



Climate Change

Copernicus Climate Change Service (C3S)

Energy Seminar

C3S Enhanced Operational Global Service for the Energy Sector – Global



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Copernicus Climate Change Service (C3S). Energy Seminar C3S Enhanced Operational Global Service for the Energy Sector - Global

Global Energy Data

Elena Restivo, Inside Climate Service (ICS)

elena.restivo@inclimateservice.com



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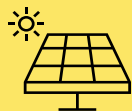
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Global Energy Data – Energy indicators

ENERGY INDICATORS:



WIND POWER



SOLAR POWER (SOLAR PV, CSP)



HYDRO POWER (RUN-OF-RIVER, PUMPED, RESERVOIR)

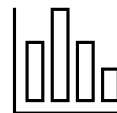


ELECTRICITY DEMAND



INSTALLATION DATA:

Where are the power plants located and how much is the **installed capacity**?



GENERATION DATA:

How much energy is generated and at which **temporal resolution**?

How much is the electricity demand for each country?



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Global Energy Data – Installation data sources

 INSTALLATION SOURCES				COVERAGE	NOTES
World Resource Institute (WRI)	✓	✓	✓	Global coverage	No technology distinction
Energy and Industry Geography Lab (JRC)	✓	✓	✓	European countries	
The Wind Power (www.thewindpower.net)	✓	-	-	Global coverage	Not free
<i>Powerplantmatching*</i>	✓	✓	✓	European countries	
Data Platform – Open Power System Data	✓	✓	✓	European countries	
Existing Hydropower Assets (EHA) - Oak Ridge National Laboratory	-	-	✓	United States	
SolarPACES (IEA)	-	✓	-	Many countries around the world	Only CSP projects

+ aggregated regional capacity data (ENTSO-E, IRENA, national statistics)

**Performing energy modelling exercises in a transparent way -
The issue of data quality in power plant databases.*

(F. Gotzens et al, 2019) <https://doi.org/10.1016/j.esr.2018.11.004>



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Global Energy Data – Constructing a unique database

Sample data from thewindpower.net:

INFO ON GEOGRAPHICAL LOCATION / NAME OF THE PP

ID	Continent	ISO code	Country	State code	Area	City	Name	2nd name
27	Oceania	AU	Australia	QLD	Queensland	Ravenshoe	Windy Hill	#ND
13	Europe	BE	Belgium	#ND	Brabant wallon	Villers-la-Ville	Marbais	#ND
12	Europe	BE	Belgium	#ND	Liège (Wallonia)	Villers le Bouil	Villers le Bouil	#ND
16	Europe	BE	Belgium	#ND	Namur (Wallonia)	Floreffe	Floreffe	#ND
11	Europe	BE	Belgium	#ND	Namur (Wallonia)	Walcourt	Tarcienne	Walcourt

Aim:

Constructing a unique database keeping as much information as possible

TECHNICAL/CONSTRUCTION ATTRIBUTES

Latitude	Longitude	Altitude/Depth	Location accuracy	Offshore Shore	Manufacturer	Turbine	Hub height	Number of turbines	Total power
-17.590	145.532	#ND	Yes	No	Enercon	E44/600	46	20	12000
50.537	4.515	#ND	Yes	No	Enercon	E82/2000	78	8	16000
50.580	5.240	#ND	Yes	No	Repower	MD77	85	6	9000
50.423	4.718	#ND	Yes	No	Enercon	E82/2350	108	1	2350
50.303	4.504	#ND	Yes	No	Repower	MD77	85	6	9000

OTHER INFO (OWNER, STATUS, ETC)

Developer	Operator	Owner	Commissioning date	Status	Decommissioning date	Link	Update
Stanwell Corp	Stanwell Corp	Ratch Australia Co	2000/08	Production		Link	25-Oct-22
Eneco	Electrastar SA	Eneco	2007	Production		Link	20-Oct-22
EDF renewables/E	EDF renewables	EDF Luminus	2005/02	Production		Link	20-May-22
EDF Luminus	EDF Luminus	EDF Luminus	2010	Production		Link	20-May-22
EDF renewables	EDF renewables	EDF Luminus	2005/11	Production		Link	20-May-22



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Global Energy Data – Constructing a unique database



UNIQUE DATABASE OF
INSTALLATION DATA



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Global Energy Data – Data cleaning routine

1

Cleaning names

Cleaning the **names** of the power plants:

- Delete **dashes, underscores, extra spaces**
- Delete **keywords** and **country names**
- Convert **roman numerals** to arabic
- **Capital letters** for initials, lowercase for the other letters
- Remove **duplicated substrings**

2

Finding neighbor points with **similar** names

Finding **neighbor points** with **similar names**:

- Computing **Euclidean distance** between points
- **Grouping** power plants that are *sufficiently* near one to each other, giving them the same **id_coord**
- **Comparing names** that have the same id_coord: if similar, giving them the same **id_name** (ignore the NaN names).

3

Deleting duplicates via **reliability** criterion

Deleting duplicates via **reliability criterion**:

- Each source is given a **reliability index**
- If duplicates are found, the entries with the best reliability index are kept, the others are deleted



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Global Energy Data – Example of the data cleaning routine

Country _long	Name before cleaning	Name after cleaning	Latitude	Longitude	Technology	Installed Capacity [MW]	Source	Reliability _index	Temporary columns: allow to manually check		
	Old Name	Name							id_coord	id_name	To_delete
Austria	Weissenegg	Weissenegg	46.912548	15.486664	Run-of-river	1	PPM	1	75	120	
Austria	Weissenegg	Weissenegg	46.912548	15.486664	Run-of-river	1	JRC	3	75	120	D
Austria	Altenw"rth Altenwoerth-KW - Altenw	Altenwoerth	48.374728	15.855343	Run-of-river	328	JRC	3	76	121	D
Austria	Altenworth	Altenworth	48.374728	15.855343	Run-of-river	328	PPM	1	76	121	
Austria	Amlach	Amlach	46.814205	12.761757	Run-of-river	60	PPM	1	77	122	
Austria	KW Amlach	Amlach	46.814205	12.761757	Run-of-river	60	DataPlatf	4	77	122	D
Austria	Annabrucke	Annabrucke	46.561407	14.479829	Run-of-river	90	PPM	1	78	123	
Austria	Annabr?cke Annabruecke Hydroele	Annabruecke	46.561407	14.479829	Run-of-river	90	JRC	3	78	123	D

Figure: Example of the data-cleaning process. Rows in red are classified as duplicates by the routine and are then removed.



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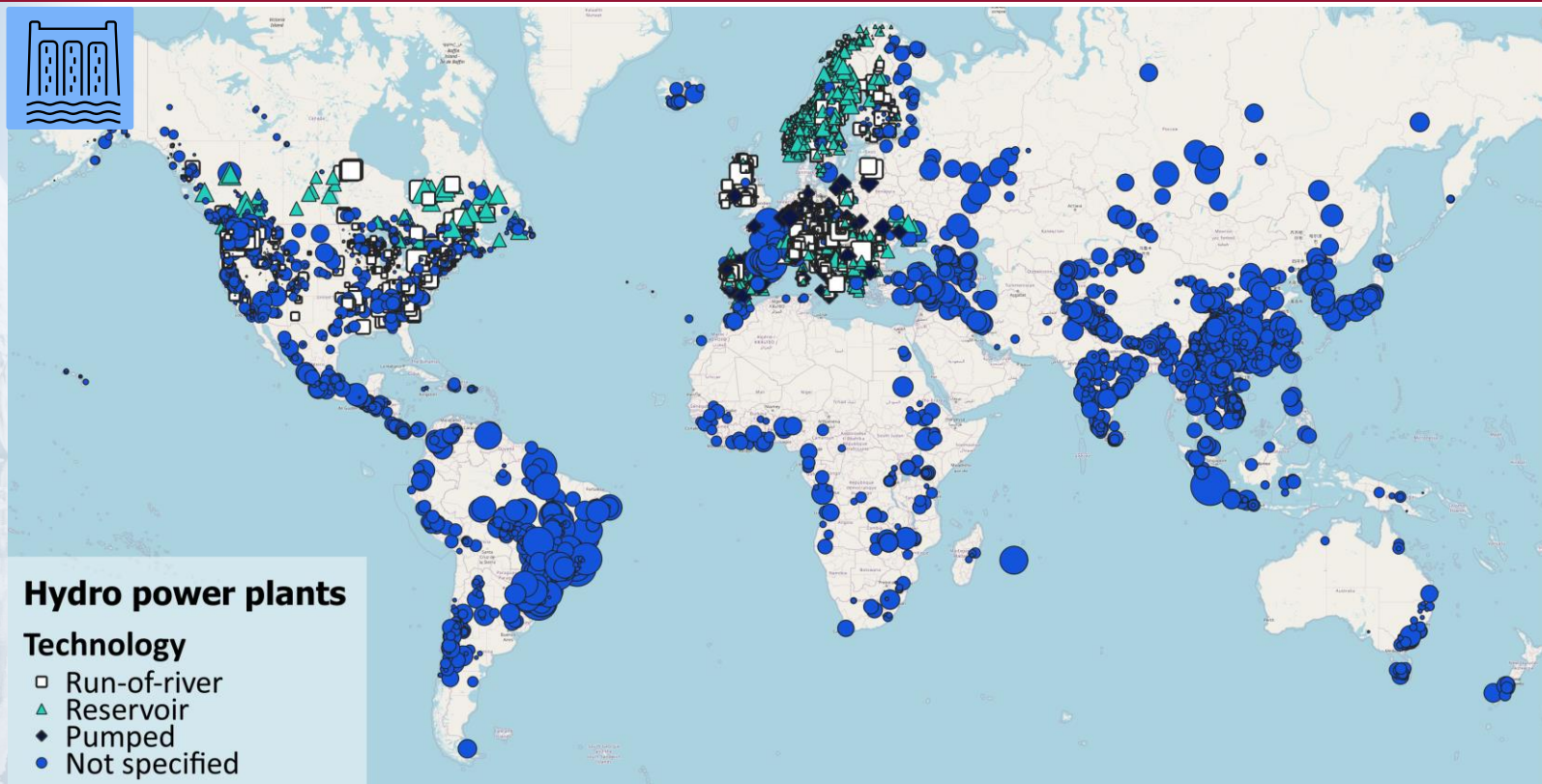
Global Energy Data – Hydro power plants database



Hydro power plants

Technology

- Run-of-river
- ▲ Reservoir
- ◆ Pumped
- Not specified



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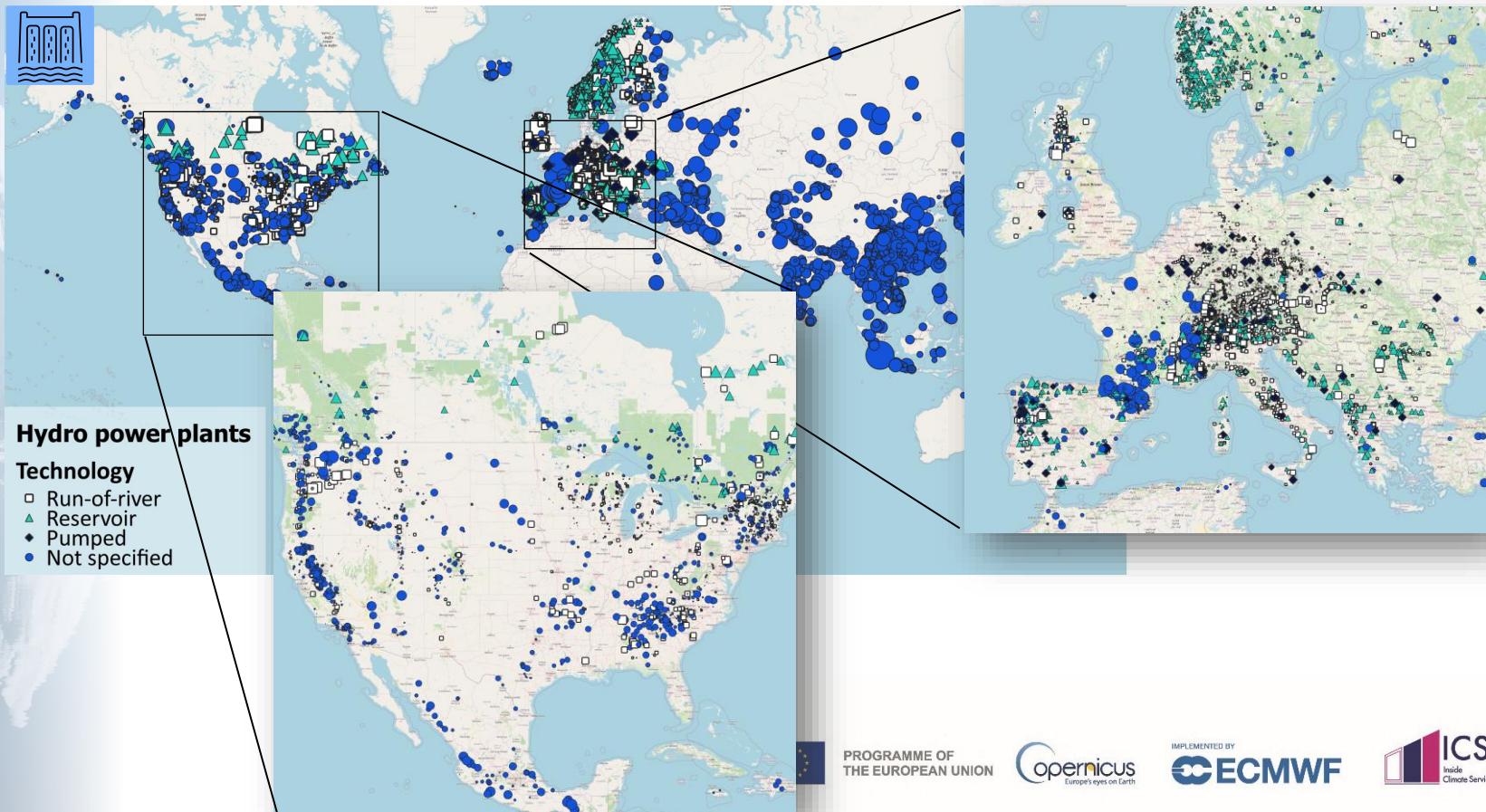
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Global Energy Data – Hydro power plants database



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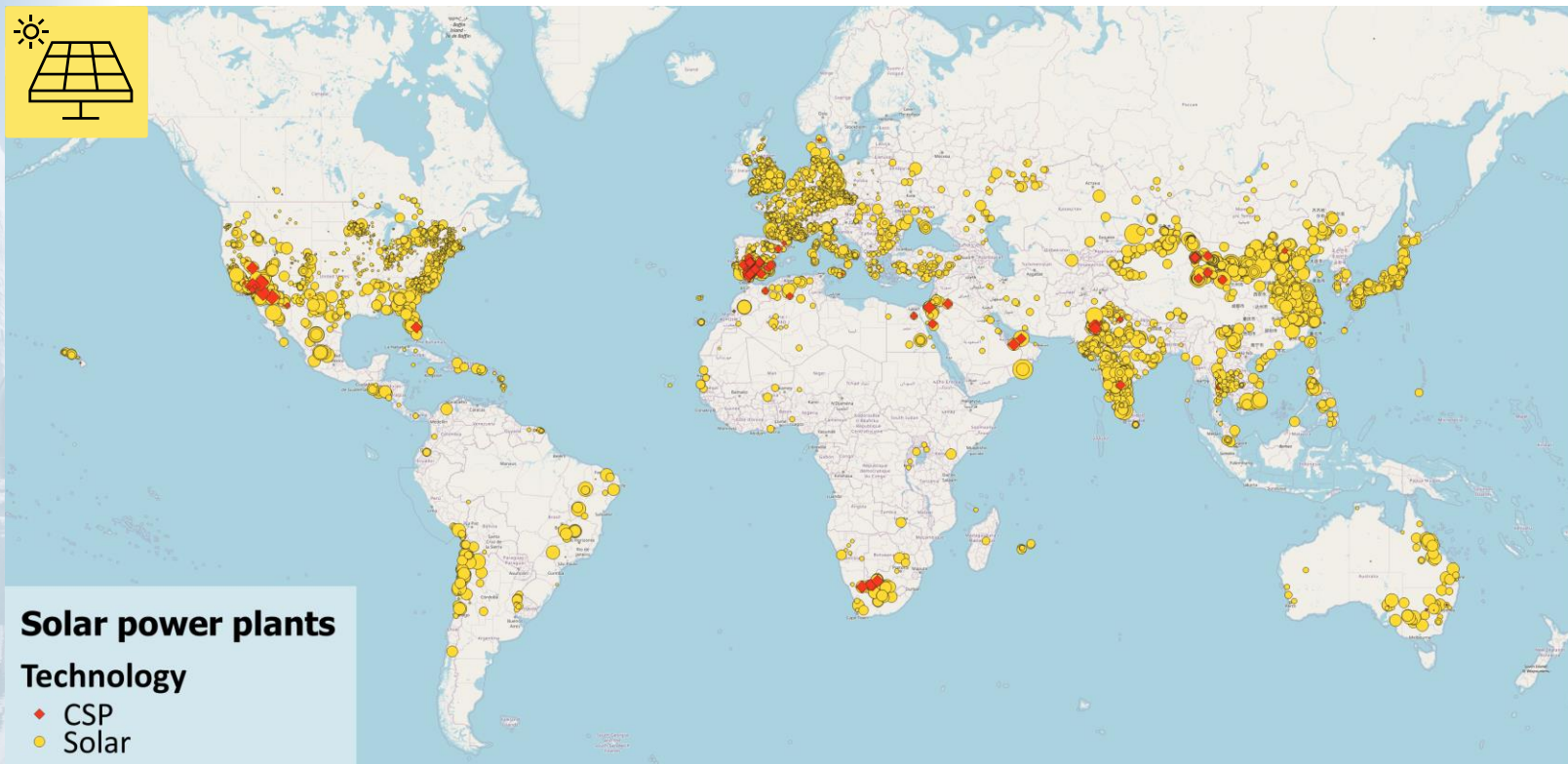
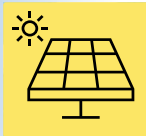
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Global Energy Data – Solar power plants database



Solar power plants

Technology

- ◆ CSP
- Solar



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Global Energy Data – Wind power plants database





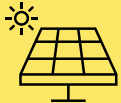

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Global Energy Data – Generation data sources

 GENERATION SOURCES				COVERAGE	TEMP. RESOL.
ENTSO-E Transparency Platform	✓	✓	✓	European countries	15 min, 30 min, 1h (2014-2023)
International Energy Agency (IEA)	✓	✓	✓	47 countries (OECD members)	Monthly (2010-2022)
Joint Research Centre (JRC)	-	-	✓	European countries	Daily and weekly (1991-2019)
<i>Carbon-Monitor Power*</i>	✓	✓	✓	37 countries over all continents	Daily (2019-2023)
Our World in Data	✓	✓	✓	Global coverage	Annual (1965-2022)
IRENA	✓	✓	✓	Global coverage	Annual (2000-2022)
Existing Hydropower Assets (EHA) - Oak Ridge National Laboratory	-	-	✓	United States (not aggregated data)	Monthly (2003-2021)

**CarbonMonitor-Power near-real-time monitoring of global power generation on hourly to daily scales.*

(B. Zhu et al, 2023) <https://doi.org/10.1016/j.esr.2018.11.004>





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Global Energy Data – Electricity demand data sources

 ELECTRICITY DEMAND SOURCES		COVERAGE	TEMP. RESOL.
ENTSO-E Transparency Platform	✓	European countries	Hourly (2014-2023)
International Energy Agency (IEA)	✓	38 OECD countries + 14 non-OECD countries	Annual/monthly (1960 - 2021)
EMBER	✓	85 countries	Monthly (1998-2023)
Australian Energy Market Operator (AEMO)	✓	Australia	Daily
Our World in Data	✓	Global coverage	Annual (1965-2022)



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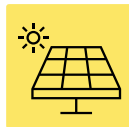




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Global Energy Data – Summary and next steps

- ✓ Many data sources have been gathered
- ✓ Best data coverage is on Europe and United States
- ✓ New sources will be added to the list as they come
- ✓ The data cleaning routine is continuously being improved
- ✓ Data will soon be stored and categorized on VM



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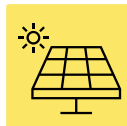




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