Climate Service and Technology: a Key Tool of Climate Change Adaptation for the Energy Sector

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EBRD, London (UK), 2 Jun 2017
Outline

- The evolving relationship between **Energy** and **Climate**
- How **Weather/Climate** impacts **Energy**
- **Copernicus Climate Service** for **Energy**: European Climatic Energy Mixes
Energy and meteorology go hand in hand

- Passing clouds
  - Drop in solar power

- Hurricanes
  - Disruptions to oil rig operations

- El-Niño
  - Changes in Demand Patterns

- Long term changes
  - Renewable Resource Assessment

Time scales:
- Seconds
- Minutes
- Days
- Months
- Seasons
- Years
- Decades
World Energy & Meteorology Council (WEMC)

Our primary goal is to enable improved

Sustainable energy
For a low carbon economy

Resilience
Of energy infrastructures

Efficiency
Of energy systems

Under ever changing weather and climate
WEMC activities are

1. The dissemination of information on products, practices, and experiences in Energy & Meteorology including the promotion of the work of our members

2. The organisation and coordination of Special Interest Groups (SIGs) leading to the production of reports, analyses and syntheses on key topics in Energy & Meteorology

3. The development and maintenance of demonstration tools to assist with the uptake of weather, climate and water services by the energy industry and the education of the general public

4. The organisation of events such as the International Conference Energy & Meteorology (ICEM), including the development and delivery of professional workshops, seminars and webinars

http://www.wemcouncil.org/
The energy industry has a multi-decadal experience in dealing with meteorological variables. So, what’s the big deal?

The landscape, in both climate and energy spaces, is changing rapidly.
Energy industry is multi-faceted
Strong growth in renewables

IRENA (2016)
C02 emissions and temperature

IPCC AR5 (2013)
Disasters due to natural events

EM-DAT (2016)
Simplified Energy & Climate feedback

Emissions

Energy

Meteorology
Weather, Climate & Water

Impacts
Climate impact on coal mines

Love et al. (2014)
Climate impacts on hydro-power

Masinga Dam Water levels in different Years

From Christopher Oludhe (2015)
Climate impact on nuclear power

The 2003 heatwave in France had serious consequences on the cooling of nuclear reactors. The overall cost of the heat wave for EDF was around €330 million

Dubus (2009)
A selection of publications

World Bank (2010)

WBCSD (2014)

WEC (2014)

ICEM (2014)
Global changes in streamflow projections

Change in streamflow for RCP8.5, 2040–2069 (2050s) vs 1971–2000

Reductions in usable capacity for 61–74% of the hydropower plants

van Vliet et al. (2016)
Global changes in water temperature projections

Change in water temperature for RCP8.5, 2040–2069 (2050s) vs 1971–2000

Reductions in usable capacity for 81–86% of the thermoelectric power plants

van Vliet et al. (2016)
Percentage difference in monthly solar radiation in El Niño relative to La Niña

Davy and Troccoli (2012)
Addressing the ever variable nature of climate
Weather Services

- Very mature: 30+ years of experience
  - Also financial products since late 1990’s
- Products well understood by many users
  - Relatively easy to identify needs
  - Users wish to be updated about latest developments in weather products but otherwise develop their own services
  - Regular (e.g. annual) users meetings and/or specific training normally offered by weather service providers
• Relatively recent: ca. 10 years
  - First products from International Research Institute (IRI)

• Services still under developments
  - Large uncertainties in climate forecast/projections makes it more difficult for users to ascertain real value of climate information
  - Need to provide concrete examples of how to use climate information in practice
But...

What is a Climate Service?

A set of actions/tools aimed at helping ‘people’ make the best use of climate information so as to improve their ‘business’
C3S ECEM in brief

- Budget: €1.6 m
- Length: 27 mth (from Nov 2015)
- Six partners: UEA (lead) EDF, U Reading, Met Office, ARMINES and ENEA

Target: proof-of-concept or demonstrator

Stakeholder engagement central to ECEM

- Five stakeholder workshops, one every 6 months
- A tailored engagement plan
Increasing share of power supply from variable renewable energy (RE) sources. Demand variability is also increasing. The transformation is taking place against a variable and changing climate.
Integration of energy & climate information for energy mixes assessment

★ Is climate important for energy operations and planning?
★ What can climate R&D learn from interaction with energy sector and make output more easily adopted by the industry/policy makers?

European Climatic Energy Mixes (ECEM) is developing a demonstrator to assess how well different energy supply mixes in Europe will meet demand, over different time horizons, focusing on the role climate has on the mixes.
Energy Mix assessment for:
- Present day
- Seasonal Forecasts
- Climate Projections
European Climatic Energy Mixes (ECEM)

- Calibrated Climate Variables
  - Temperature
  - Rainfall
  - River Discharge
  - Wind Speed
  - Cloud Cover
  - Solar Radiation
  - Others

- Energy Variables
  - Hydro Power
  - Solar Power
  - Thermal Power
  - Demand
  - Wind Power

- Ancillary
  - Cloud Cover
  - Others?

Skills & Reliability
- Assessment of Seasonal Forecasts of Energy Variables

- Define models & transfer functions
- Select / Gather relevant datasets

Sub-Country Scale
- Historical Period
- Seas. Fcst

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WEMC
World Energy & Meteorology Council
Multi-faceted Stakeholder Engagement

- Workshops
- Advisory Committee
- Survey
- Presentation at events
- Webinars
- Web site
- Twitter
European Climatic Energy Mixes (ECEM)

1st Stakeholder Workshop
Paris, Tuesday 16 February 2016, 09:00-17:00
The Workshop is kindly hosted by EDF at their Clamart Campus.

Help us shape the European Climate Services in support of the Energy Sector of the future!

Stakeholder Engagement: Workshops

Shaping European Climate Services to support the Energy Sector of the future!
Stakeholder Engagement: Workshops
Stakeholder Engagement: Links & Committee

- Close links with international activities such as the Global Framework for Climate Services, a UN-led initiative

- Advisory Committee
  - A good mix of energy companies, energy industry association, climate/energy service providers and academia
Assessing ERA-Interim quality by comparison to gridded observed data (over land areas) for various variables.

Emphasis here on Climate Variables of greatest relevance to Renewable Energy (radiation/sunshine and wind), but others (e.g. temperature, RH influence Demand, precipitation influences HEP) are also relevant.

ERA-Interim despite possibly being the best Reanalysis is not perfect. We can assess how good it is (when and where) by comparisons with gridded observational datasets. Improving on it is termed bias adjustment.
ECEM Domain and ERA Interim

ERA-Interim regridded from its ~0.7° by 0.7° grid to a latitude/longitude grid at 0.5° by 0.5° spacing

ERA-Interim available every 6-hours. Some variables are from the analysis, some from the forecasts

Many gridded climate datasets available for assessment on the 0.5° by 0.5° grid

Gridded climate datasets produced by interpolation of station observations accounting for elevation

ECEM will also average variables across 33 countries and 96 clusters within Europe from the E-Highway 2050 project
Ensuring Climate variables are fit-for-purpose

Fit of 10 m observations to Weibull distribution

Jan (Obs Weibull AIC GOF)

Jul (Obs Weibull AIC GOF)

Low number (blue) good fit; high number (red) poor fit

Jones et al (2017)
Seasonal forecast information will be part of the ECEM Demonstrator

What seasonal statistics can be provided to the energy sector, to help with energy system balancing?

Main points:
1. How skilful are current models in predicting relevant climate variables in European countries?
2. Where there is skill, can it be translated into skilful forecasts of energy indicators (supply/demand)
3. Demonstrate the use of seasonal forecast information through Case Studies and in the Demonstrator.

Skill is varies across countries, variables, seasons or models.
→ Seasonal forecasts must be used carefully and selectively.

How skillful do seasonal forecasts need to be, to help in decision-making?
Ensuring we use the most accurate Energy data

The Energy data challenge:

- There is no single reference database for energy
- Many data sources, inconsistencies between them, incompleteness, access rights (minimal open/free access data) …

→ Need strong support to collect & organise the huge amount of energy data required for a useful service
→ ECEM is demonstrating that good data allows a good service!
Energy data: what’s available?

Net Generation Capacity:

★ Present:
• country level (all countries, all energies)
• plant level (all countries, wind energy)
• plant level (France, ~all energies – Nuclear, Thermal, Wind, Solar, Hydro)

★ 2050:
• country & cluster levels, from eHighWay2050 (all countries, all energies)

Generation and demand data:

★ Monthly values, most countries, different record lengths
★ Sub-daily (to 30min) demand data for some countries (e.g. France, from 1996)
★ Daily generation for some countries (e.g. France, 2013...)
Computation of power supply and demand

From Climate \((T, \text{ Wind, Precip...})\) to Energy \((\text{Demand, Generation})\), 2 options

**OPTION 1**

\[
\text{Energy} = \text{TF} (\text{Climate, Ancillary})
\]

\(\Rightarrow\) if Transfer Function \(\text{TF}\) is known

**OPTION 2**

\[
\text{Energy} = \hat{F} (\text{climate, ancillary})
\]

\(\Rightarrow\) \(\hat{F}\) being calibrated empirically based on climate & demand / power generation data
Demand modelling

Challenge: identify role of climatic factors

[Graphs showing energy consumption trends in France and Italy over years, with data for GDP, population, and average temperature]
Historical monthly generation

Monthly hydropower production in Norway

Monthly solar generation in Germany

Statistical models: no big differences between different models (MLR, SVR, GAM, CARTs ...) ➔ ideal for monthly time scales @ country level

Where no data is available for testing, need to use physical models
Wind Power Capacity Factor – 1986 -2014

Mean Capacity Factor per Country from 1986-2014

- AT
- BE
- BG
- CH
- CZ
- DE
- DK
- EE
- ES
- FI
- FR
- HR
- HU
- IE
- IT
- LT
- LU
- LV
- NL
- NO
- PL
- PT
- RO
- SE
- SI
- SK
- UK

- ECEM phy mix
- ECEM phy noc
- ECEM stat
- EMMIPES
- NINJA

[Graph showing capacity factors for various countries and projects]
Investor/owner/planner: Volumetric generation risk

Annual-total wind production

Best year

Worst year

Load-duration

Addition of wind capacity

Climate uncertainty (best to worst year)

Ideas: p5-p95 of production volume for RE, p5-p95 of annual hours at a specified load level for conventional plant, “best” and “worst” case years, Curtailment, Spatial correlations maps for neighbouring zones

Cannon et al (2015, RE)
Bloomfield et al (2016)
The purpose of the ECEM demonstrator is to enable the energy industry and policymakers to assess how well different energy supply mixes in Europe will meet demand, over different time horizons (from seasonal to long-term decadal planning), focusing on the role climate has on the mixes.
An online interactive tool to test energy mixes
ECEM Summary

Integration of energy & climate information for energy mixes assessment

★ Is climate important for energy planning?
★ What can climate R&D learn from interaction with energy sector and make output more easily adopted by the industry/policy makers?

More info at: http://ecem.climate.copernicus.eu/
Summary

- Energy and Meteorology are closely connected
- Energy systems are already experiencing sizeable impacts, which are likely to become more severe
- Climate services are emerging as robust useful tools for Energy planning, and operations/maintenance
- There is a strong need:
  - to improve knowledge of meteorological data and processes
  - to improve access to meteorological and energy data for improved products
4th International Conference Energy & Meteorology

Challenges in Weather, Climate and Water Services for Energy

JOIN US IN BARI!
27–29 June 2017
Villa Romanazzi Carducci
Bari, Italy

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