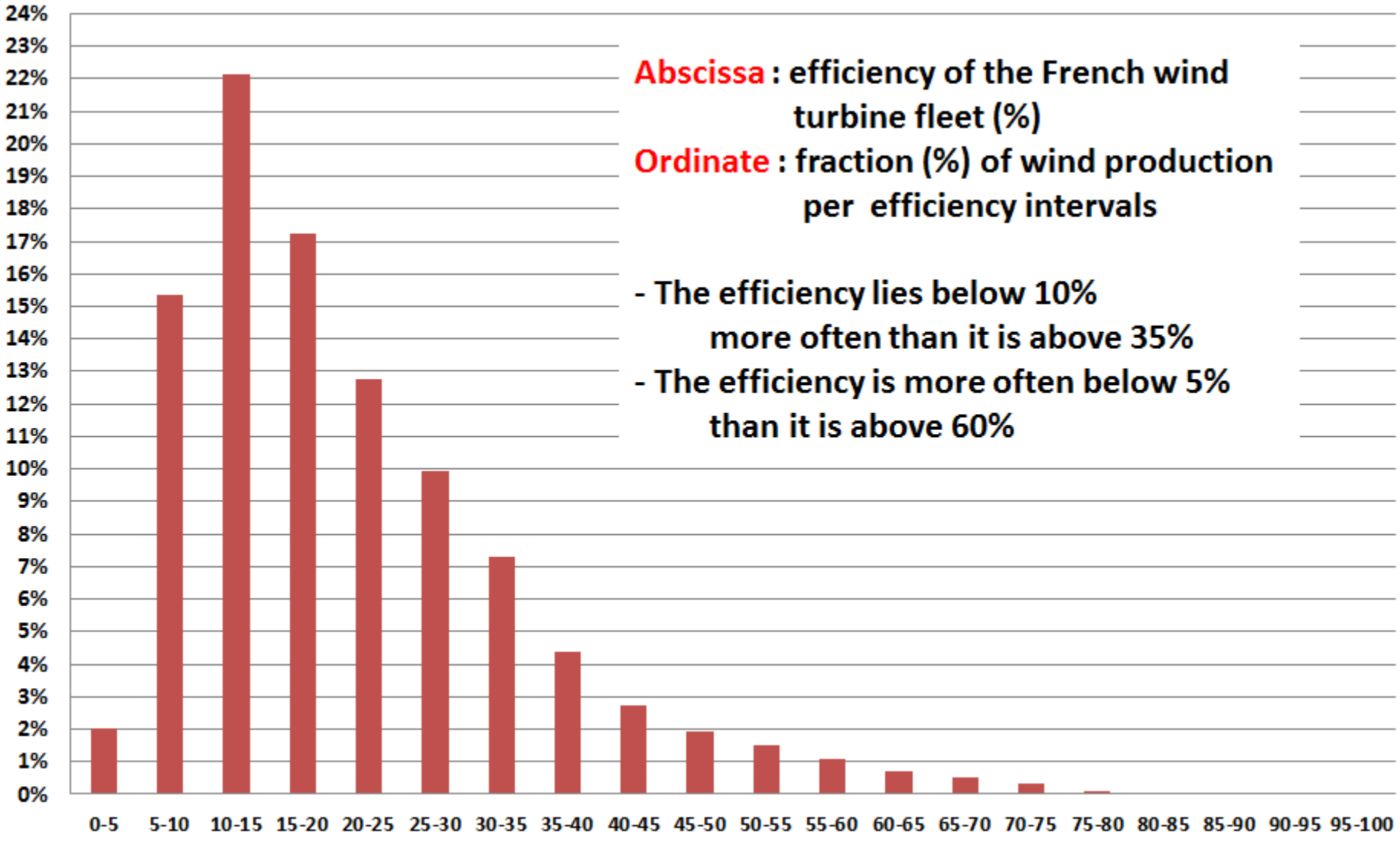
Consumption monotone (MW) and Wind efficiency (%)



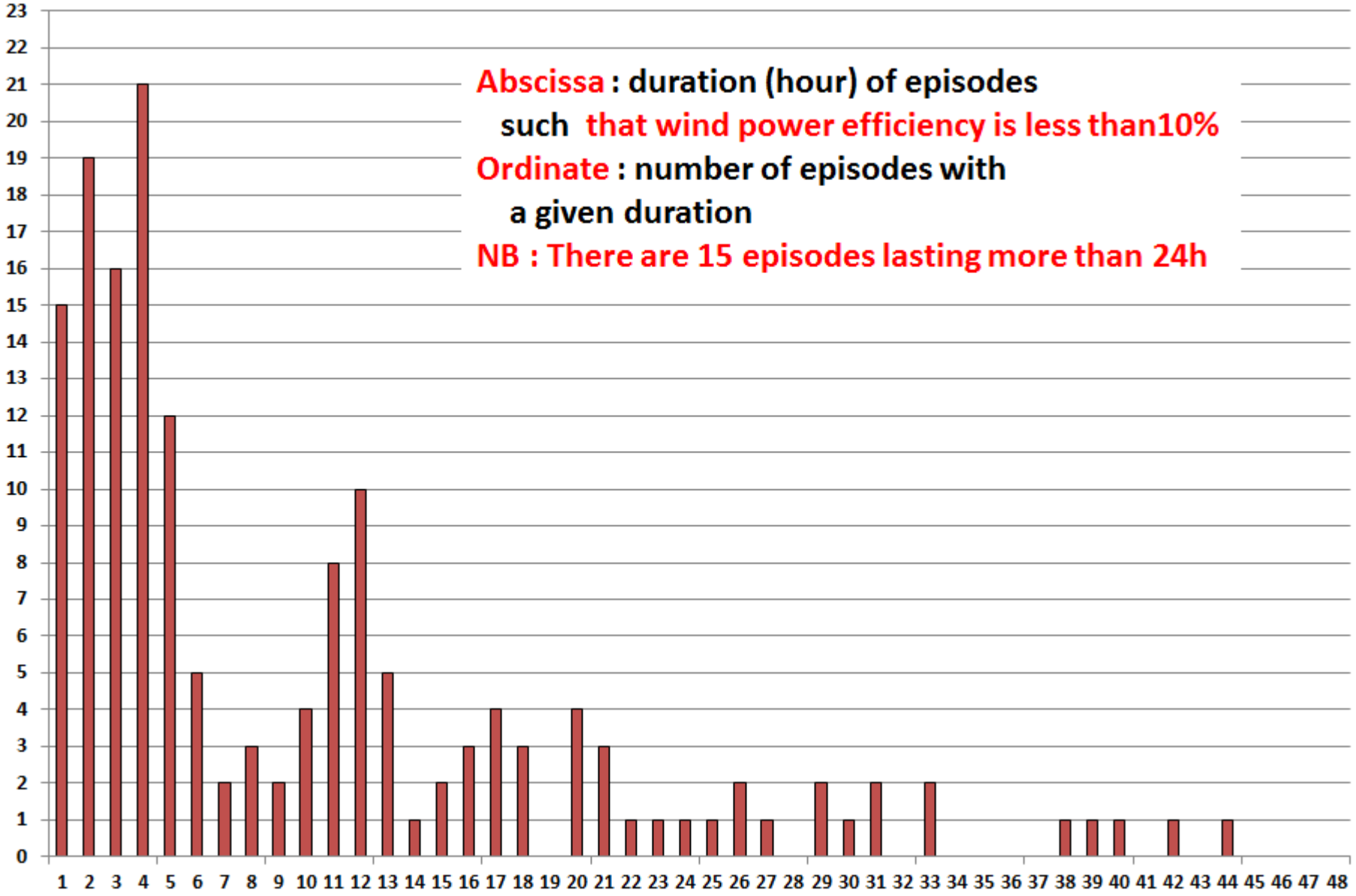
Consumption monotone : red curve left scale Wind production Blue curve; right scale

Different scales

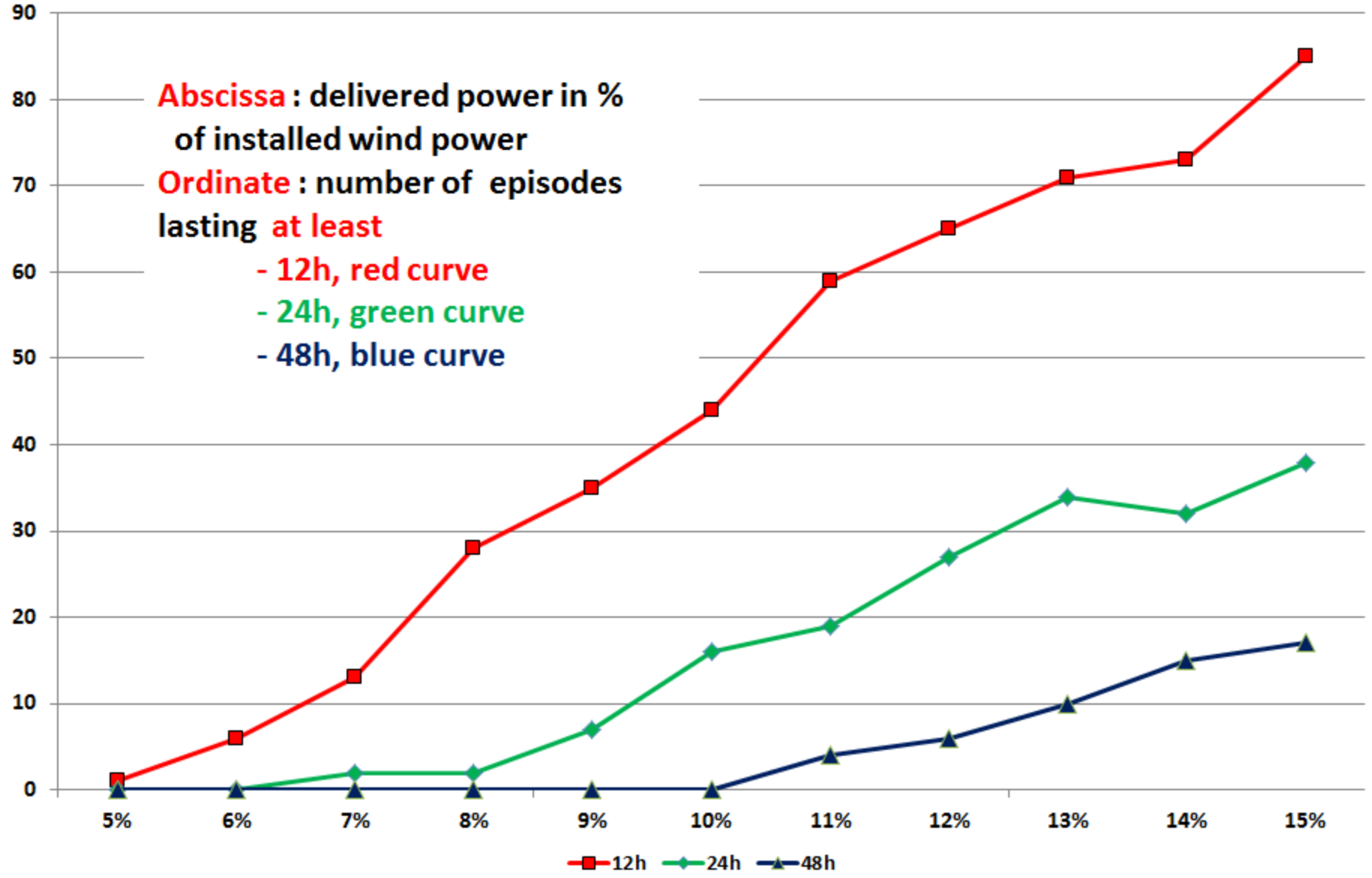
Temporal distribution of French wind power efficiency



Long episodes with weak wind power (I)



Long episodes with weak wind power (II)



An anticipation exercice based on the « Grenelle » decisions

Government decisions for wind (announced realization date 2020)

- **19 GW onshore wind (thus 12,6GW more than today)**
- **6 GW offshore wind (1st call for proposals, July 15th 2011)**

Possible motivations for the « Wind-Grenelle »

1) Economy ?

- **Guaranteed onshore tariff 80€/MWh**
  as a matter of fact, effective 2010 tariff is 87€/MWh (source CRE)
- **Guaranteed offshore tariff 130€/MWh**
  For such a tariff no construction takes place, the recent call for proposals indicates that tariffs requested in the range 170-200€/MWh will be accepted by the government
- **Cost of strengthening the electric network in order to handle intermittency**

2) An investment for the future ?

Subsidies are guaranteed for 20 years. Most turbines won't last that much (see Denmark).

3) Energetic independence ?

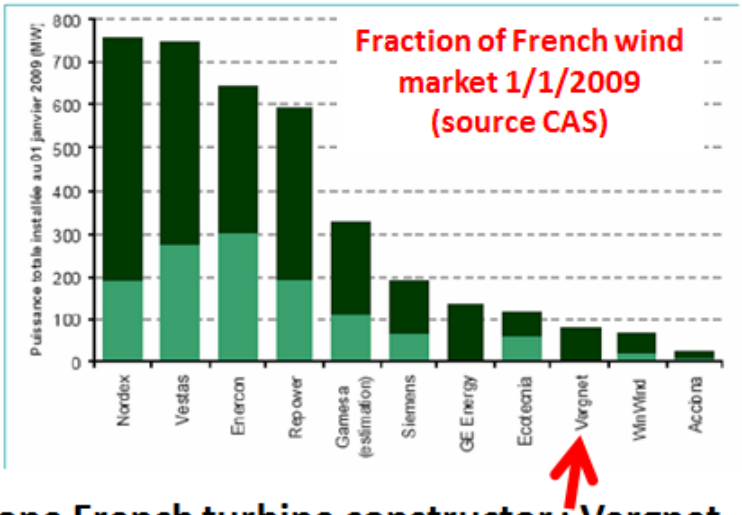
It will be necessary to build gas powered plants to handle the **4 days (out of 5) without wind**

4) Industrial and employment policy ?

- **No wind turbine erected in France has been (and will be) built in France**
- **Maintenance and Operation effected from abr**

The only justification for a massive deployment of wind energy in France might be Ecology !

Wind power may reduce CO2 emissions from the electric sector.



Only one French turbine constructor : Vergnet. It only builds small turbines for DOM-TOM

Test scenario of the ecological potential of the Wind « Grenelle » decisions

1) Twenty « France »s

- under the same climate as 2010-2011 –> identical electric consumption,
- with a wind park with 1, then 2, then 3 … then 20GW more installed turbines.

2) Hypotheses

- Wind production grows in proportion to installed power
- Just as today, wind electricity has a priority for injection into the network
- Every effort is made to use wind electricity in order to reduce CO2 emissions
- Being a fatal energy "others" can't participate to balancing
- Import-Export (dominated by Export + strong correlations between wind productions of EU countries) can't participate to balancing

3) Consequences

- Productions modes that can be dispatched will adjust to insure constant balance between production and consumption
- Wind power is used first to reduce "Coal" production, then "Gas" producton and then 'Oil + Peak" production

Test scenario of the ecology of wind « Grenelle » decisions : The three phases

Phase 1 : « Instantaneous »

Available wind power at time t is used to reduce or stop "Coal", then "Gas", then "Oil + Peak" at the same time t.

Phase 2 : « Hydraulic »

If following phase 1, there remains some "unused" wind power

1) one stops the flow of water from mountain dams (hydraulic electricity)

2) later, as soon as possible, this "preserved" water is used to stop "Coal", then "Gas", then "Oil+ Peak" power which has not been stopped by phase 1

Phase 3 : « STEP » (Station de Transfert d'Energie par Pompage)

If following phase 2, there still remains some "unused" wind power

1) water is pumped in French STEPs (~5GW and ~100GWh)

2) later, as soon as possible, this "saved" through pumping water is used to stop "Coal", then "Gas" then "Oil + Peak" power which has not been stopped by phase 1and 2

Once all this has been done, if there still remains some wind power,
one either stops wind turbines or reduce nuclear plant power.
At this stage, there is no associated CO2 emission reduction

Test scenario of Wind « Grenelle » decisions

A selection of hypotheses systematically favorable to wind energy

1) The grid can instantaneously handle any requested transfer of electricity

2) The two entities in charge of handling production ERDF (wind turbines) and RTE (power plants) can coordinate their information and actions instantaneously.

3) During electricity transfers there is no energy loss

4) “Fossil” power plants (coal, gas, oil) can adjust their production instantaneously to match any wind power fluctuation.

5) At any time dam reservoirs have the capacity to accept any amount of wind energy one wants to “save”.

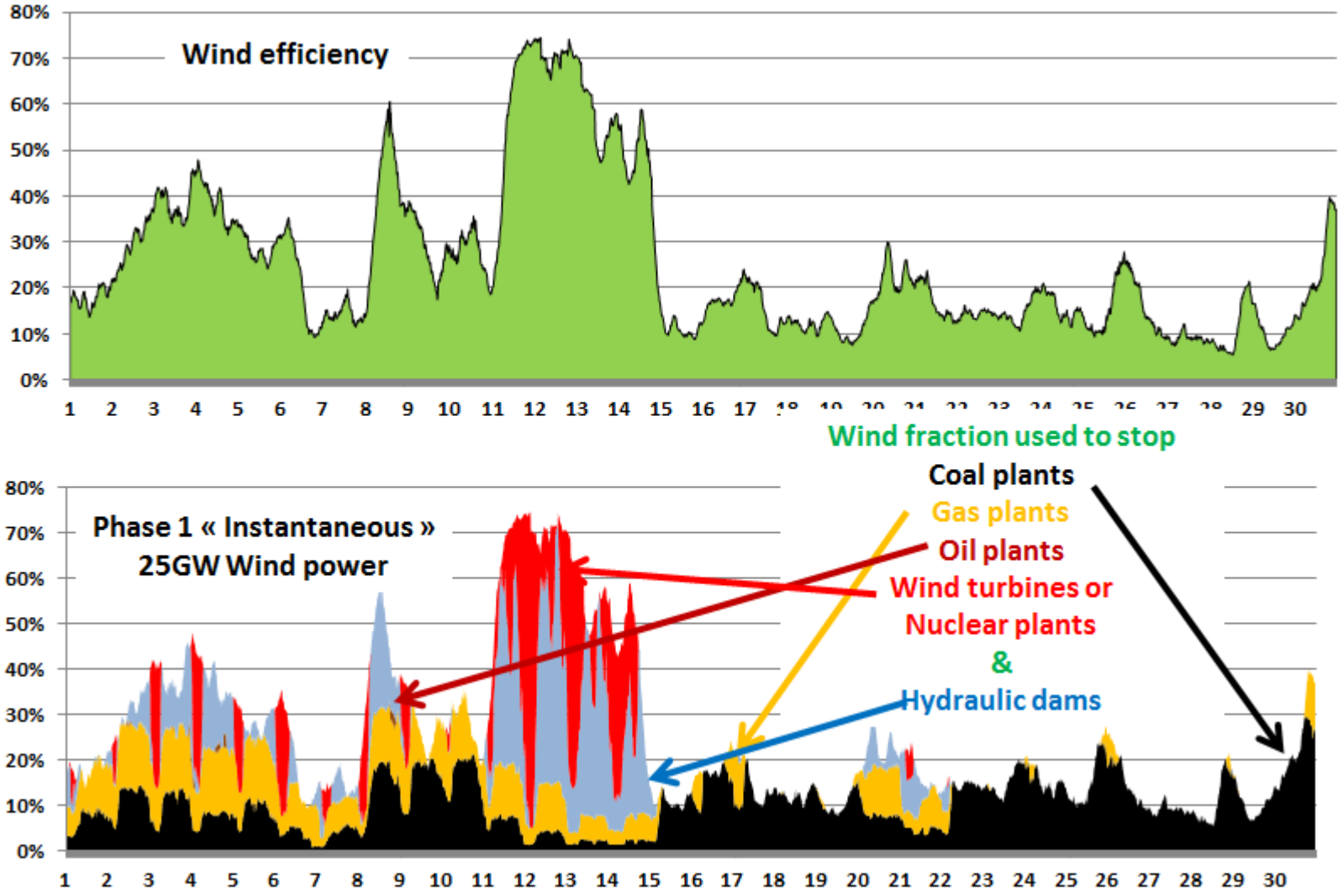
6) During phase 2 and 3, when hydraulic production is used simultaneously to balance production vs consumption while using “saved” water to erase some “fossil” productions, water turbines are always available to fulfill these two missions at the same time.

7) STEPS are used exclusively to help the CO2-emission-reduction wind policy.

8) Owners of “fossil” power plants graciously accept that their plants be used in a non efficient and non economical way.

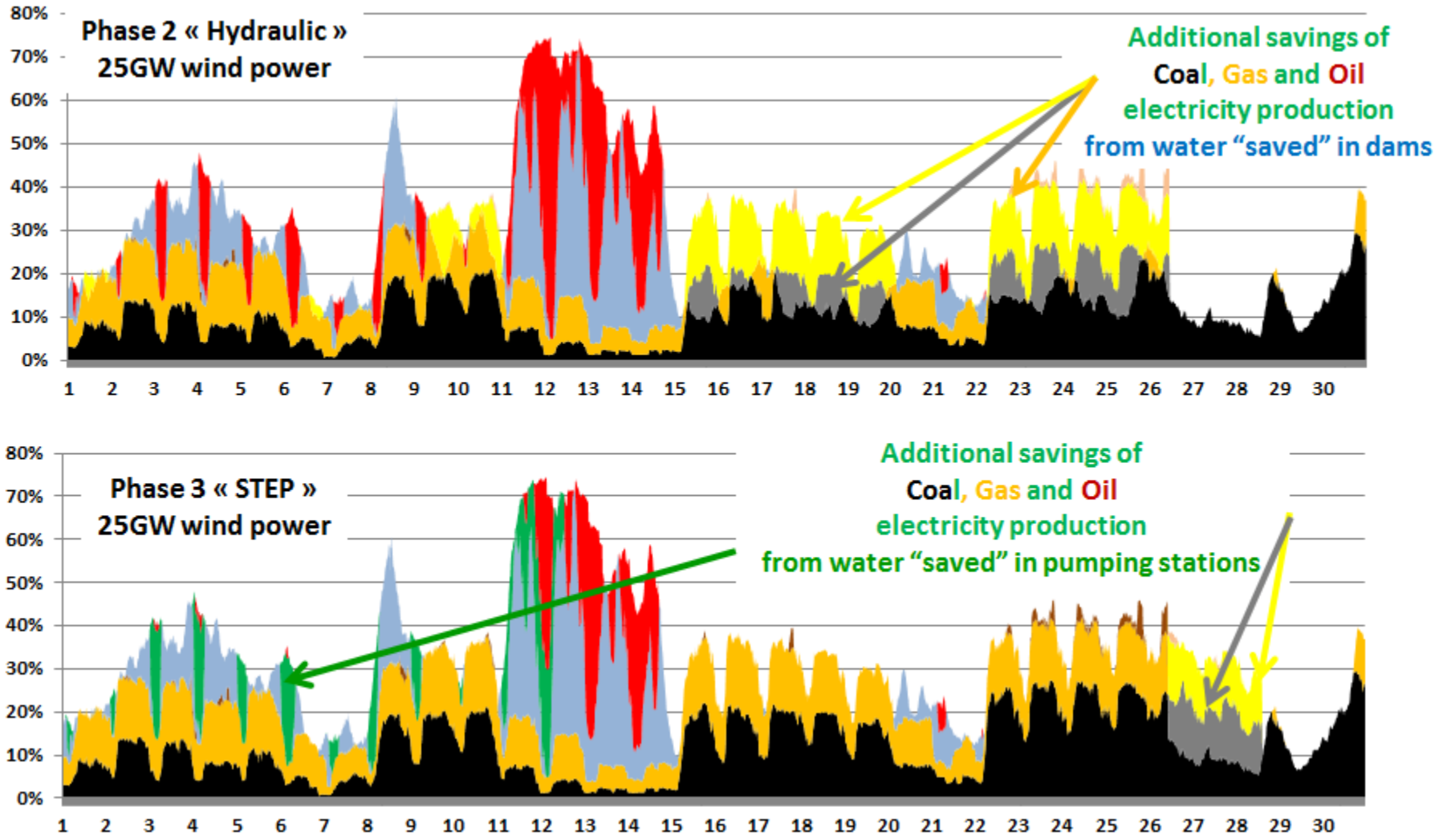
Test scenario of wind « Grenelle » decisions

Illustration of phases 1 to 3 for November 2010 (I)



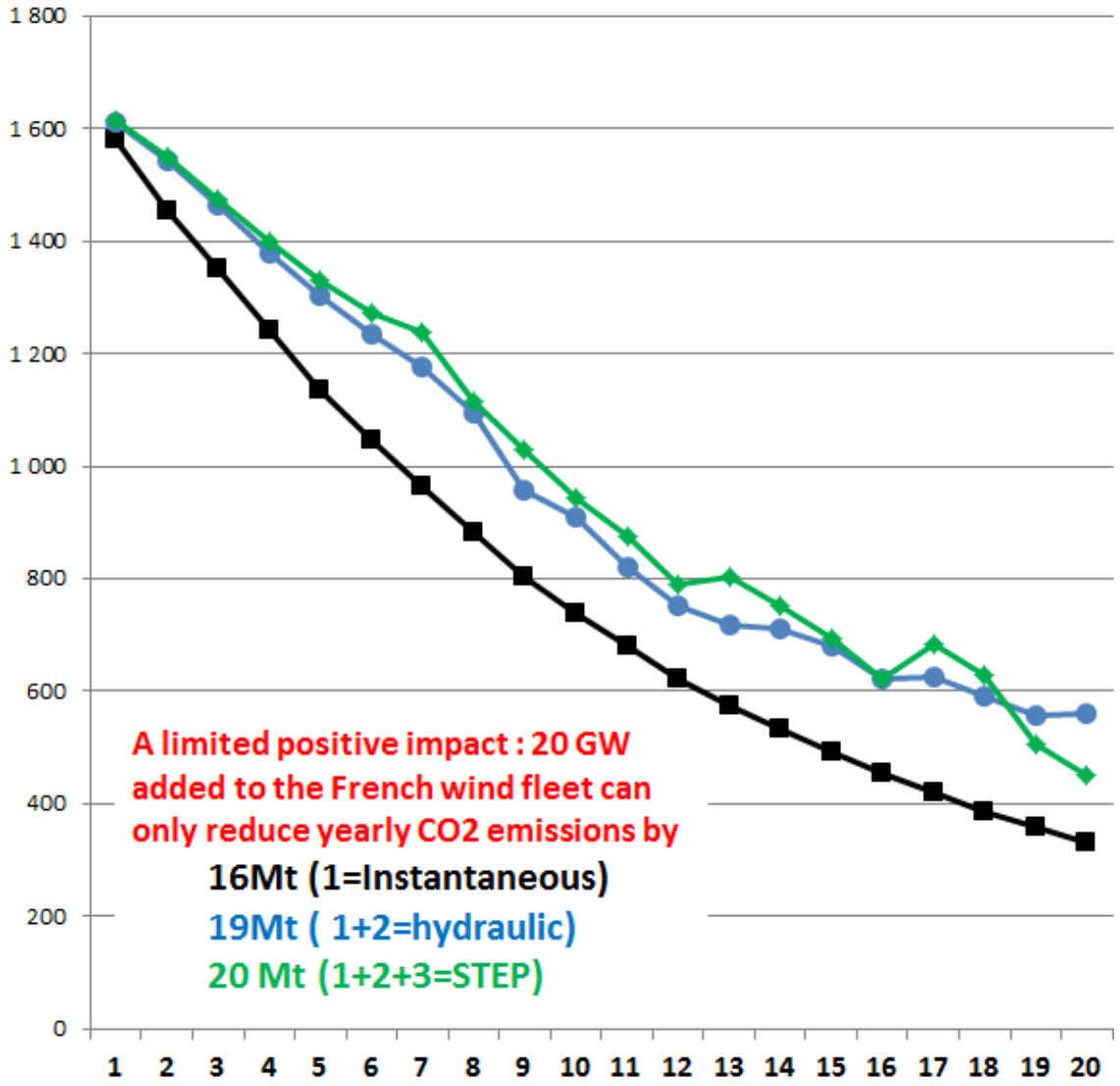
Test scenario of wind « Grenelle » decisions

Illustration of phases 1 to 3 for November 2010 (II)



Test of the ecology of Wind « Grenelle » decisions

Maximal amount of avoided CO2 emission for each additional wind GW



Abscissa :

Number of additional GW of installed wind turbines (1 to 20)

Ordinate:

Mass (kt) of avoided « electric CO2)

Phase 1 « Instantaneous » (black)

Phase 1+2 « Hydraulic » (blue)

Phase 1+2+3 « STEP » (green)

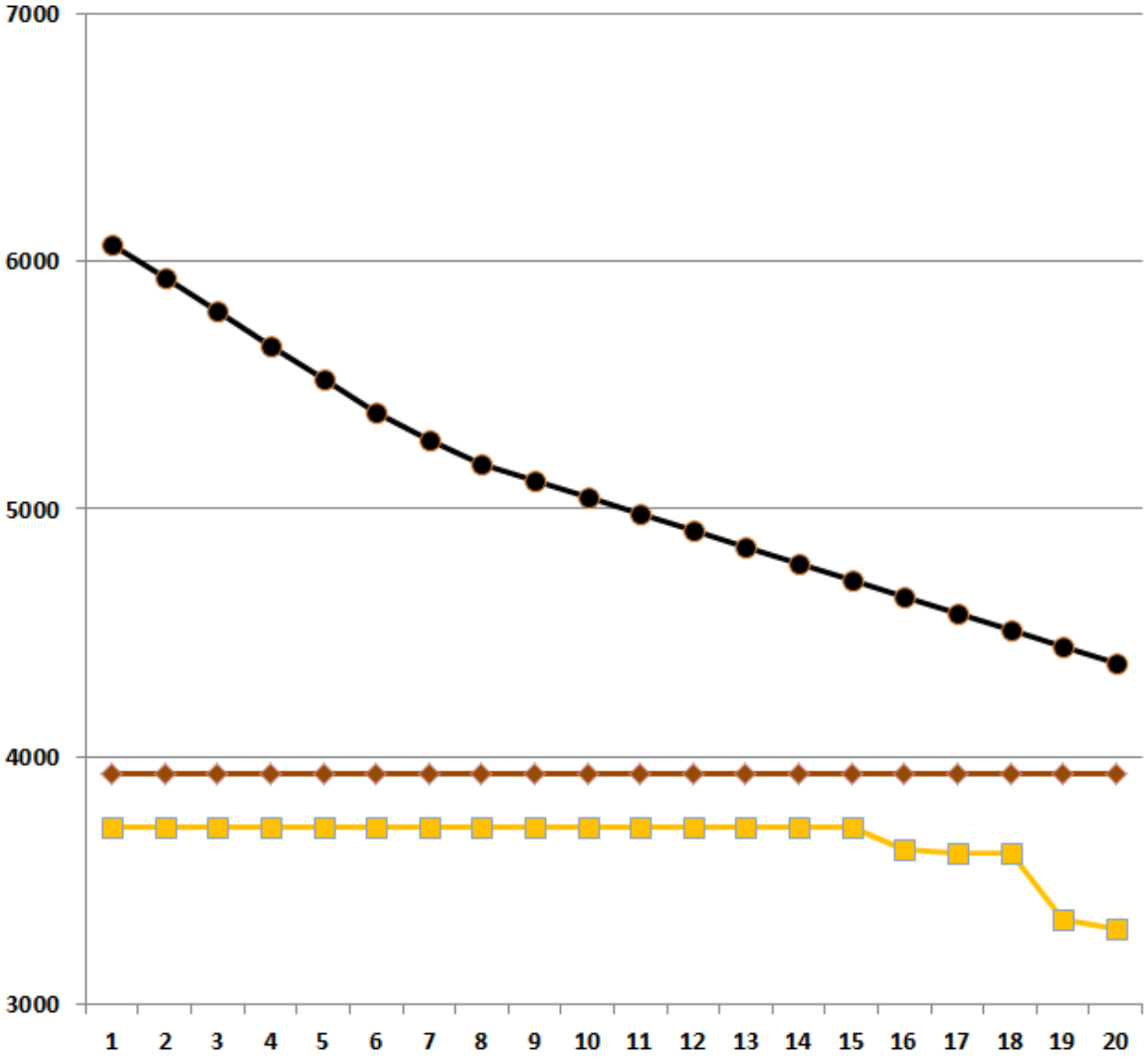
Comparison with problem scale

in 2010 world CO2 emissions reached 30,7Gt. According to IPCC our planet can« handle » 10Gt. Thus 20Gt CO2 have to be eliminated.

For each installed GW the wind ambitions of the « Grenelle » are 4 orders of magnitude smaller than the scale of the problem.
(3 orders of magnitude for a total 25GW installed wind turbines)

Test of wind « Grenelle » scenario

How much « fossil » power can be eliminated thanks to wind turbines ?



Abscissa :

Number of additional GW of Installed wind turbines (1 to 20)

Ordinate :

« Fossil » power (MW) which it is necessary to keep

- **« Coal » (black)**
- **« Gas » (yellow)**
- **« Oil + Peak » (brown)**

"Diminishing returns"

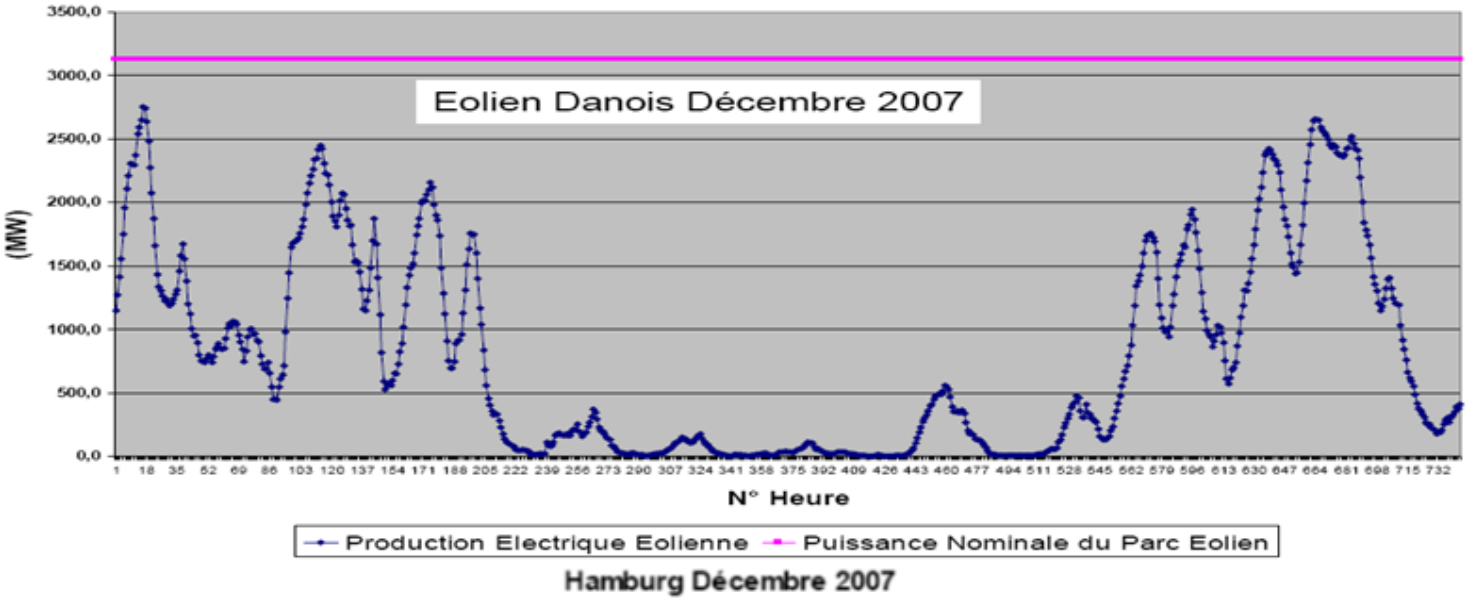
The first added wind GW allows « retirement » of 130 MW of « Coal » power and "can" save 1.6Mt CO2 emissions

The 20th added wind GW allows « retirement » of 110MW of « Coal + Gas » plant and "can" save 0.55Mt CO2 emissions

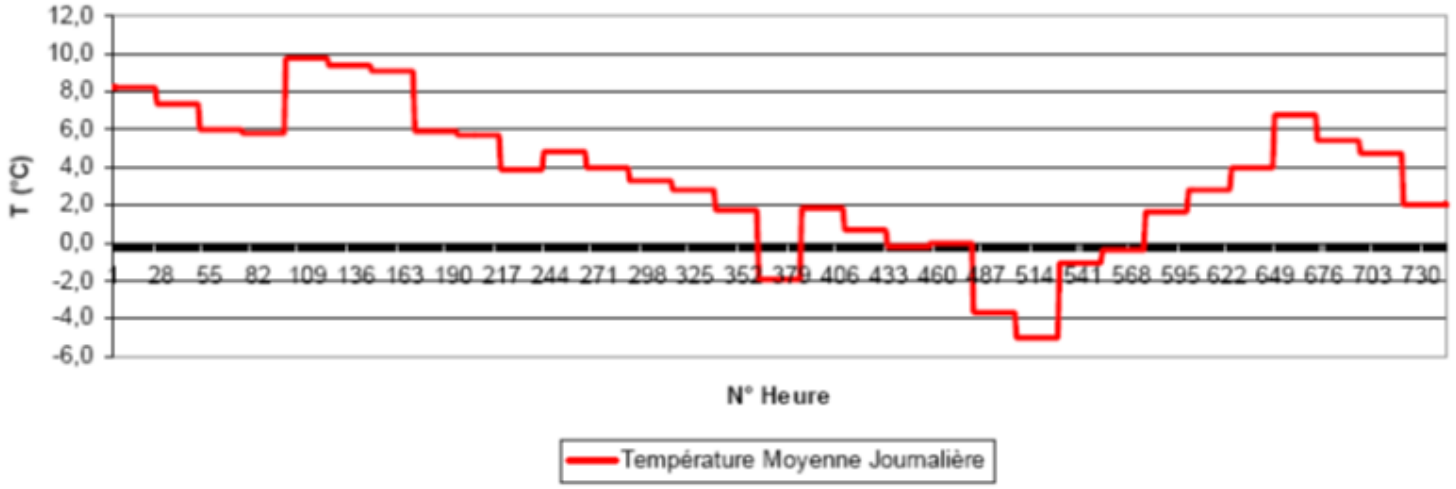
Perspectives
A role for the academic world ?

Former cases abroad: Denmark

Long lasting cold waves (Siberian anticyclone)



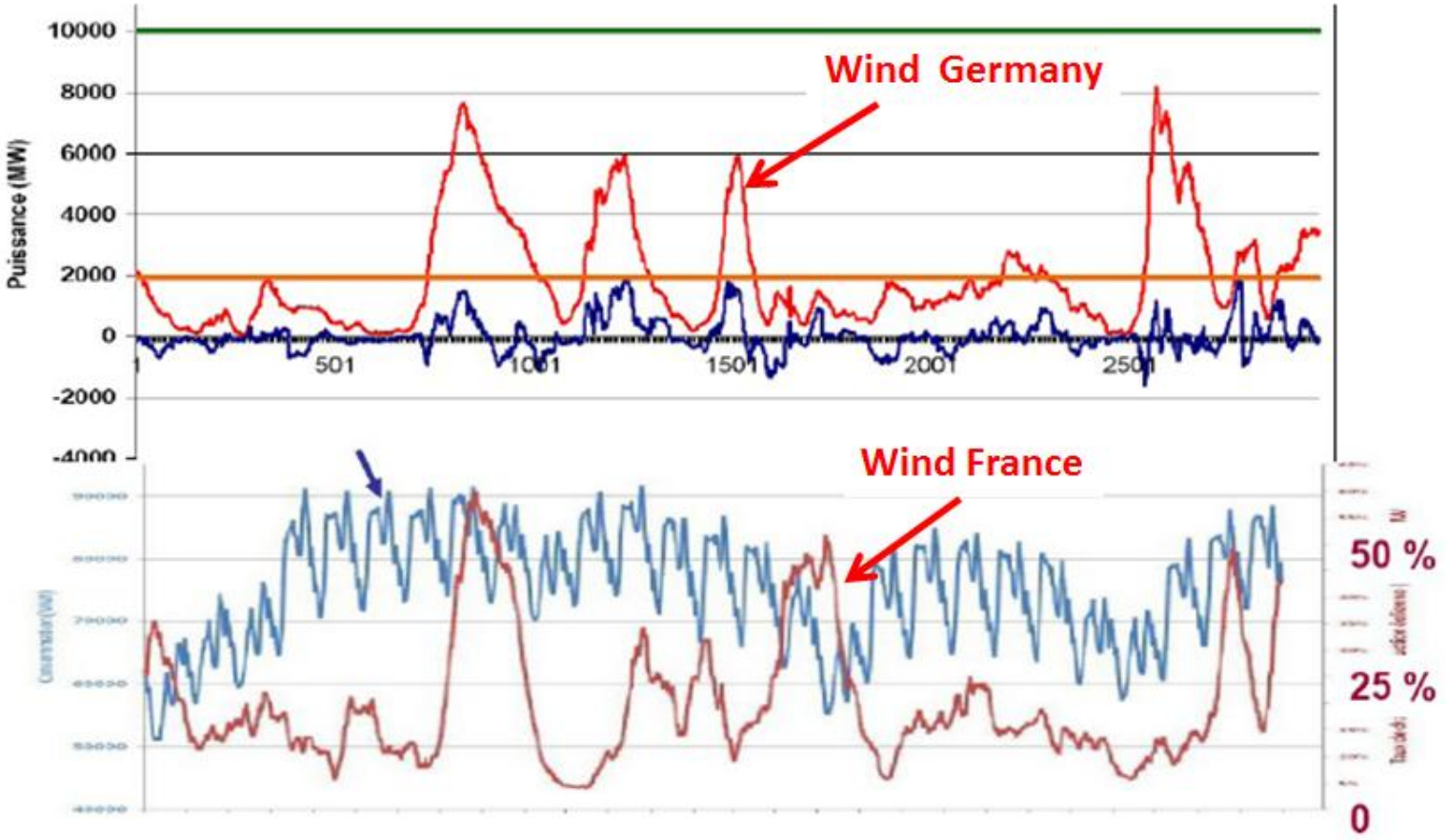
Hamburg Décembre 2007



Former cases abroad: Germany

Wind « averaging » within EU is far from guaranteed.

The two January-2010 cold waves



Abscissa : quarter hour over January 2010 month

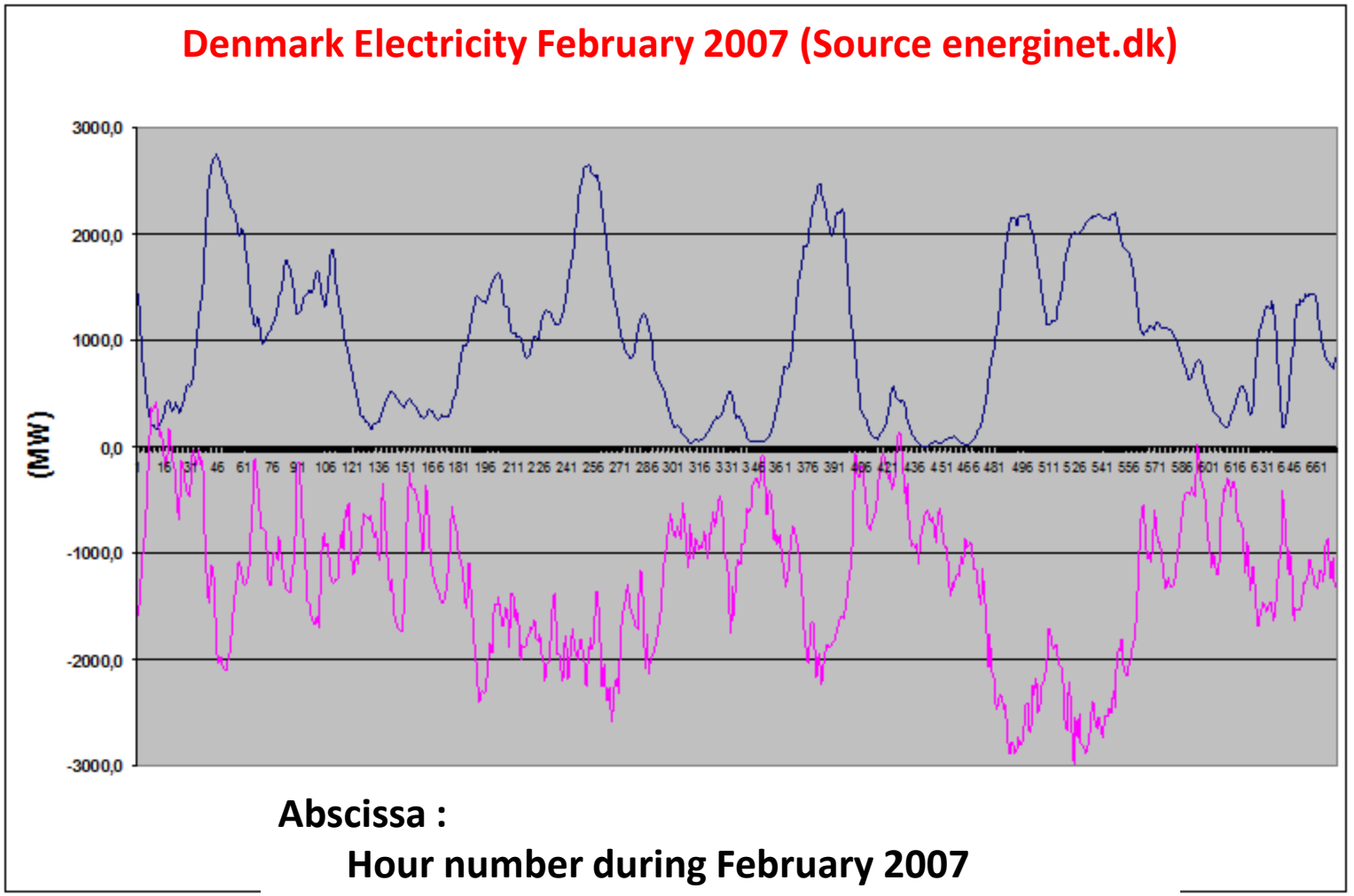
Ordinate :

Top figure : delivered Eon wind power (red MW), installed wind power (green line MW)

Bottom figure : French wind efficiency (brown %), electric consumption (blue MW)

Former cases abroad: Denmark

Often too much wind can only be handled via exportation.



Abscissa :

Hour number during February 2007

Ordinate (positive et negative scales are identical)

Blue curve: delivered wind power (positive)

Pink curve : Exported electric power (negative)

A third approximate law on social electricity

Third approximate Lemna

Fatal productions add poorly predictable fluctuations to the initial variations associated to society consumption

- Still no public data on photovoltaic production (although 1GWc are already installed)
- For a wind fleet of the size decided following the "Grenelle", one can expect (mostly unpredictable) wind power gradients between 1 and 2GW/hour, while presently maximum French consumption power gradients are between 6 and 8GW/hour)

Third approximate theorem on social electricity

The present nuclear fleet won't be able to handle the power fluctuations of a "Grenelle-sized" wind fleet.

- Already 10GW variations of nuclear power over few hours are sometimes needed for a 6GW wind fleet. How much more will be required for a 25 GW fleet ?
- Moreover, some presently discussed political platforms insist that the nuclear power fleet be reduced.

Third consequence

France will have to import gas and build gas powered plants

Which impact on French trade deficit and CO2 emissions ?

A role for the academic world ?

In our country, most stakeholders to the energy debate are either

1) **incompetent (the majority of citizens, journalists and politicians).**

   Read newspapers, web forums or listen to parliament debates.

2) **strongly politically motivated (Green parties or lobbies)**

   For all practical purpose, in France, « independent » is equivalent to « antinuclear ».
   See the so-called "independent scientists".

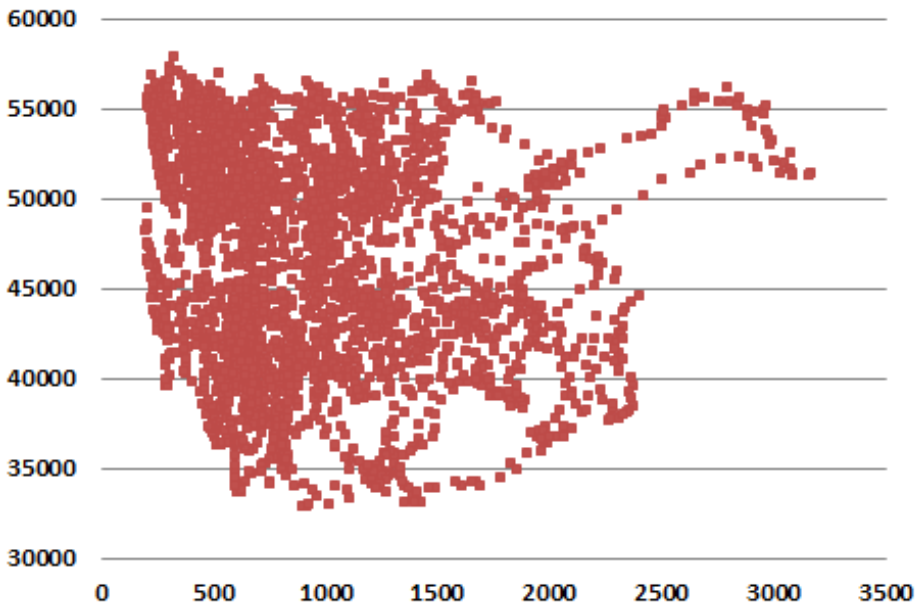
3) **competent but with very much controlled discourses and conflicting interests**

   - EDF : nuclear plants and dams but also EDF-Energie nouvelle (wind & solar)
   - GDF-Suez : gas and nuclear plants but also « Compagnie du Vent »
   - AREVA : nuclear, but also wind (Multibrid) and solar (Australia)
   - CEA : nuclear but also in charge of a national solar photovoltaic program.
   - RTE : its policy is strongly coupled to government decisions.

For this stakeholder category, there is a risk of confusion between "analysis" and "communication".

A member of the scientific academic world (in France, Universities and CNRS) has the needed full statutory independence and can acquire the competence. He is only required to motivate his statements and conclusions on the basis a reasoning which can be analyzed (approved or contradicted) by colleagues.

On the other hand, the academic world cannot work properly without an open access to the relevant data.
Why not a « transparency » law for all energies including renewable energies ?



A « goose » with many dots in the region of the tail.
RTE data France – Mai 2011
Correlation between
a) electric consumption (ordinate)
and
b) delivered wind power (abscissa).
On both axes , Unit is MW

Thank you for your attention

A beautiful stanza on intermittency
Dante Gabriel Rossetti (The woodspurge)

"The wind flapp'd loose, the wind was still,
Shaken out dead from tree and hill:
I had walk'd on at the wind's will,
I sat now, for the wind was still.
…."