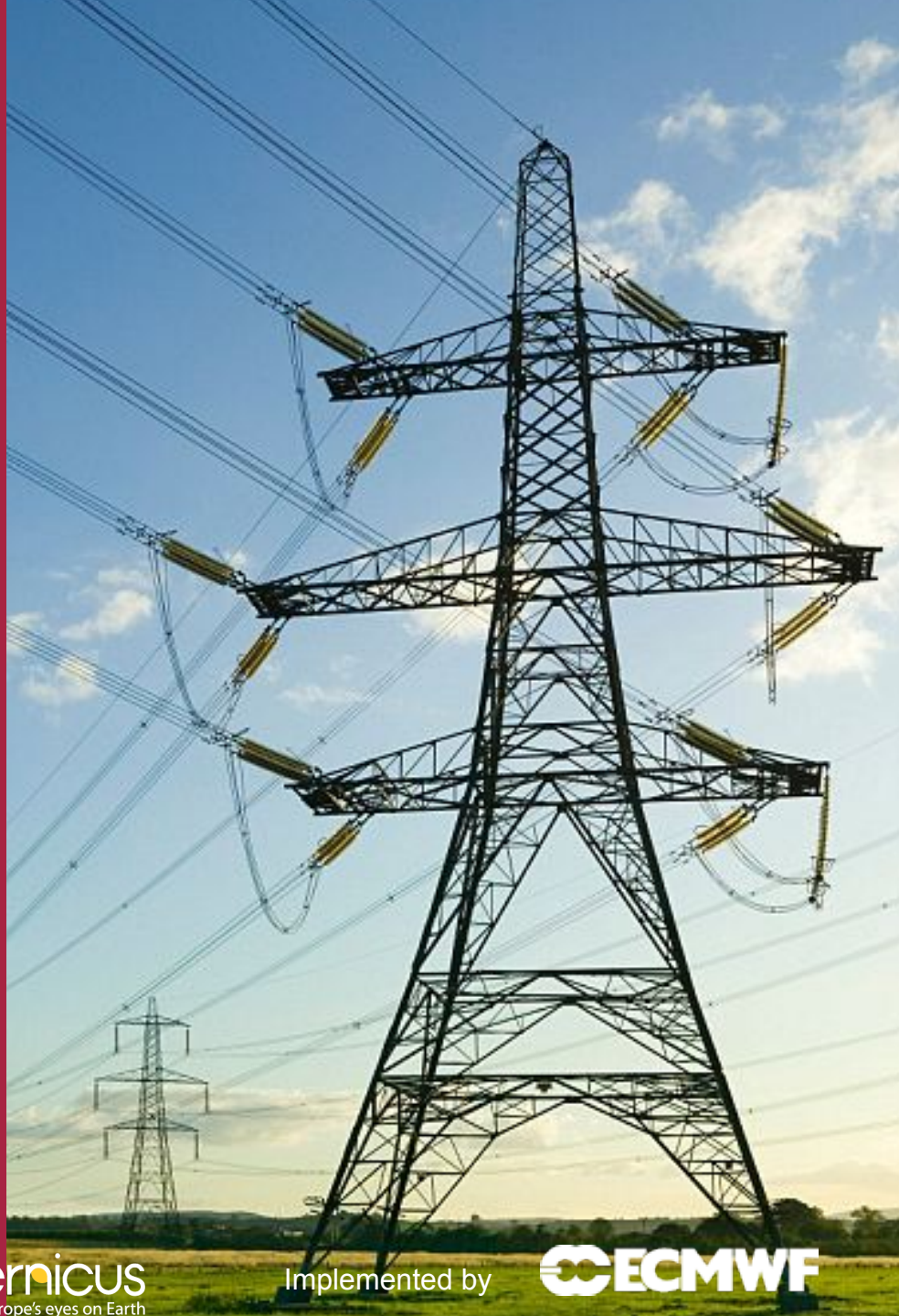
WP3: From Climate to Energy

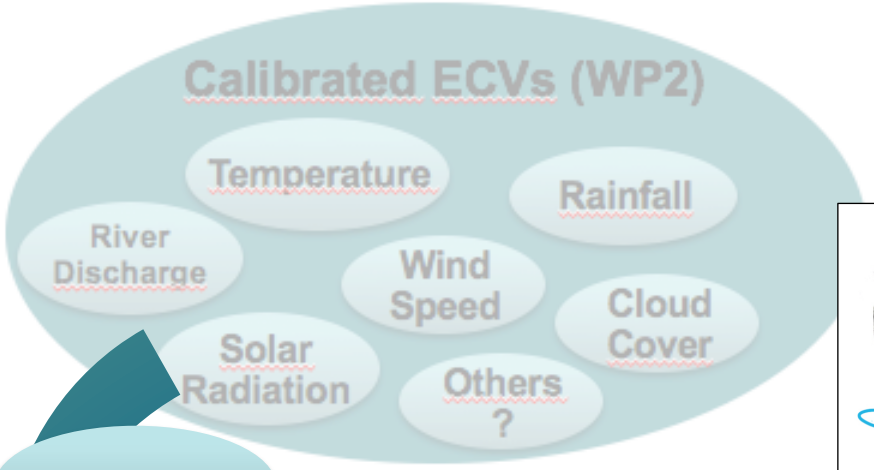
Laurent Dubus & Sandra Claudel, EDF
Matteo de Felice, ENEA
Thierry Ranchin, ARMINES
David Brayshaw, Univ. Reading
Hazel Thornton, Met Office

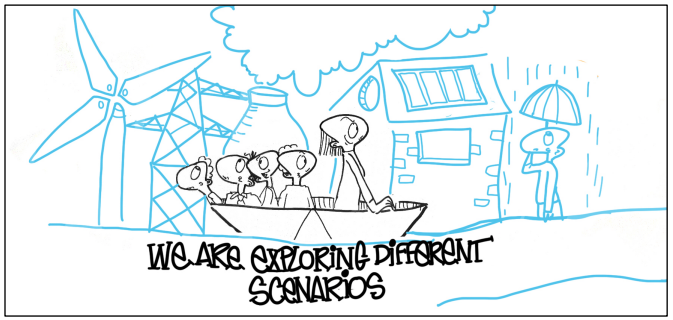
London, June 28 2016



EDF European Commission Copernicus Europe's eyes on Earth Implemented by ECMWF

WP3 – From Climate to Energy: Databases & Transfer Functions



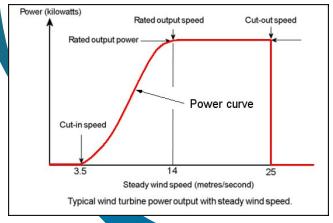


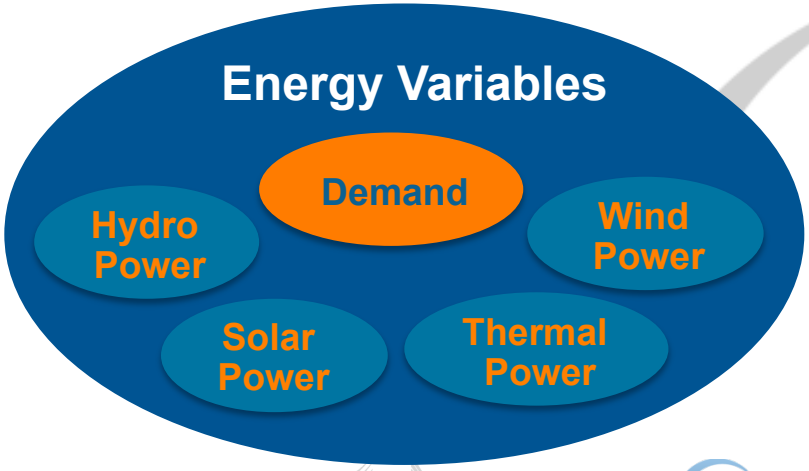
+Ancillary

Define Models / Transfer Functions

Select / Gather relevant Datasets

+ Extreme Events Case Studies





- Country Scale
- Historical Period
- Seas. Fcst
- Clim. Proj.

YOUR ATTENTION PLEASE

We ask you to carefully look at  **s**

These are questions/choices we'd like you to help us solve

From Climate to Energy: Databases & Transfer Functions

From Climate (T, Wind, Precip…) to Energy (Demand, Generation), 2 options

?

OPTION 1

Energy = **TF** (Climate, Ancillary)

➔ if **Transfer Function TF** is known

➔ For wind, solar and ?

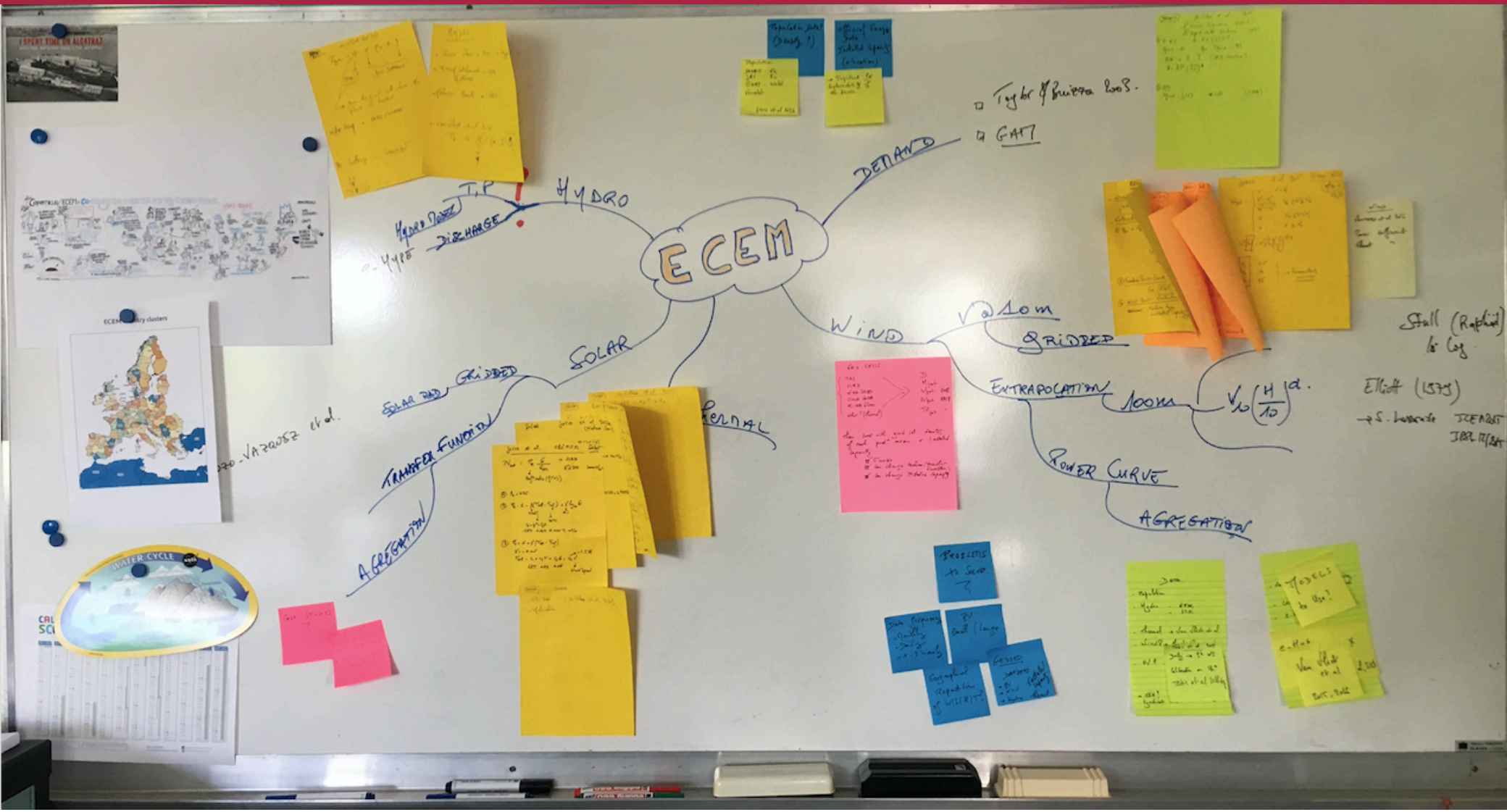
OPTION 2

Energy = F (climate, ancillary)

➔ F being determined/calibrated empirically based on climate & demand / power generation data

➔ For demand and ?

Some literature review & thinking has been necessary !



FIRST RESULTS: ANALYSIS OF 6 HOURLY DEMAND FRANCE / GENERALIZED ADDITIVE MODELS (GAM)

Calibration 01/01/2006 to 31/12/12 / Validation 01/01/13 to 31/12/14

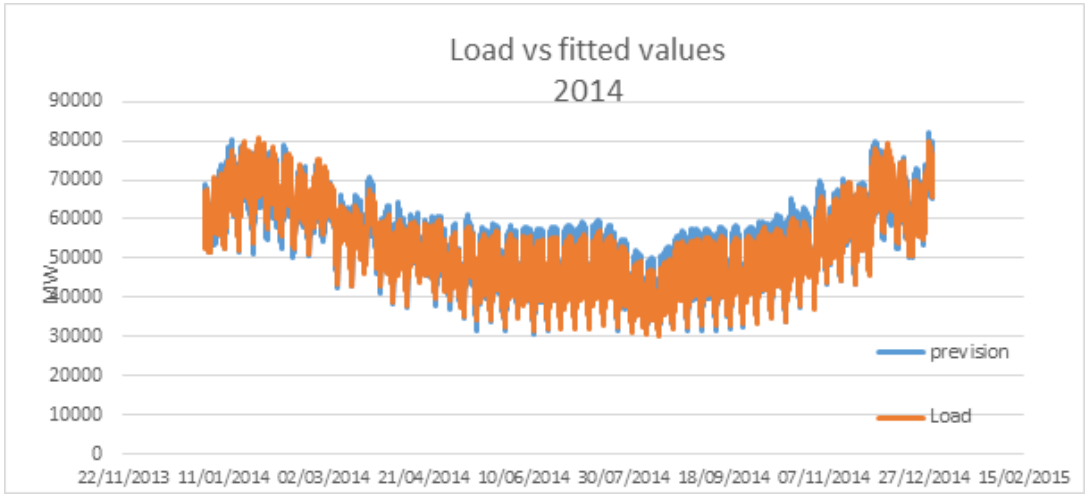
Load ~ s(Temperature)	*Temperature / Spline*
+ s(Nebu)	*Cloud Cover / Spline*
+ s(toh)	*Demand trend / Spline*
+ s(Posan, bs = 'cc', k = 40,by=as.factor(TypeJour7))	*Seasonality*
+ as.factor(JourSemaine):as.factor(JourFerie)")	*week days / feries*

Calibration period

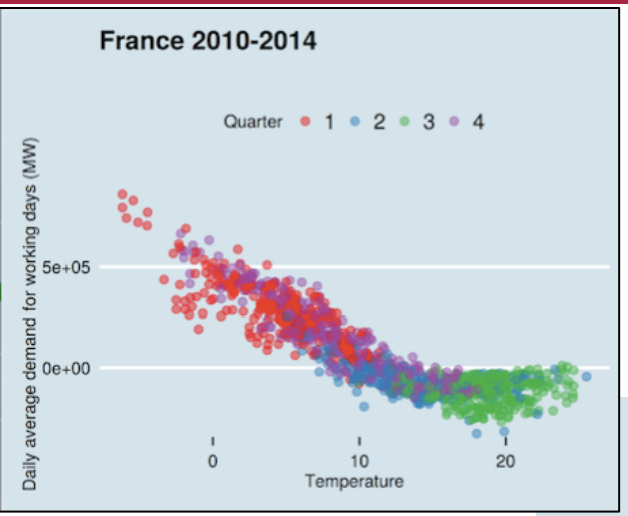
	0h	6h	12h	18h	Global
RMSE	1729	1788	1716	1652	1722
MAPE	2.3%	2.7%	2%	2.1%	2.3%

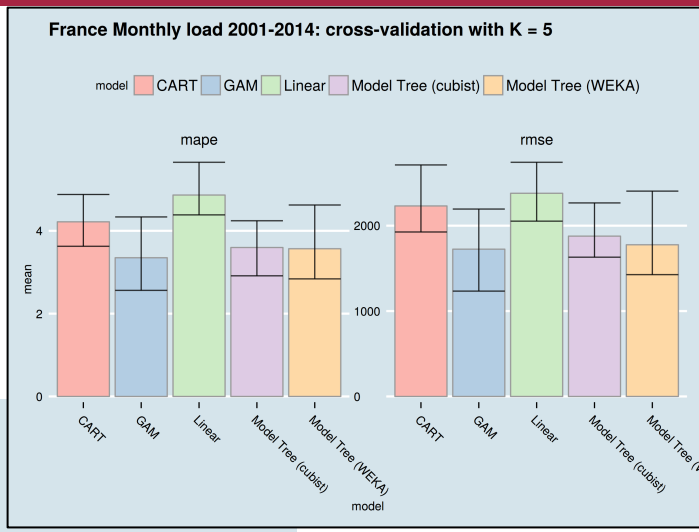
Validation period

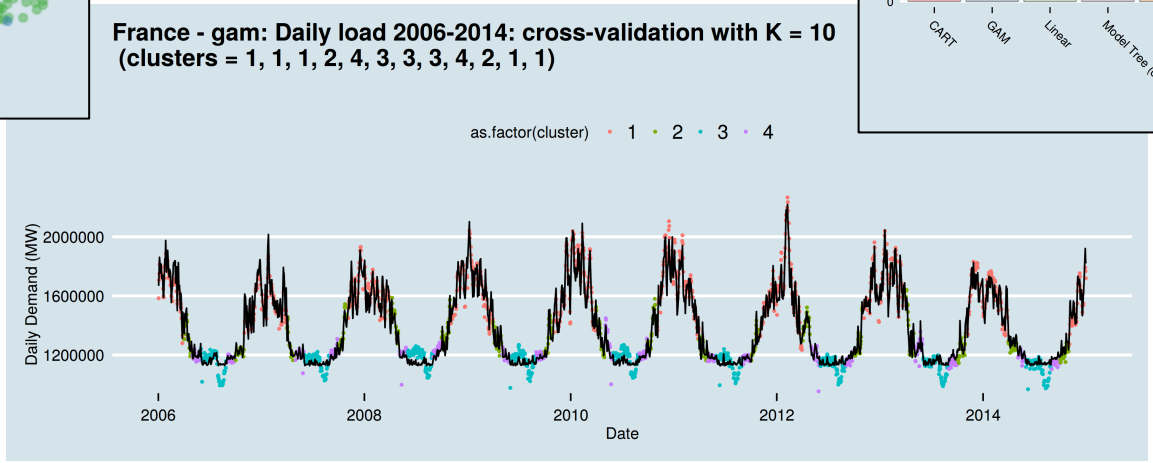
	0h	6h	12h	18h	Global
RMSE	2133	2202	2556	1979	2218
MAPE	2.6%	3.1%	3.7%	2.5%	3%



FIRST RESULTS: ANALYSIS OF MONTHLY & DAILY DEMAND





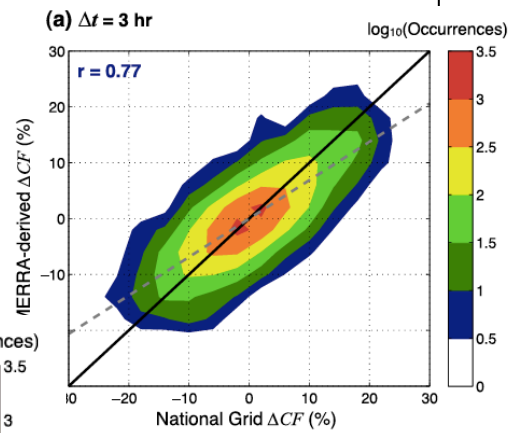


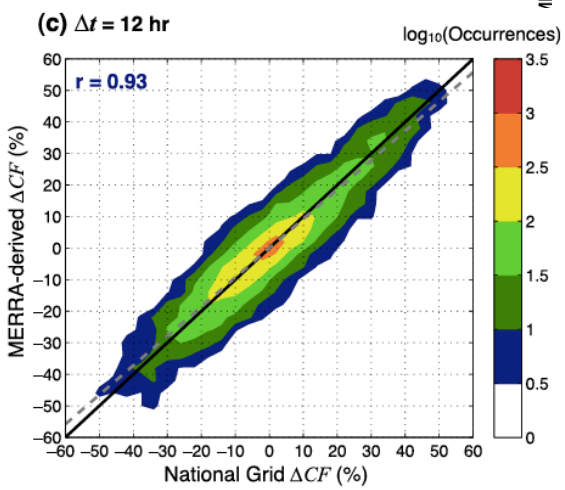
- **Simple models can perfom well, but we need input DATA:**
  - **Demand data (at least daily resolution) – sub-country level ?**
  - **Economic data**
  - **Working days / bank holidays…**

POWER SUPPLY: WIND & SOLAR GENERATION

- Use generic TFs
  - Implemented so that they can be changed easily
  - **Do you have preferred one(s)** ?

- Determine grid point (50x50 km^2) **installed capacity** for WIND & SOLAR
- Compute WIND/SOLAR power output for each grid point
- Average at CLUSTER and COUNTRY scale





Cannon et al., 2015

Databases: WIND: www.thewindpower.net SOLAR: ?

POWER SUPPLY: WIND & SOLAR GENERATION

✅ Generic Transfer Functions (TF_W & TF_S) available from the literature

$$W_{pot} = \begin{cases} 0 & \text{if} \quad V < V_I \\ \frac{V^3 - V_I^3}{V_R^3 - V_I^3} & \text{if} \quad V_I \le V < V_R \\ 1 & \text{if} \quad V_R \le V < V_O \\ 0 & \text{if} \quad V \ge V_O \end{cases}$$

V_I = 3.5 m/s
V_R=13 m/s
V_0=25 m/s

$$V(h) = V(h_0)\left(\frac{h}{h_0}\right)^{1/7}$$

Jerez et al., 2015

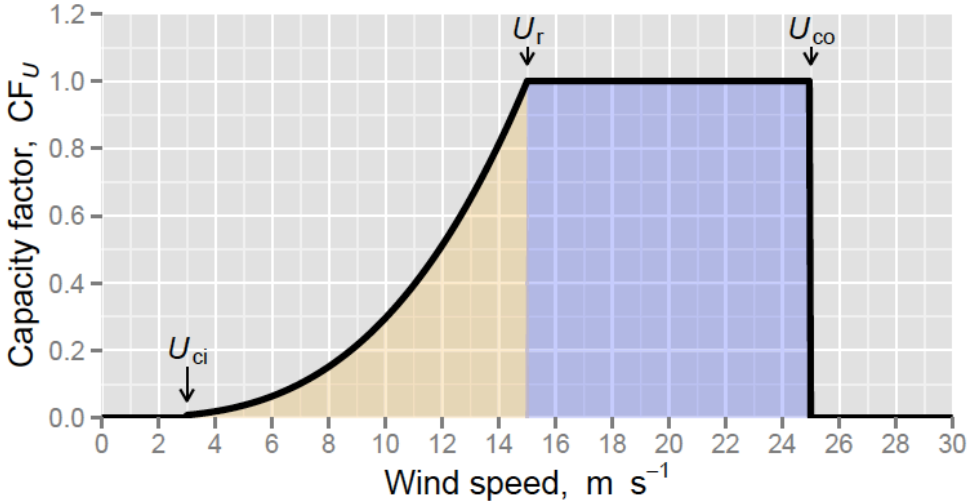


Figure from Bett & Thornton, 2016

POWER SUPPLY: HYDROPOWER GENERATION

- Installed capacity: any database available welcome ?
- Required information:
  - Location (lat/lon/alt)
  - Hydraulic Head
  - Plant type: run-of-river, dam, reservoir
- River flow from SMHI & SWICCA Project

?

OPTION 1

➔ Calculate plant generation with TF: use van Vliet et al, 2016

Hydropower usable capacity was quantified using the following equation.

$$P_{hydro} = Q \cdot H \cdot \rho_w \cdot g \cdot \eta \qquad (1)$$

Where: P_{hydro} = usable capacity of hydropower plant [W]; Q = streamflow [m^3/s]; H = hydraulic head [m]; ρ_w = density fresh water [kg/m^3]; g = gravitational acceleration [m/s^2]; η = total efficiency.

OPTION 2

➔ Calibration of a statistical ***F Hydro*** model for each cluster/ country

➢ *Some examples in carousel session this afternoon*

POWER SUPPLY: THERMAL & NUCLEAR GENERATION

- **Installed capacity**:any public database available welcome ?
- Required information:
  - Location (lat/lon/alt)
  - Cooling system: Air, Seawater or River (+River Name)
- Need River flow (from SMHI & SWICCA) & water temperature: **observations welcome** ?

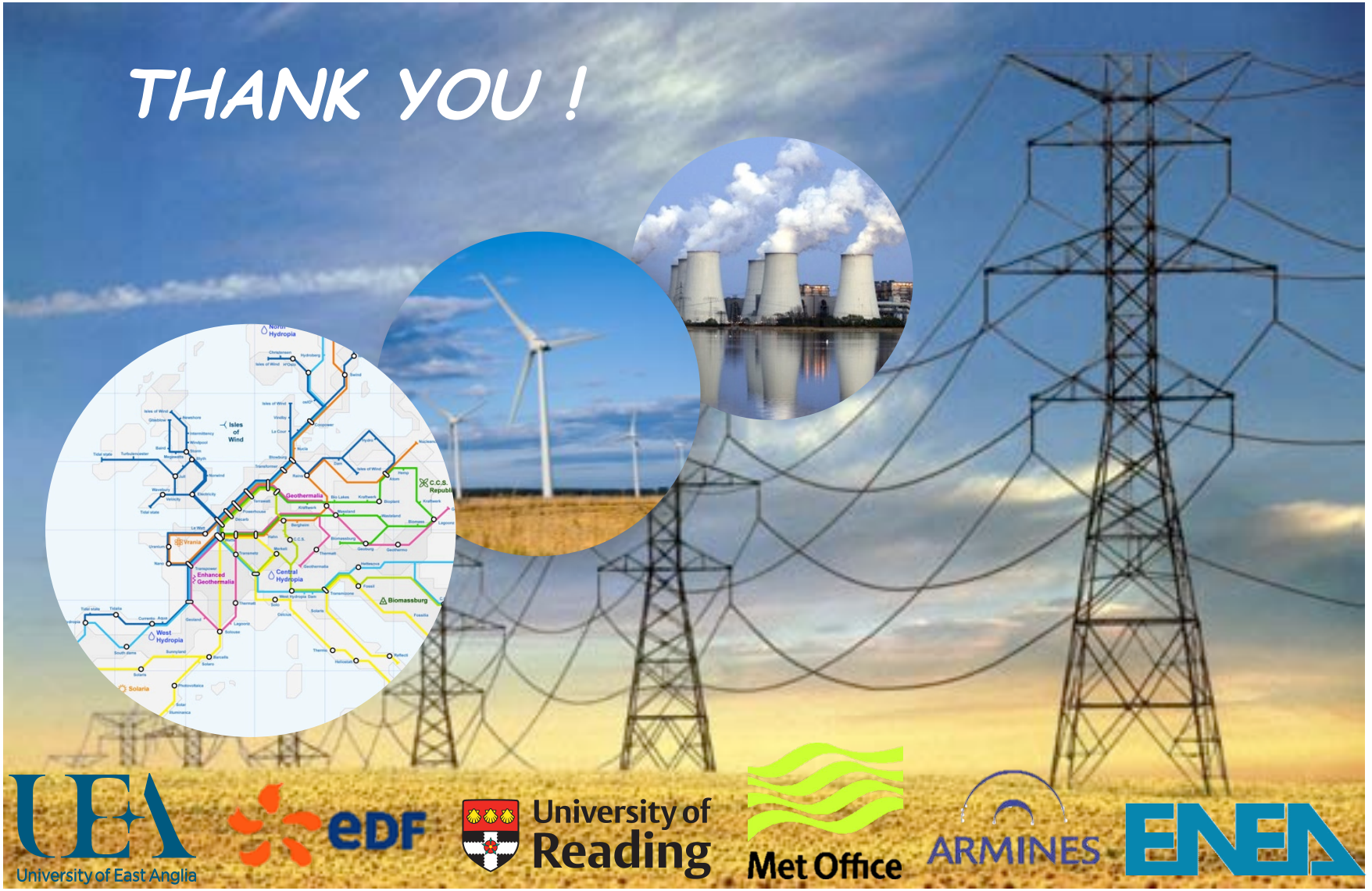
➔ Determine availability of plant depending on cooling system (0/1 parameter) with simple **thresholds**

↳ **relevant thresholds ?**

Any other suggestion ? ?

ENERGY VARIABLES - KEY QUESTIONS

- ★ **Do you have any preference for specific transfer functions / models ? Experience to share ?**
- ★ **Do you have any database that you can share with us ? Especially installed capacity**
- ★ **Do you think the proposed approaches will provide you useful information ?...**
- ★ **...at an appropriate level of quality and authority, including uncertainty?**


THANK YOU !
University of East Anglia
eDF
University of Reading
Met Office
ARMINES
ENEA