Pathways to a fossil free, integrated energy system

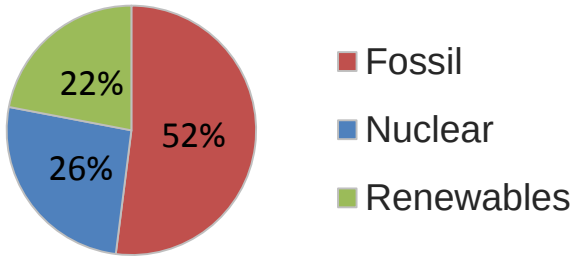
EUDP / Smart Energy Network, Copenhagen
May 29th, 2017

Erland Christensen

Content

Who we are (1/2)

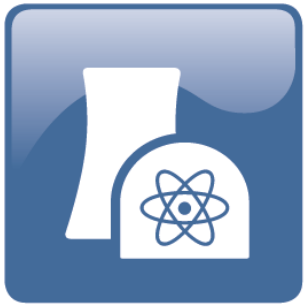
- We have **478 members in 34 countries**, over 90 % European based.
- We represent an installed capacity of **466 GW** based on a wide energy mix and covering all sources for electricity and heat production:



VGB is the International Technical Association for Generation and Storage of Power and Heat.

Who we are (2/2): Our main areas of activities

In our five competence areas we are dealing with all questions regarding power and heat generation as well as their storage:



Nuclear Power Plants

Power Plant Technologies

Renewables, Distributed Generation

Environmental Technology, Chemistry, Safety and Health

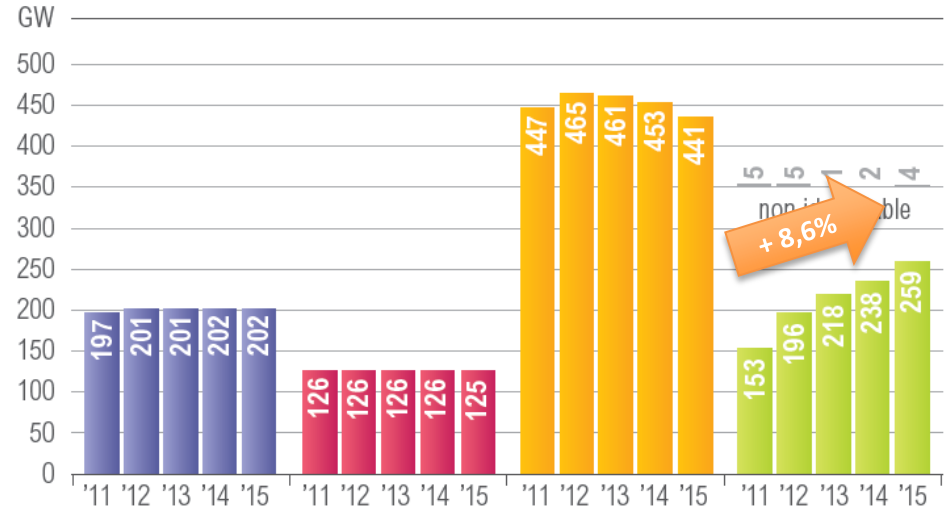
Technical Services

Since its foundation in 1920, VGB has become the technical center of competence for the operators. The membership is open for companies and institutions active in the energy business.

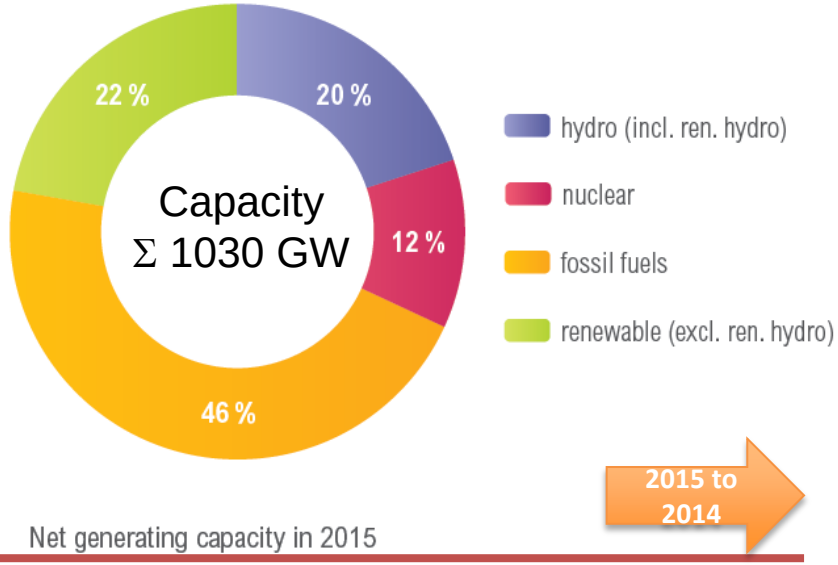
Content

The European generation mix 2015

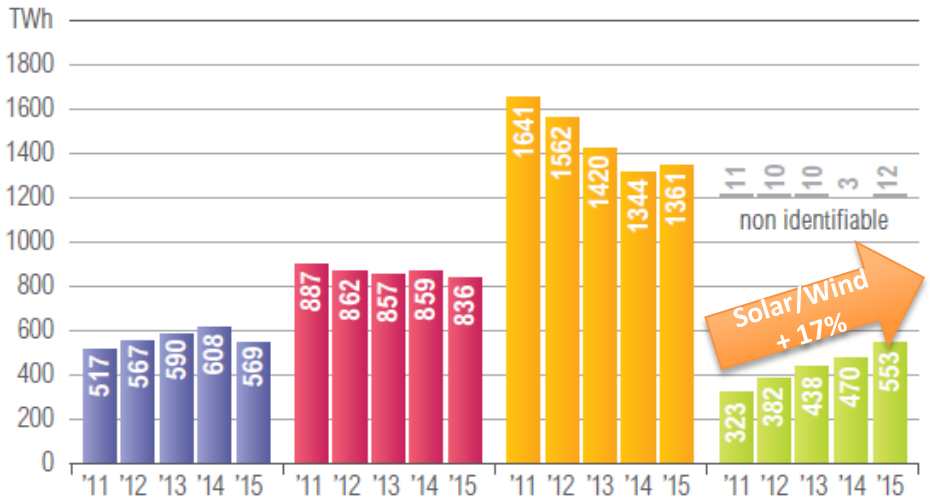
POWERTECH



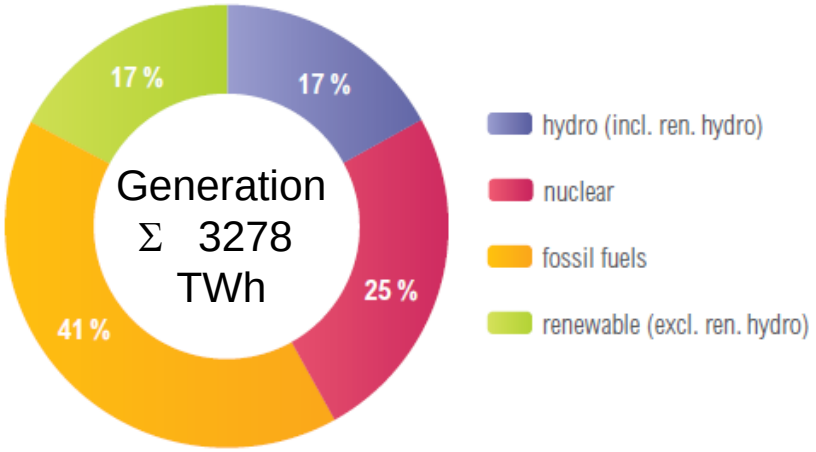
Net generating capacity from 2011 to 2015 in GW



Net generating capacity in 2015



Energy net generation from 2011 to 2015 in TWh

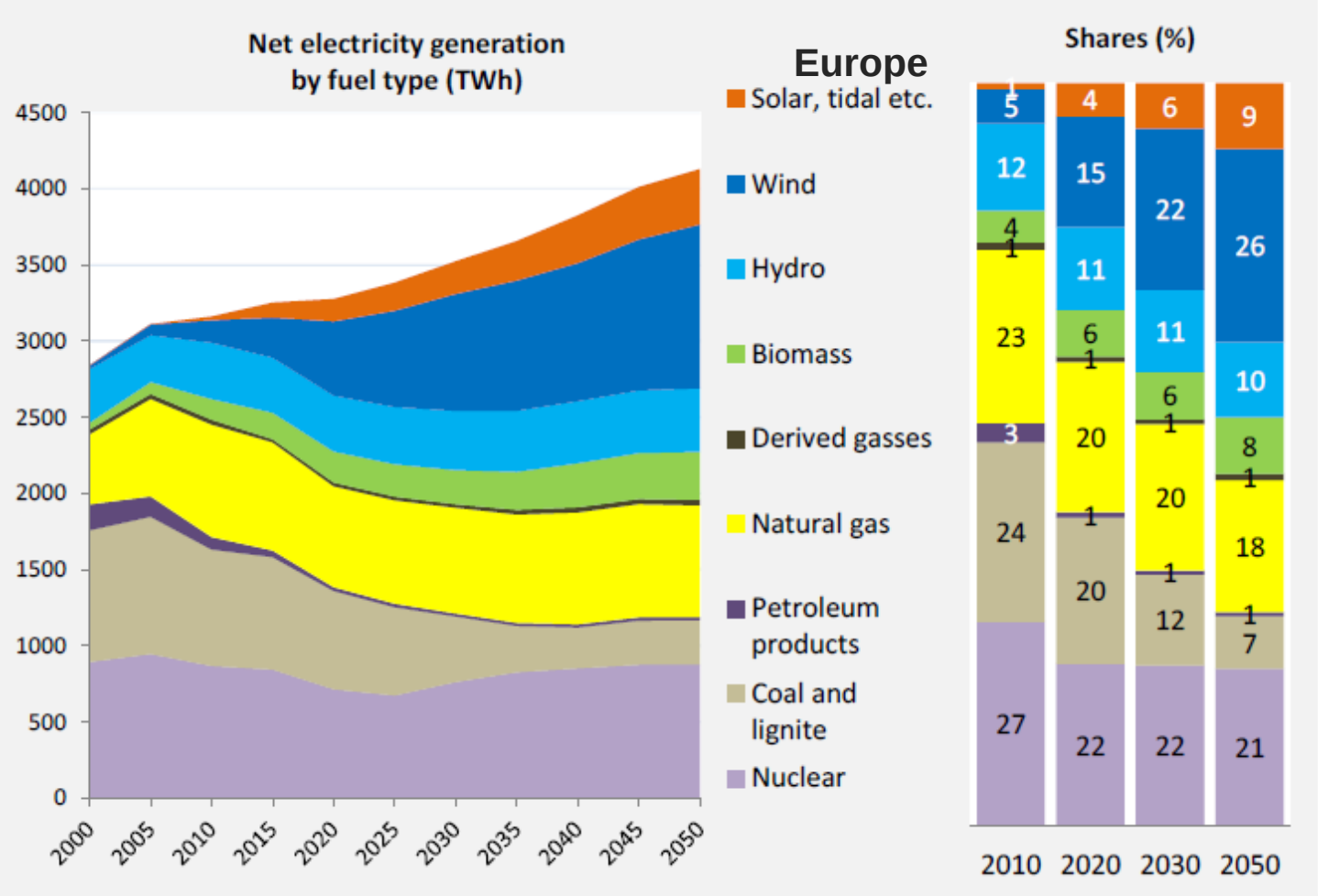


Energy net generation in 2015

Source: Entso-E, Electricity in Europe 2015

EU Reference scenario electricity generation 2013-2050

POWERTECH



Source: EU Energy, Transport and GHG Emission – Trends to 2050, EU Commission 2013

Reduction of coal based generation until 2050.

Content

ENERGINET

”**Dansk vindstrøm slår igen rekord – 42 procent**
Vindmøller leverede i 2015, hvad der svarer til 42,1 procent af danskernes elforbrug. I Jylland og på Fyn leverede vindkraft faktisk mere strøm end det samlede forbrug i over 1460 af årets timer.”

Agora Energiewende

„**2015 war Rekordjahr für Erneuerbare Energien, Stromerzeugung und Stromexport.** Im deutschen Stromsystem wurden im abgelaufenen Jahr mehrere Rekorde gebrochen. So lieferten Erneuerbare Energien mehr Strom als jemals ein anderer Energieträger in Deutschland: **Jede dritte Kilowattstunde (32,5 Prozent),** die hierzulande verbraucht wurde, stammte aus Wind-, Solar, Wasser und Bioenergiekraftwerken.“

BILD,

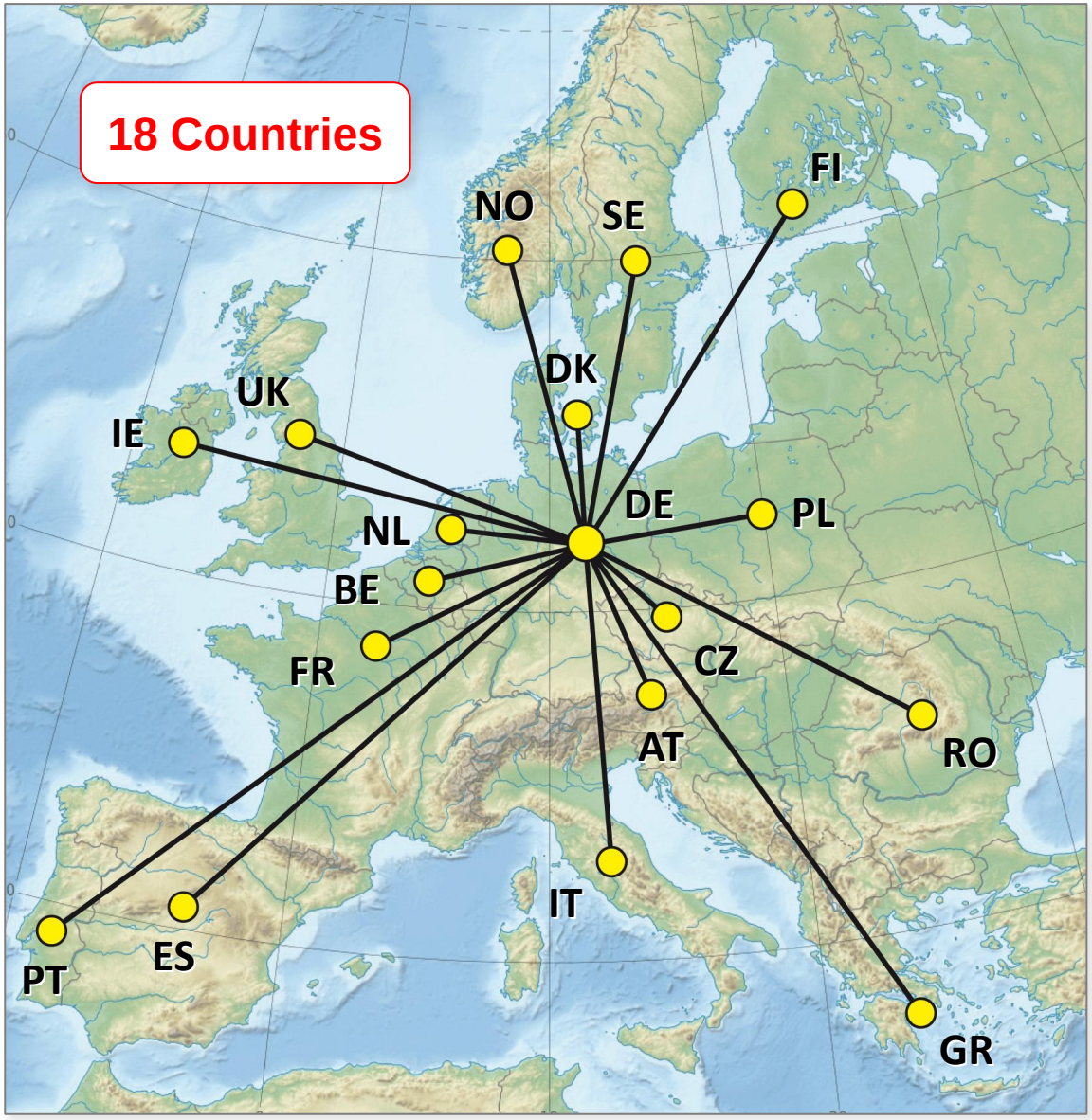
03. 05. 2017 Seite 2

Energie - **Kohle-strom auf All-zeit-Tief** Wegen der Strommenge aus Sonnen- und Windkraft sank am Sonntag die Produktion aus Kohle auf ein Rekordtief. Zeitweise lieferten die Kraftwerke nur 8 von möglichen 50 Gigawatt (Agora Energiewende).

Success? : Yes: we reduce CO_2 emission

But : We totally neglect the difference between MWh and MW

Europe: Wind power production in 2016



AT	Austria
BE	Belgium
CZ	Czech Republic
DE	Germany
DK	Denmark
ES	Spain
FI	Finland
FR	France
GR	Greece
IE	Ireland
IT	Italy
NL	Netherlands
NO	Norway
PO	Poland
PT	Portugal
RO	Romania
SE	Sweden
UK	United Kingdom

Starting position

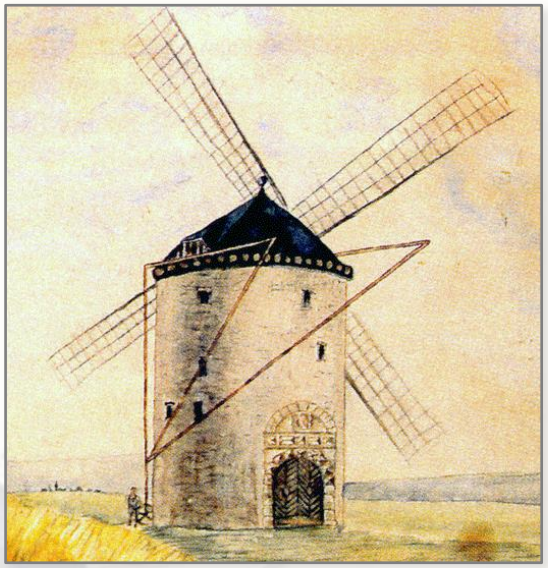


Illustration: www.kultur-denkmal-merzenich.de

European transparency data

- Time series for power supply
- Quarter-hourly to hourly values
- Nominal output of wind power plants
- Total output of wind power plants
- Total output of consumers (load)

Note

- No own data, but plausibility checks of temporally synchronized transparency data (UTC: coordinated universal time)
- Linear interpolation in case of data gaps
- Verification of interpolated values based on further data sources

Central question

- Is wind always and anywhere blowing for basic electricity supply?

based on a Wind Study by Thomas Linnemann and Guido Vallana, VGB PowerTech e.V.

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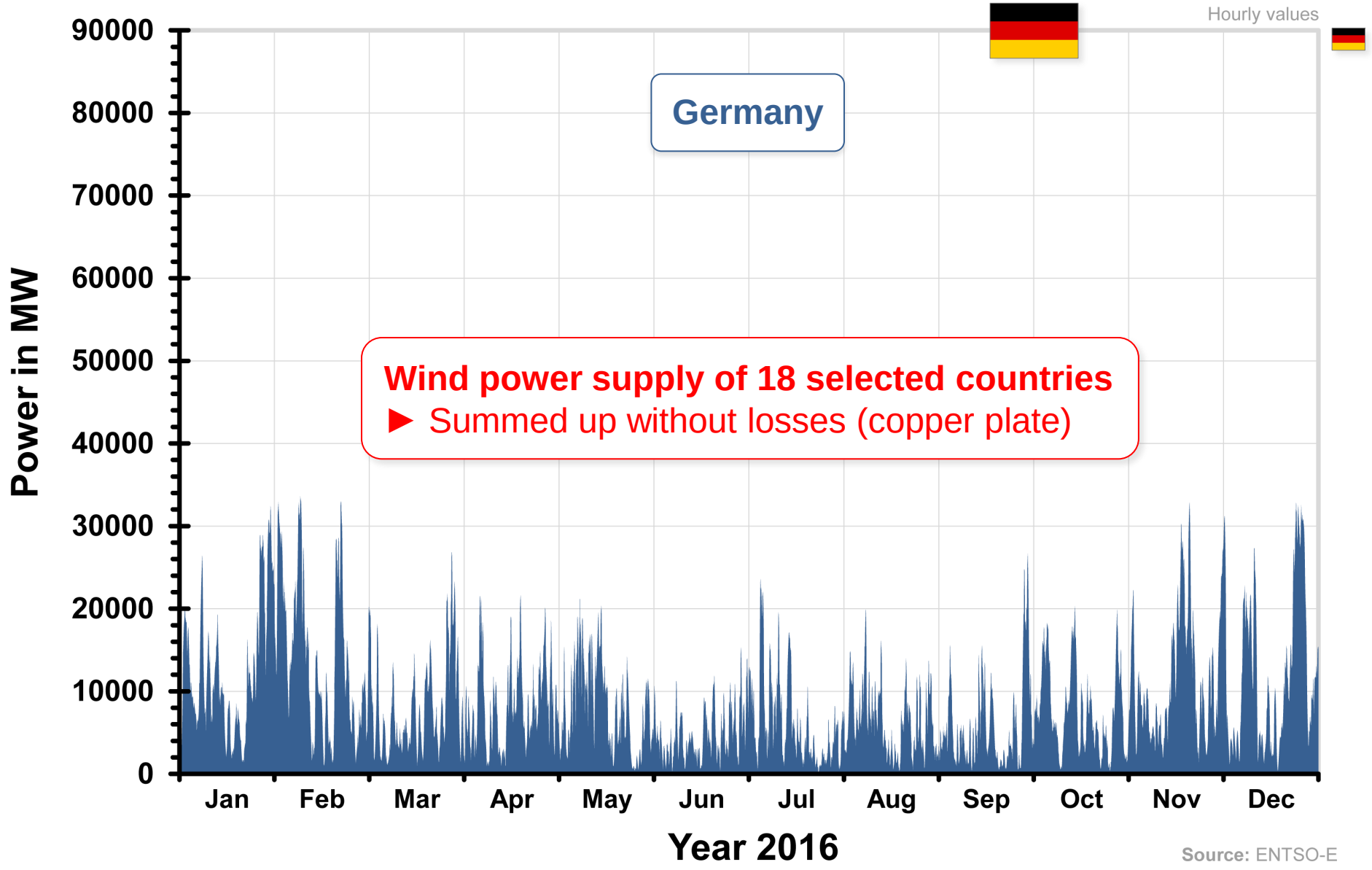

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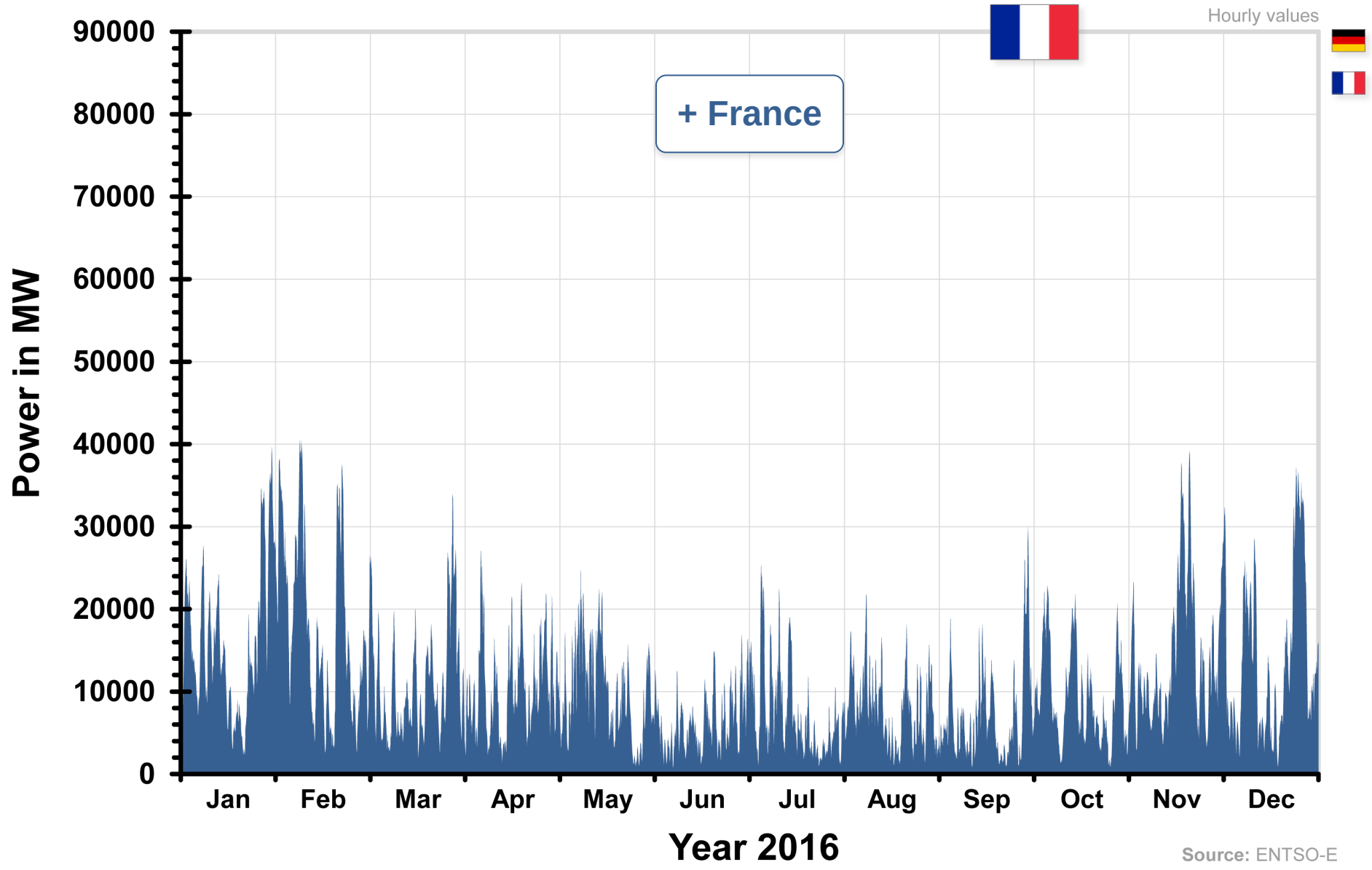

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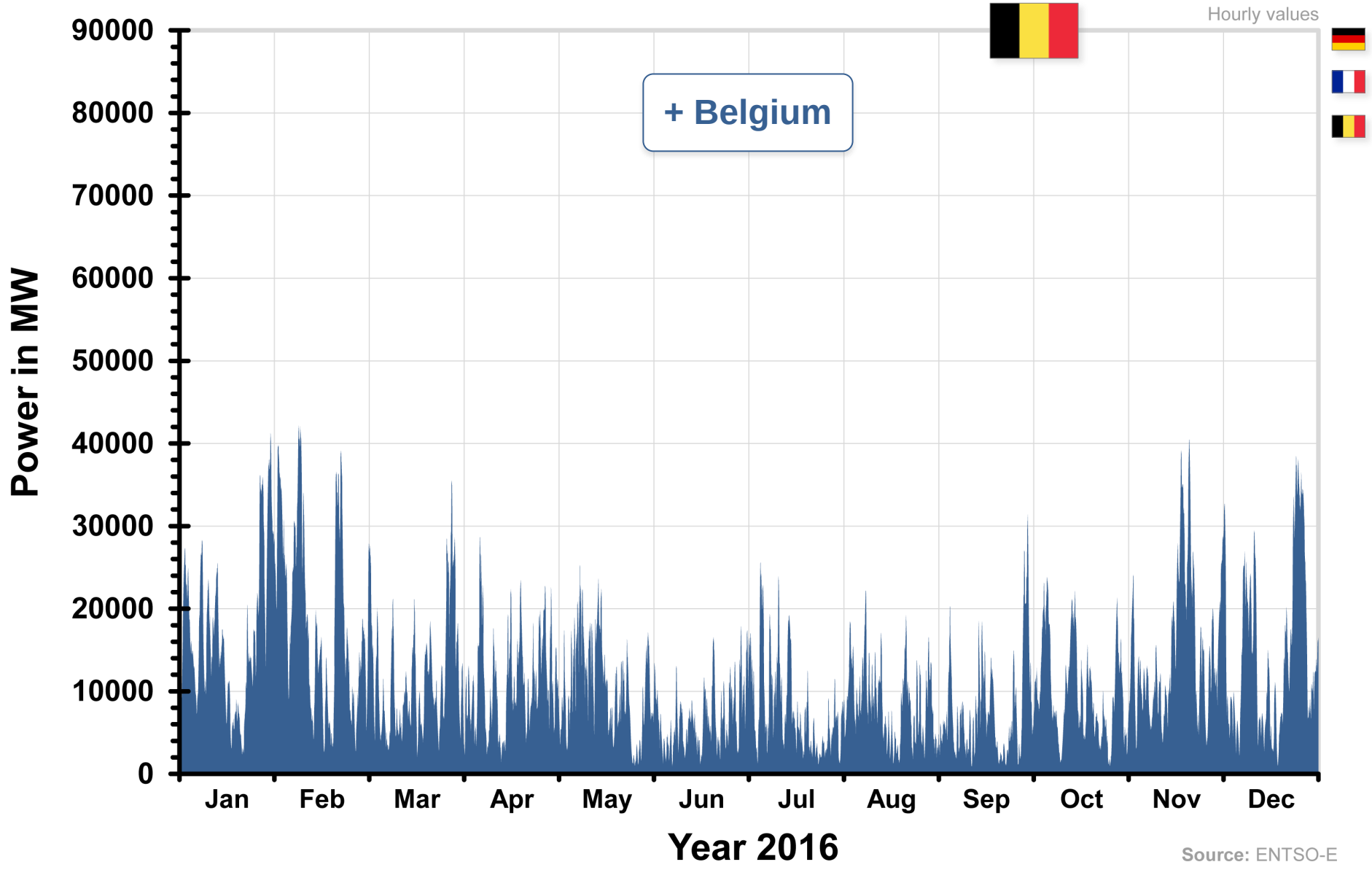

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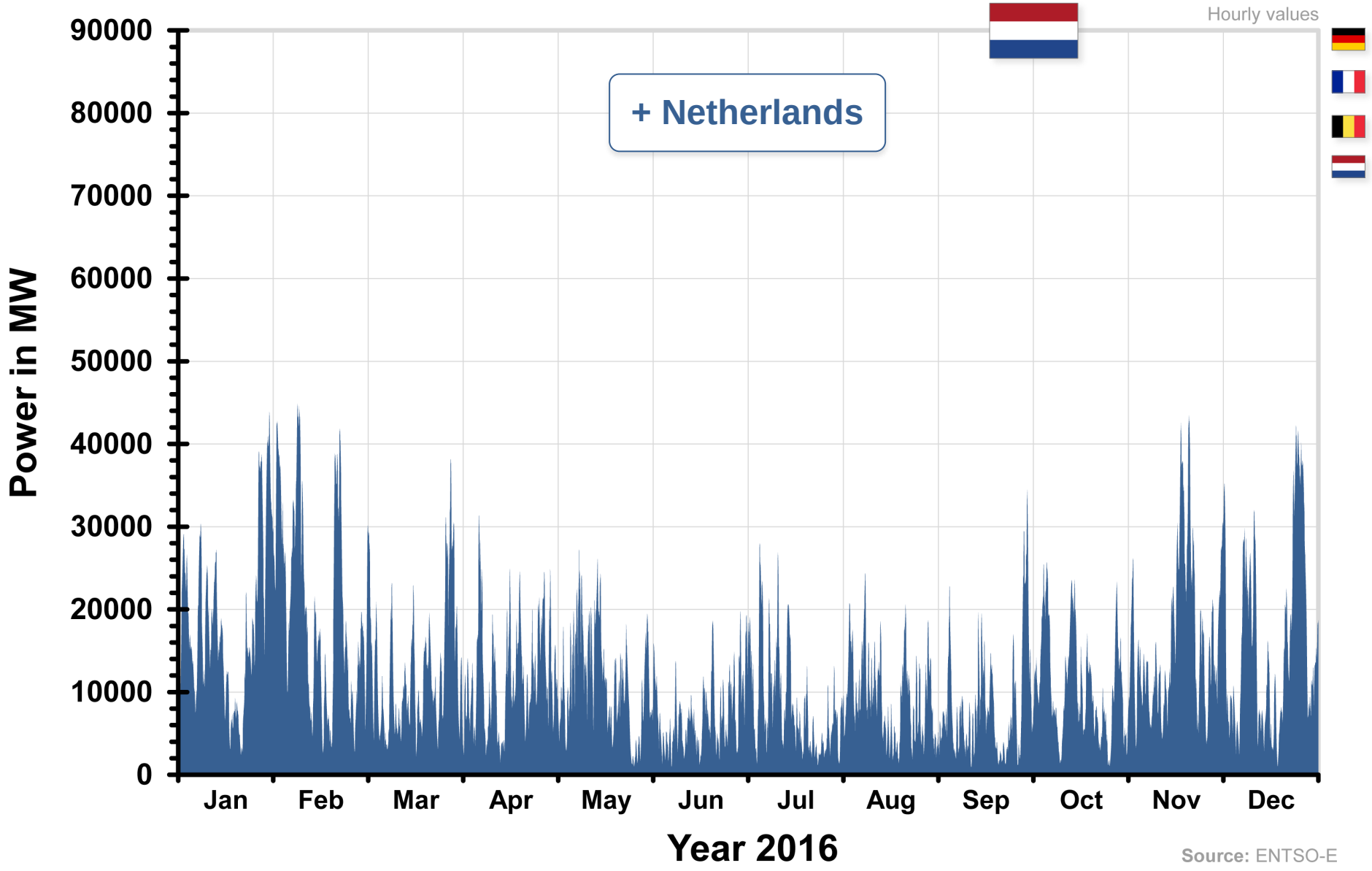

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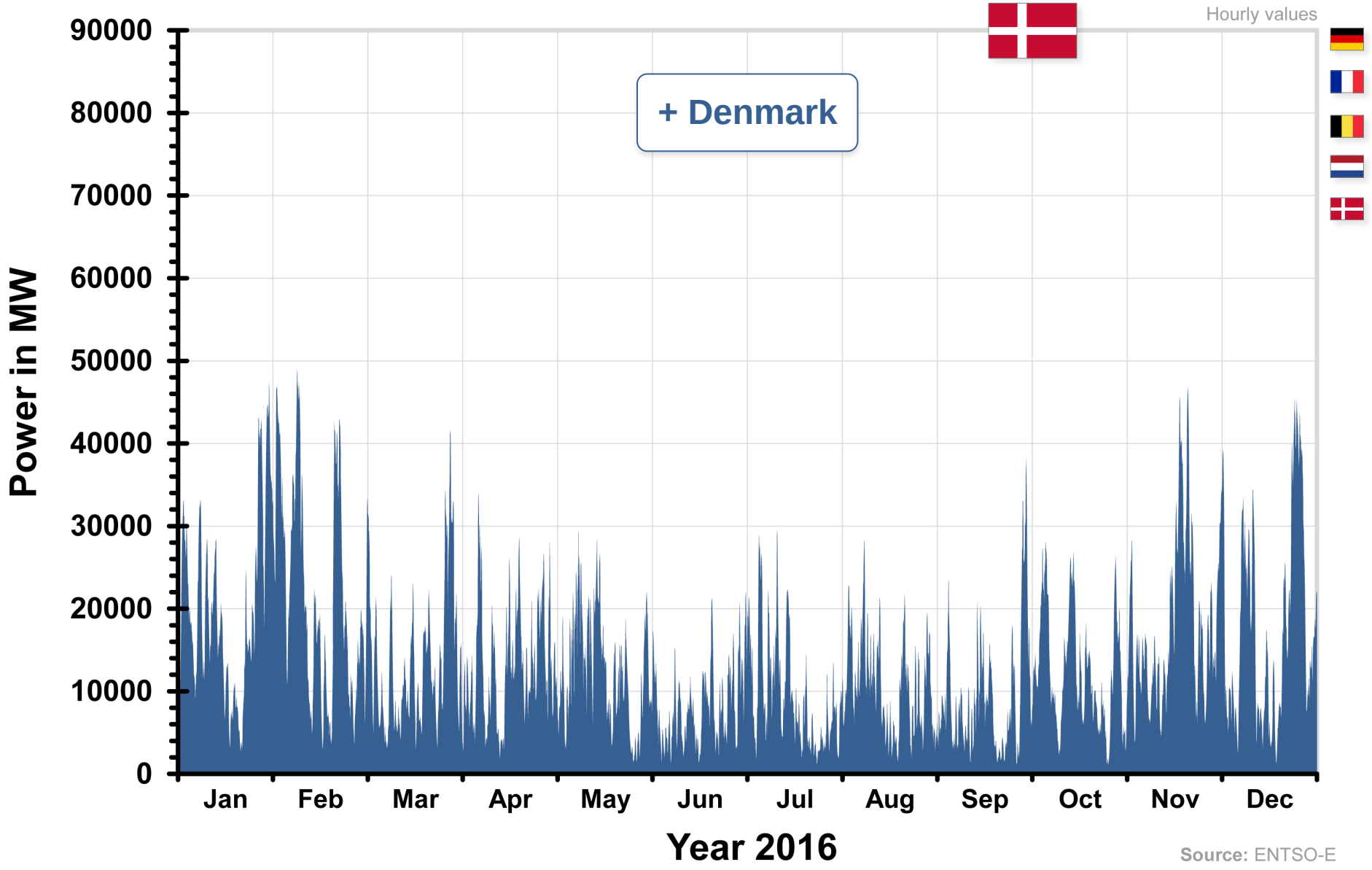

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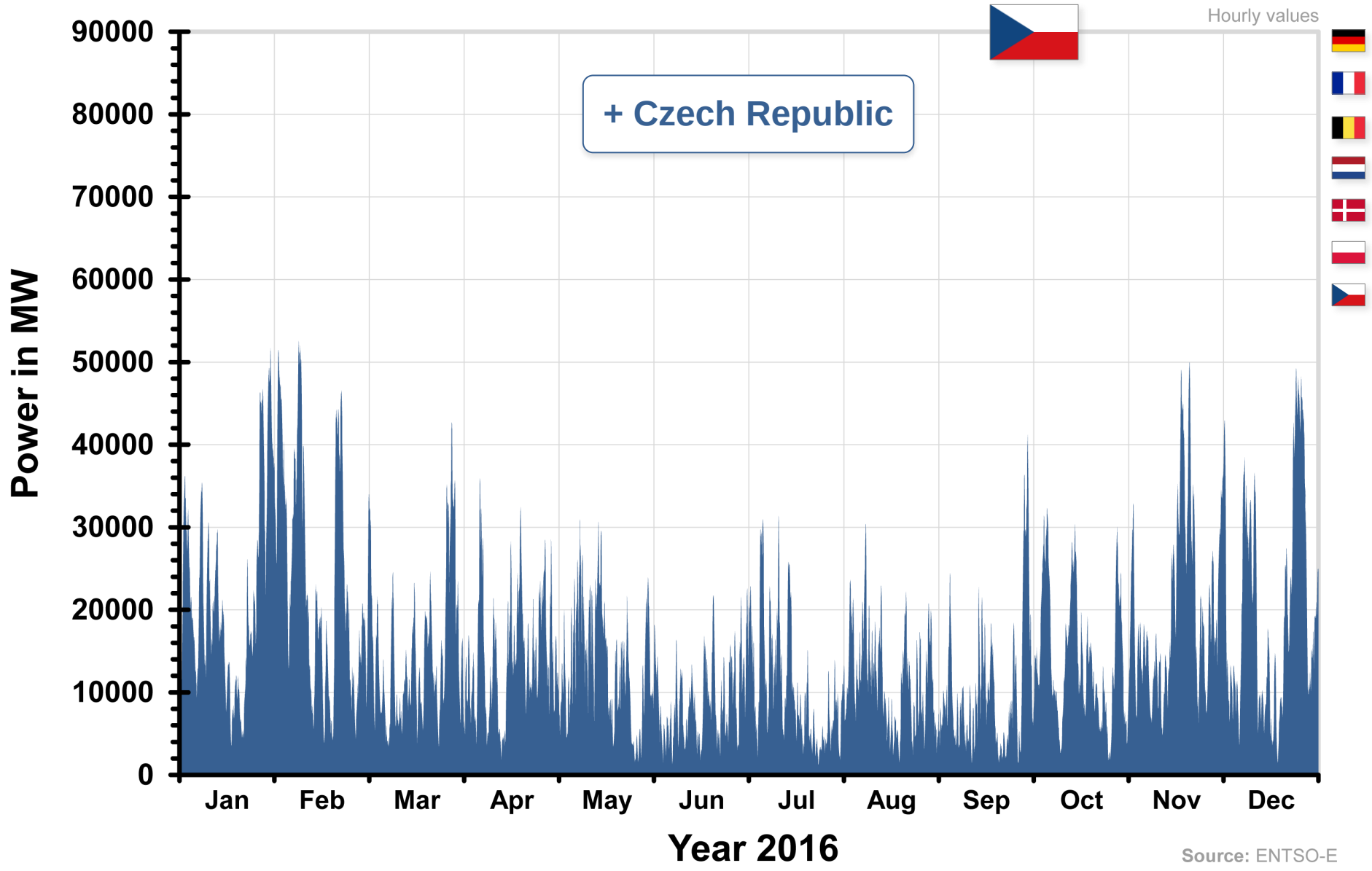

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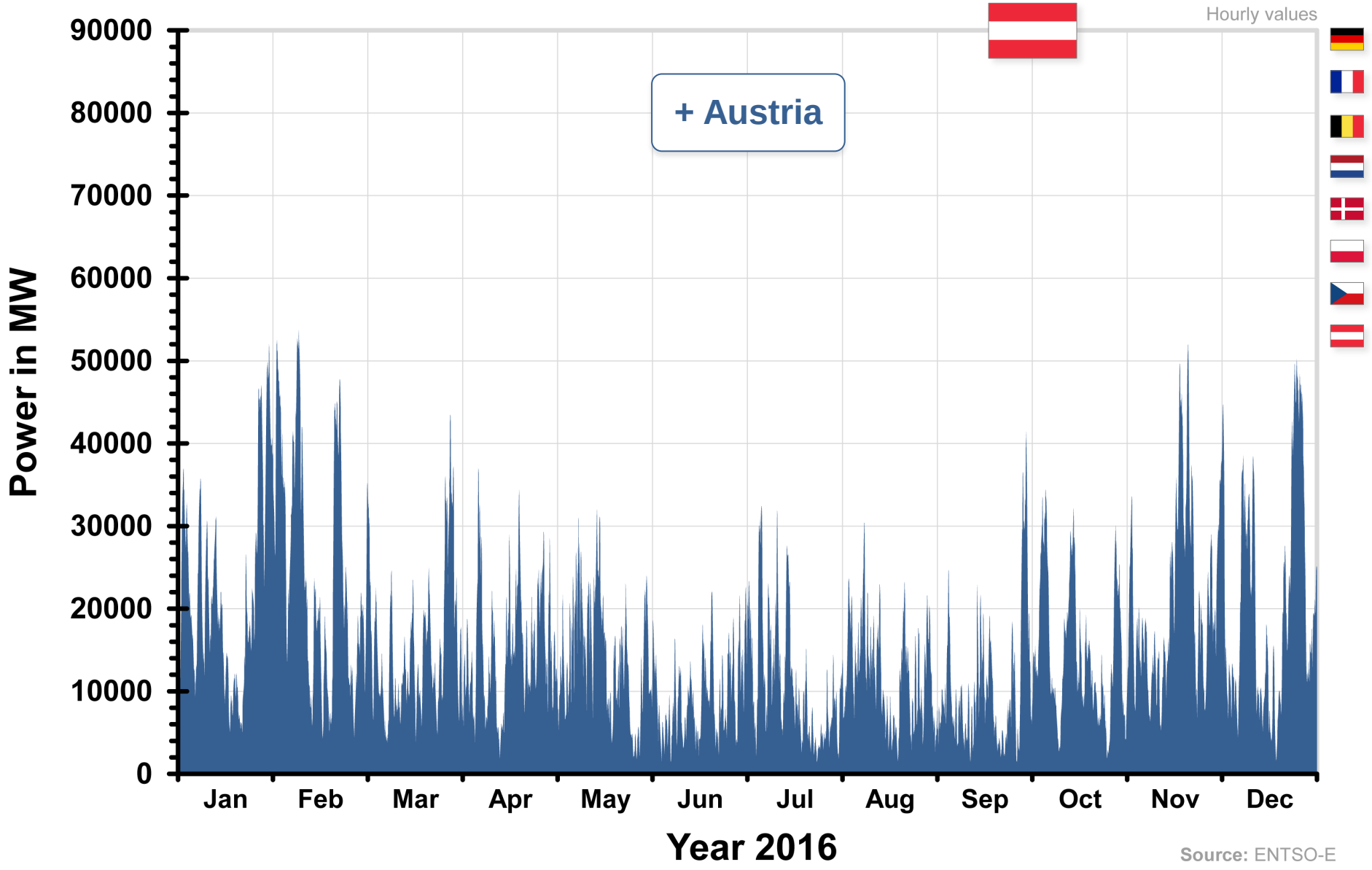

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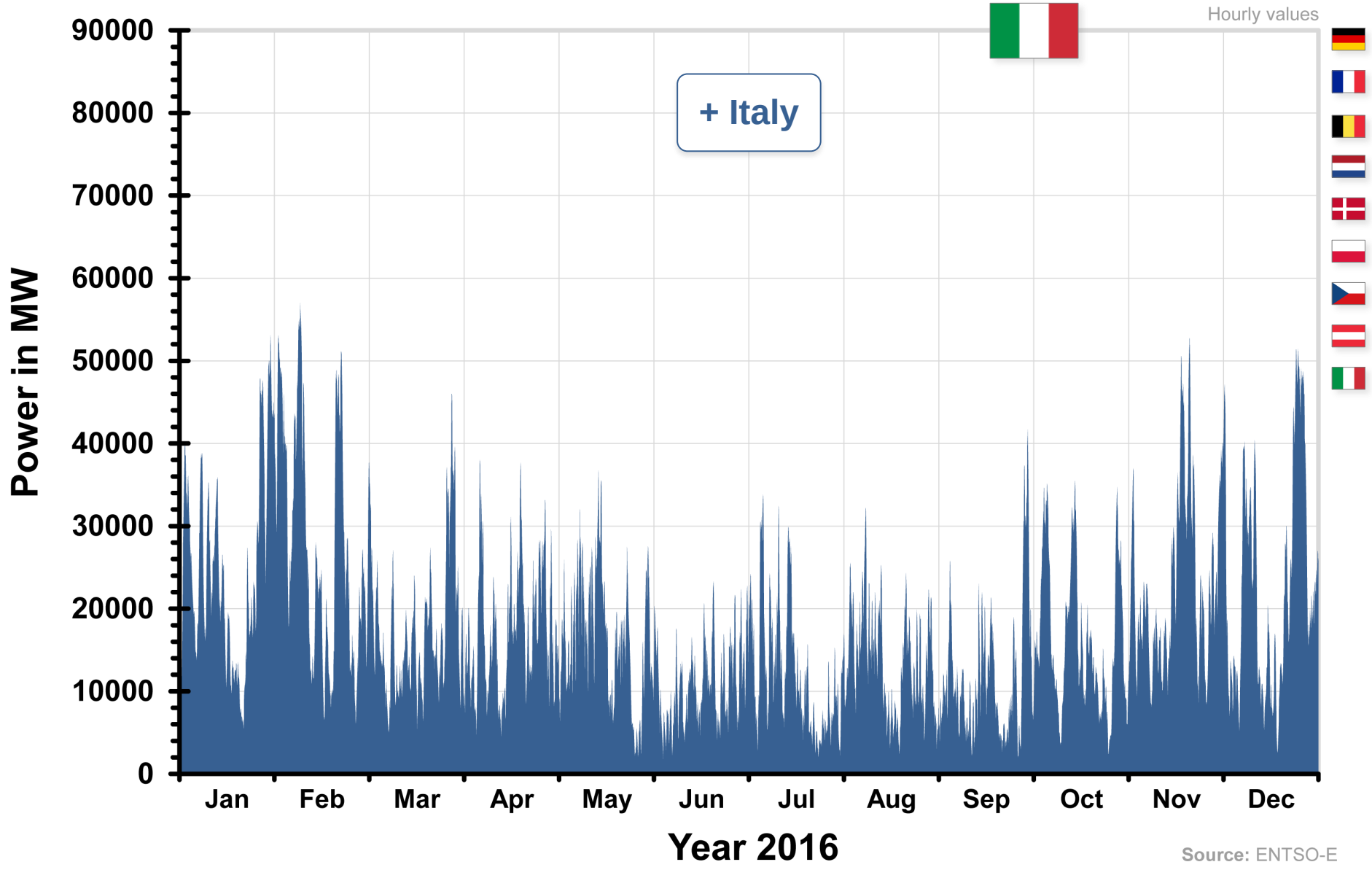

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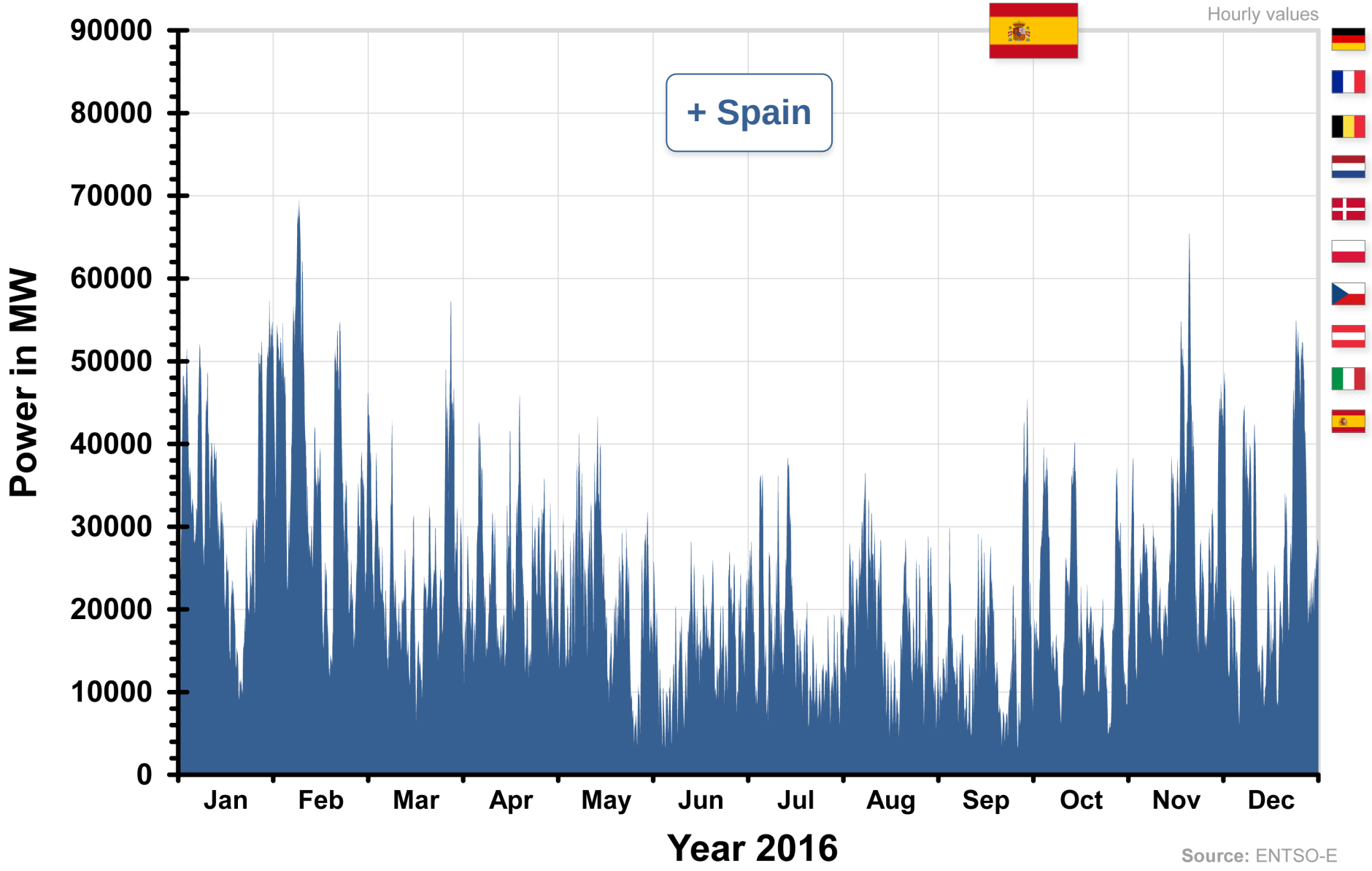

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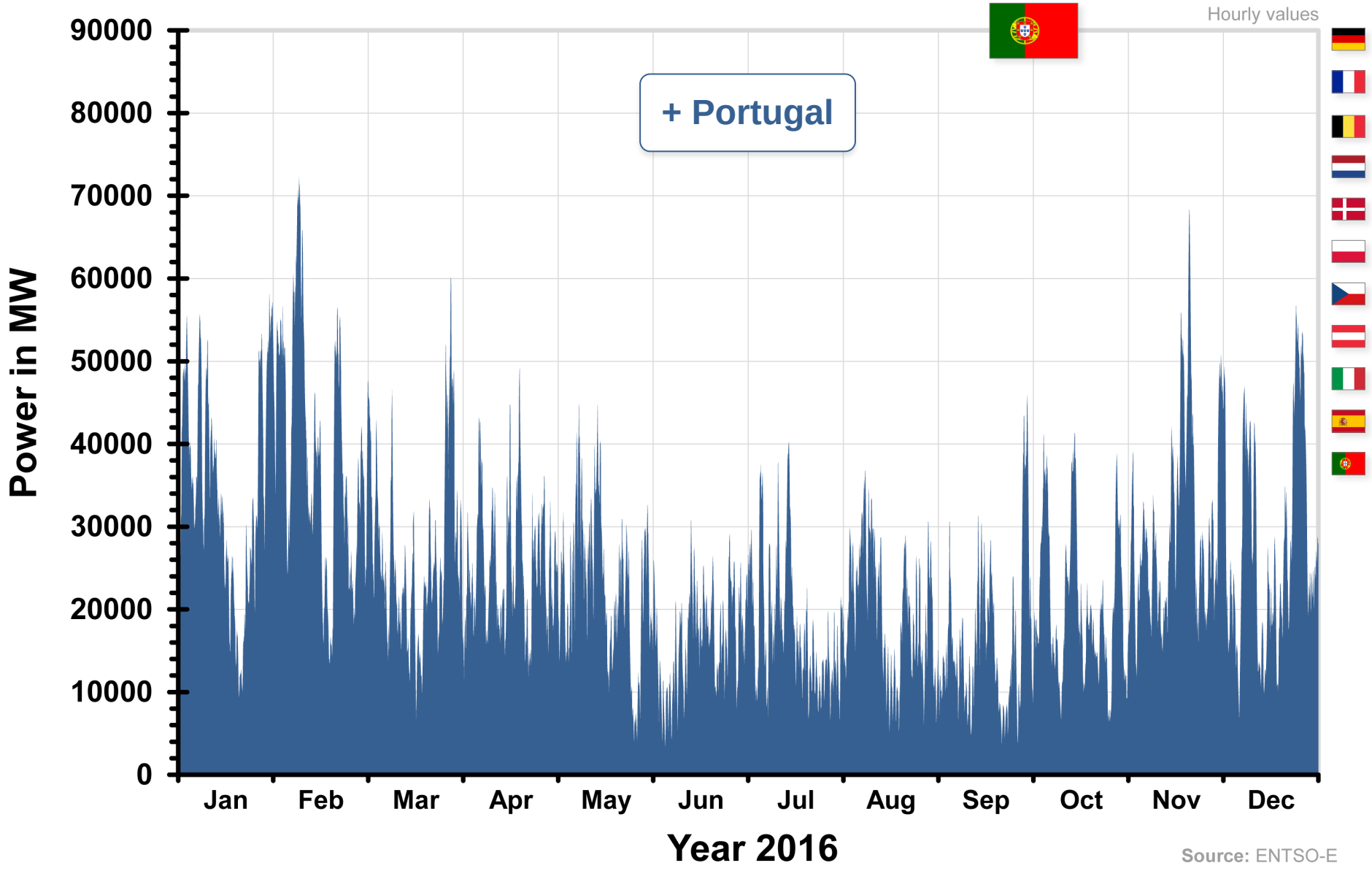

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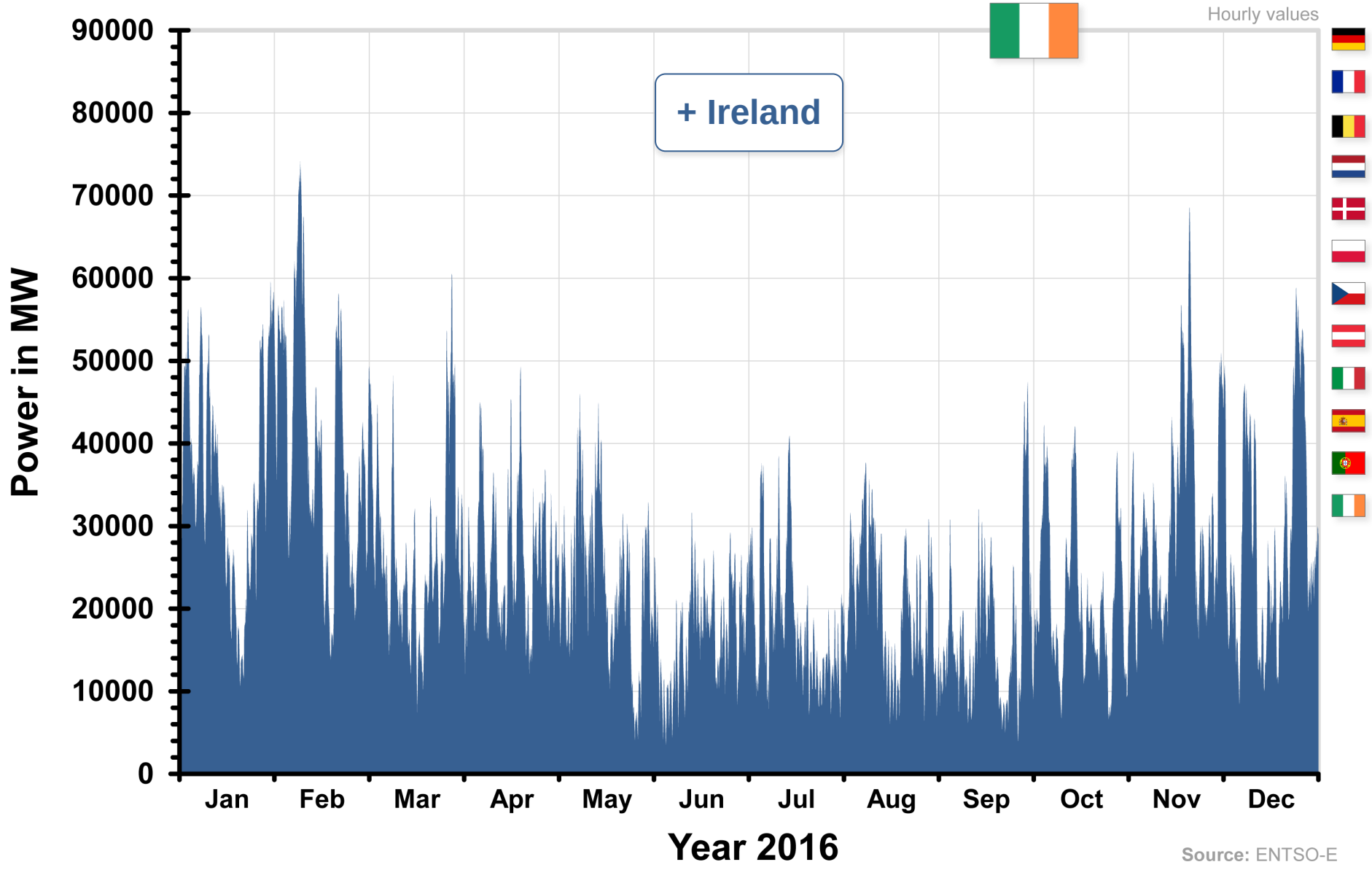

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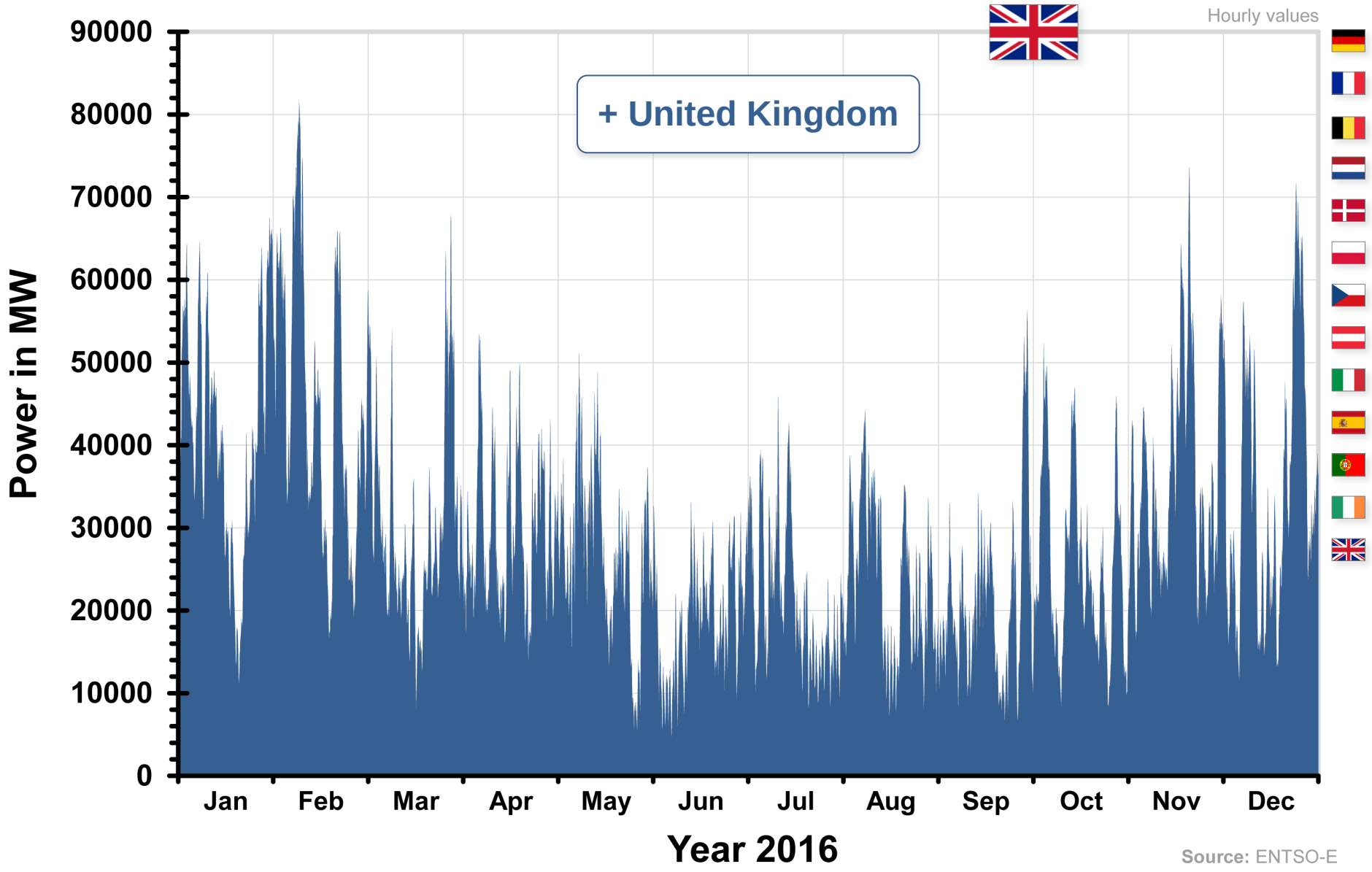

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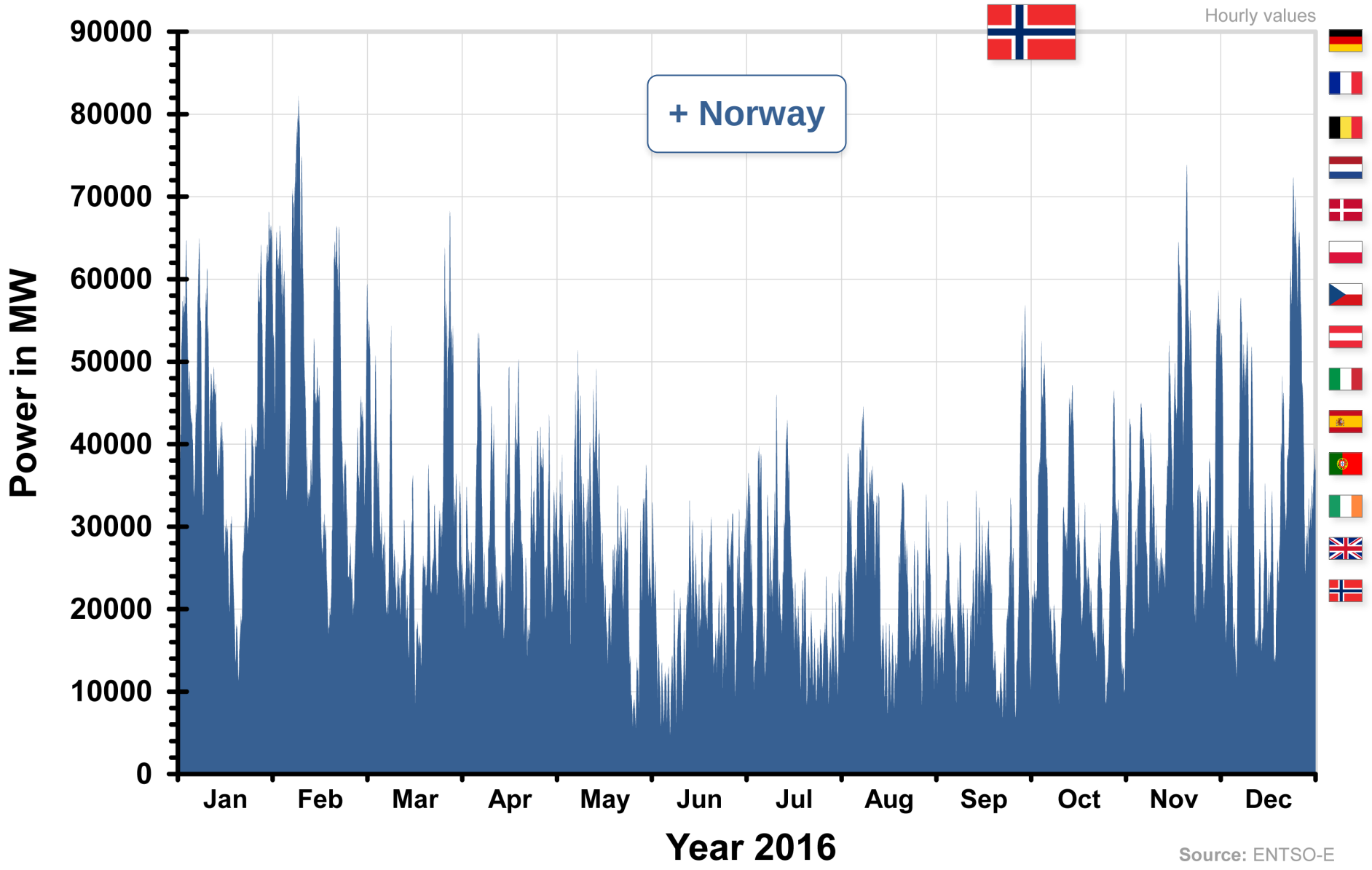

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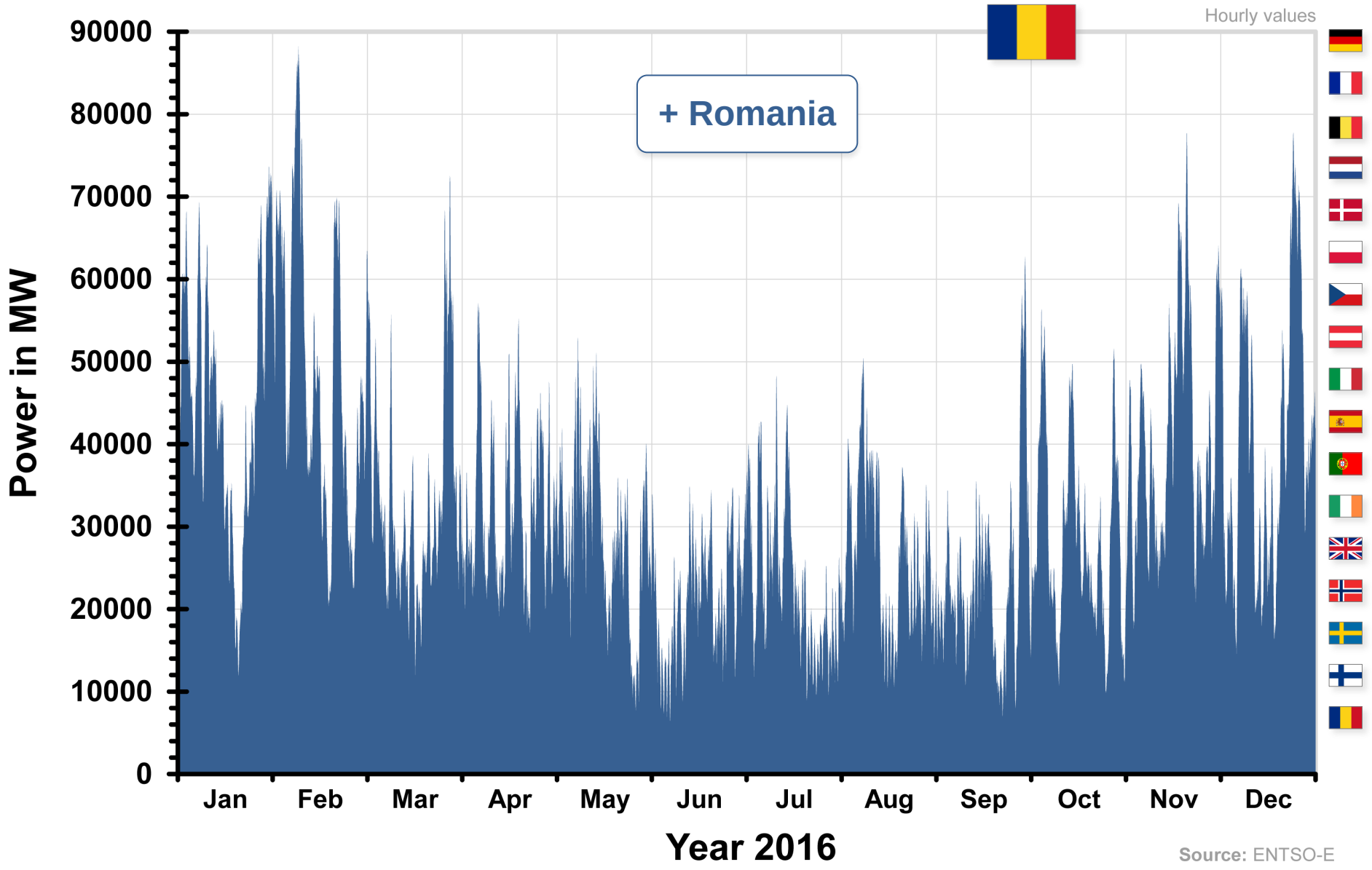

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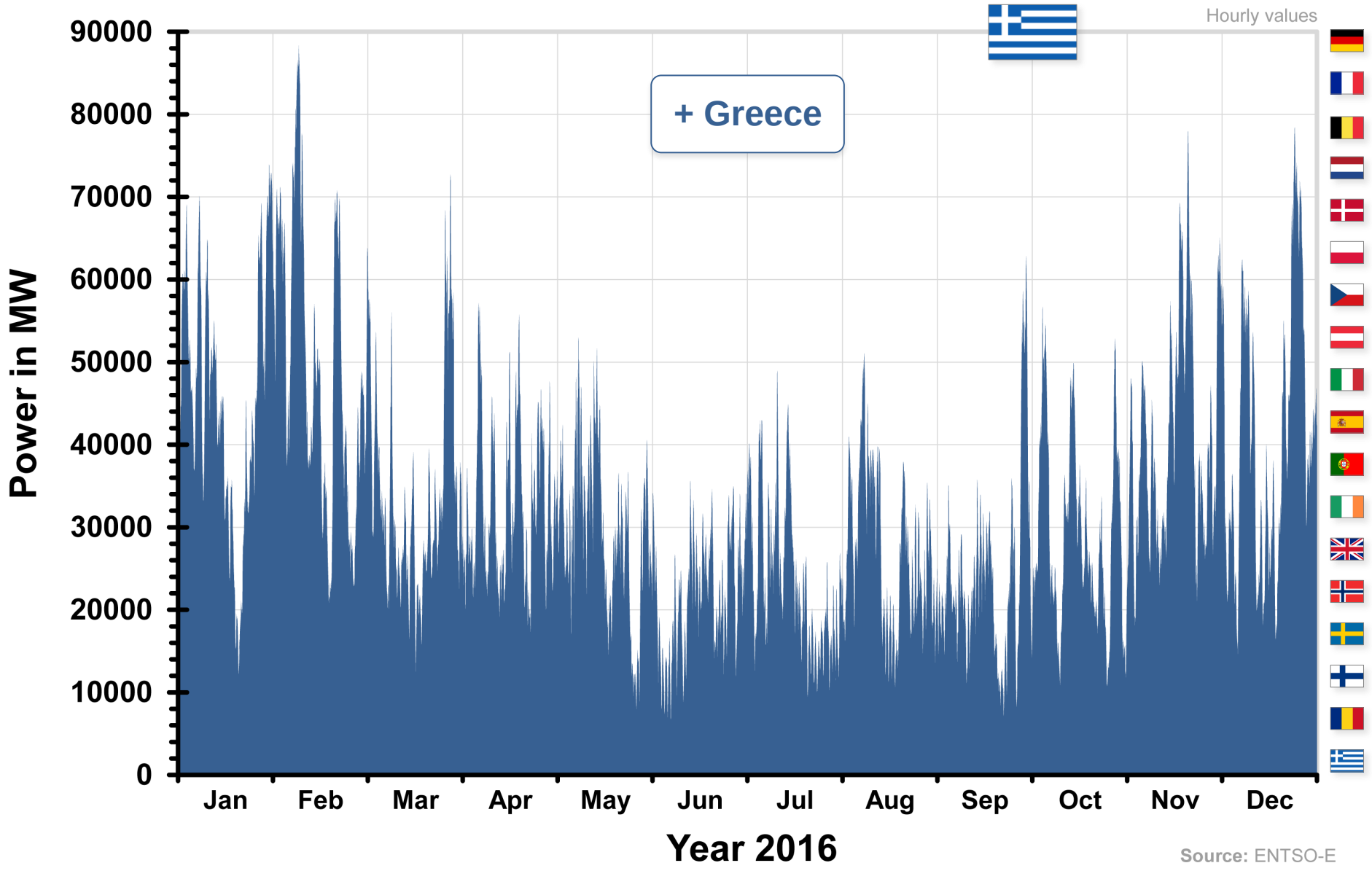

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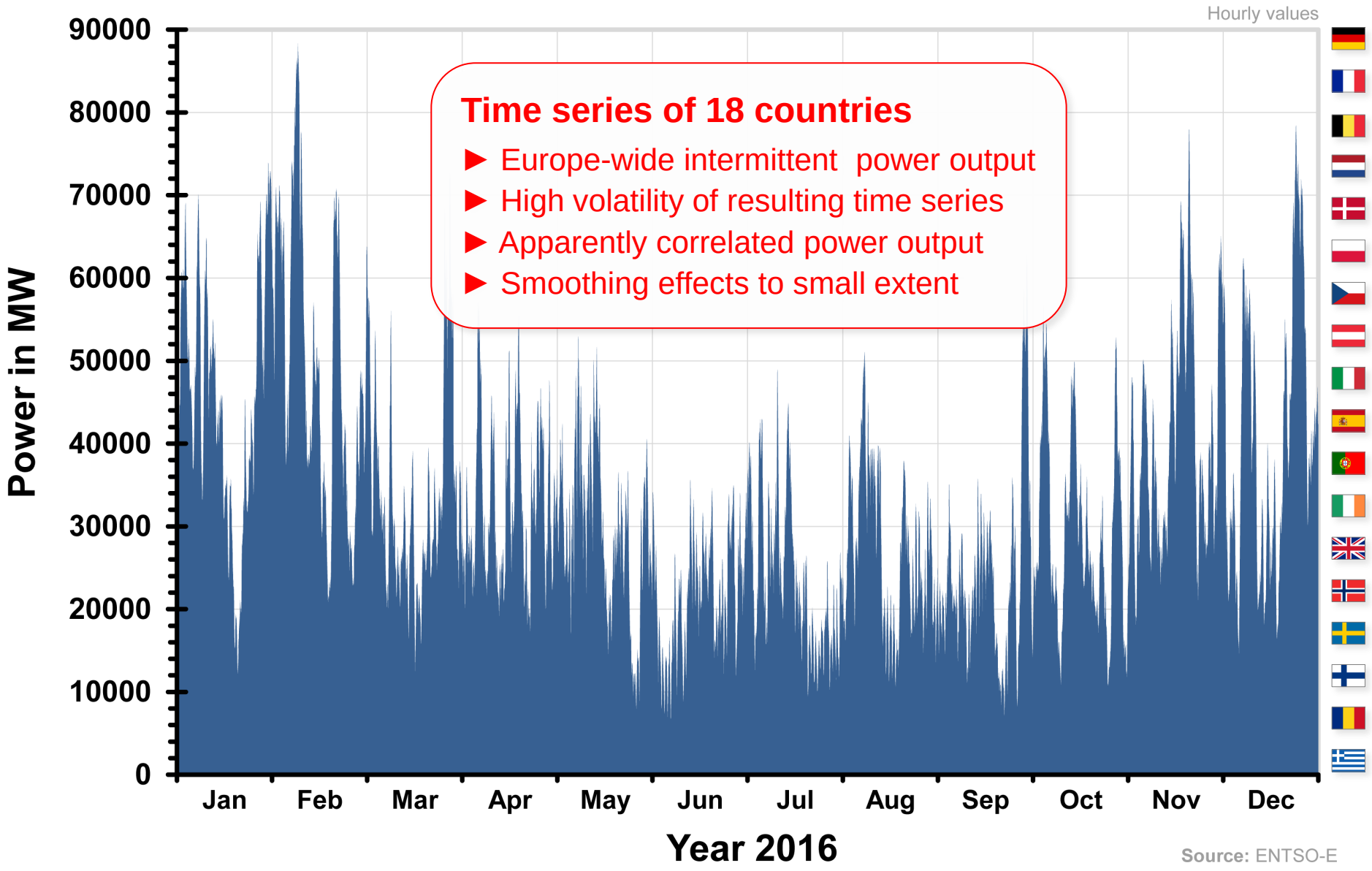

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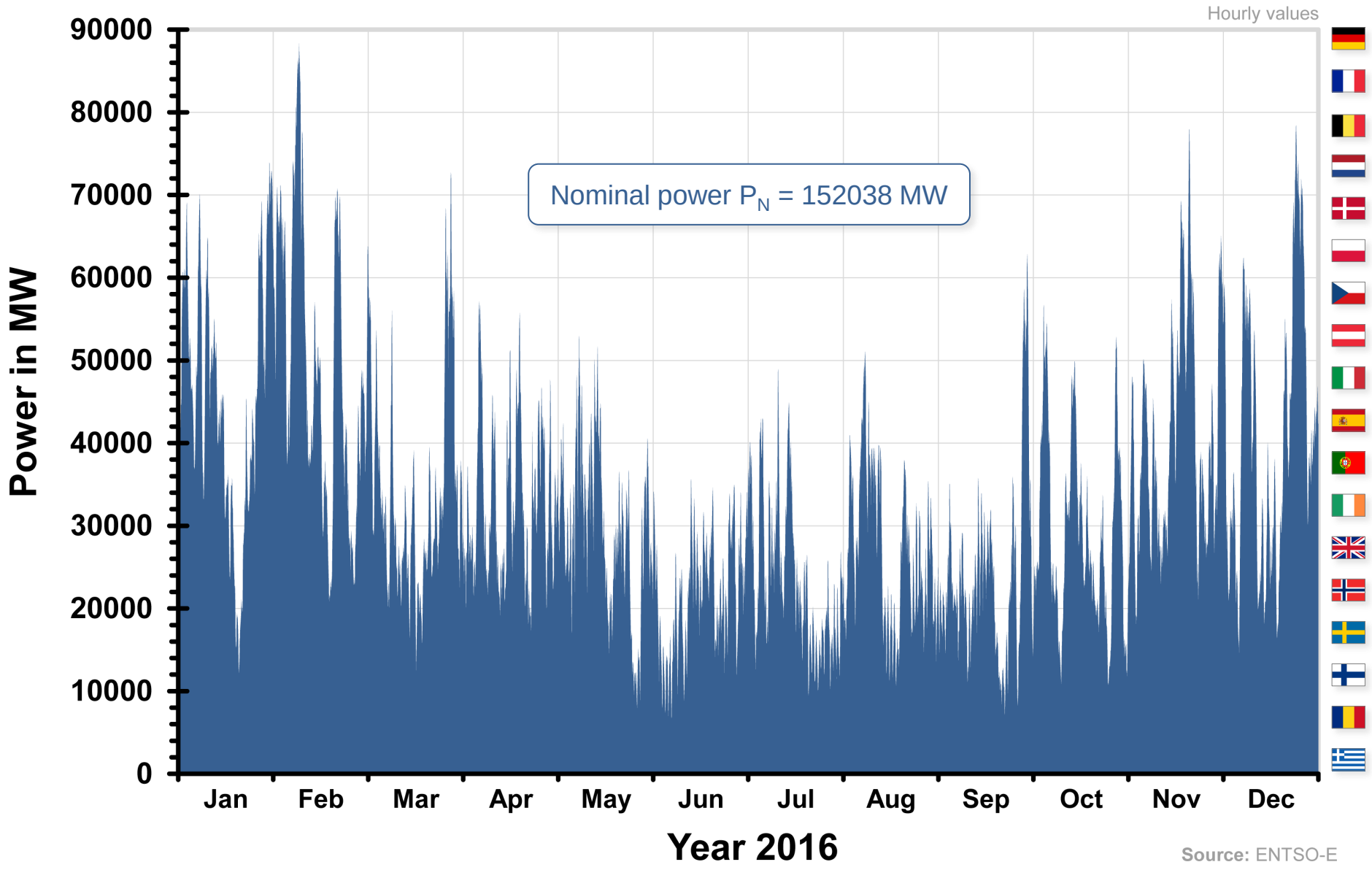

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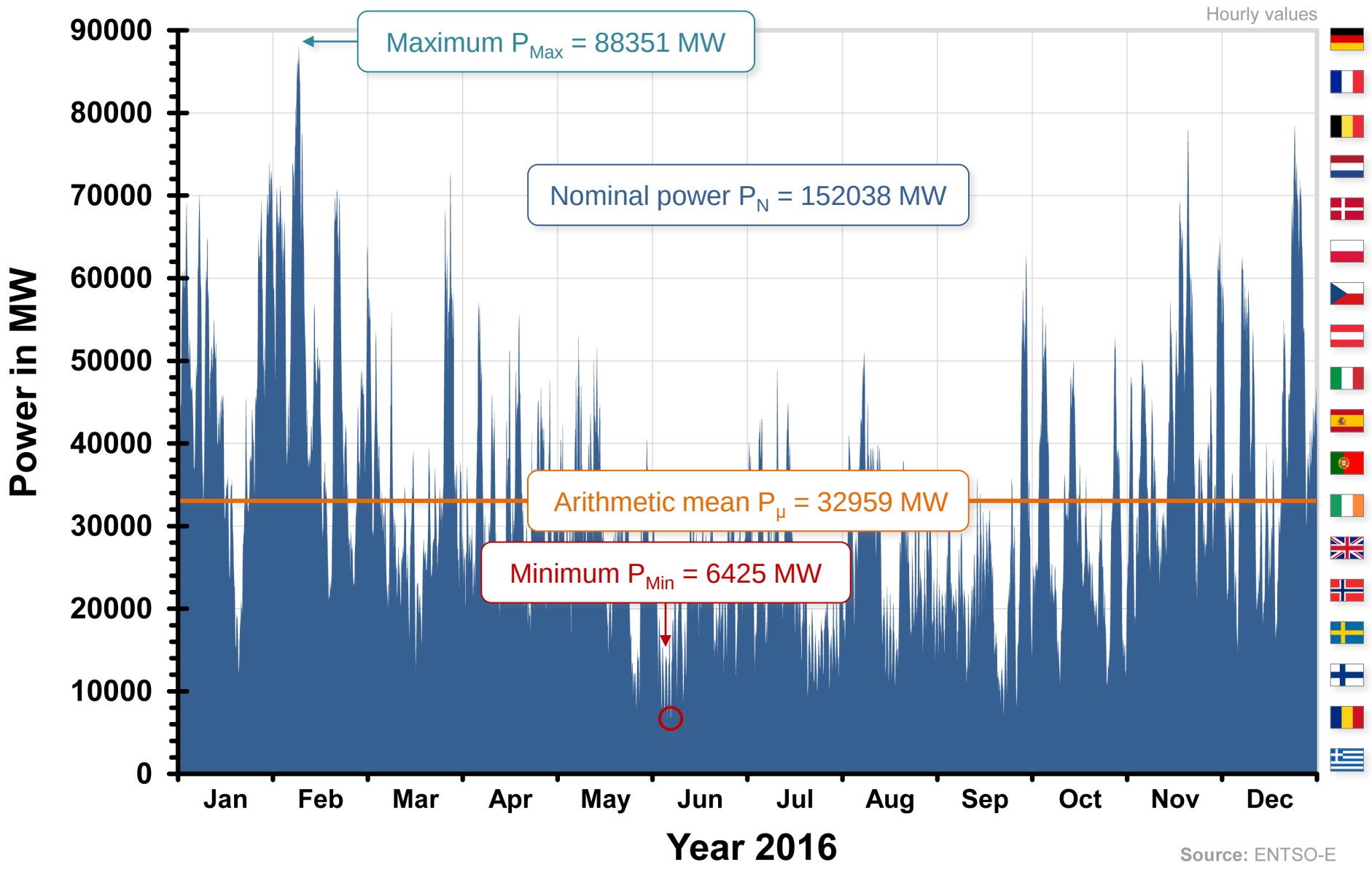

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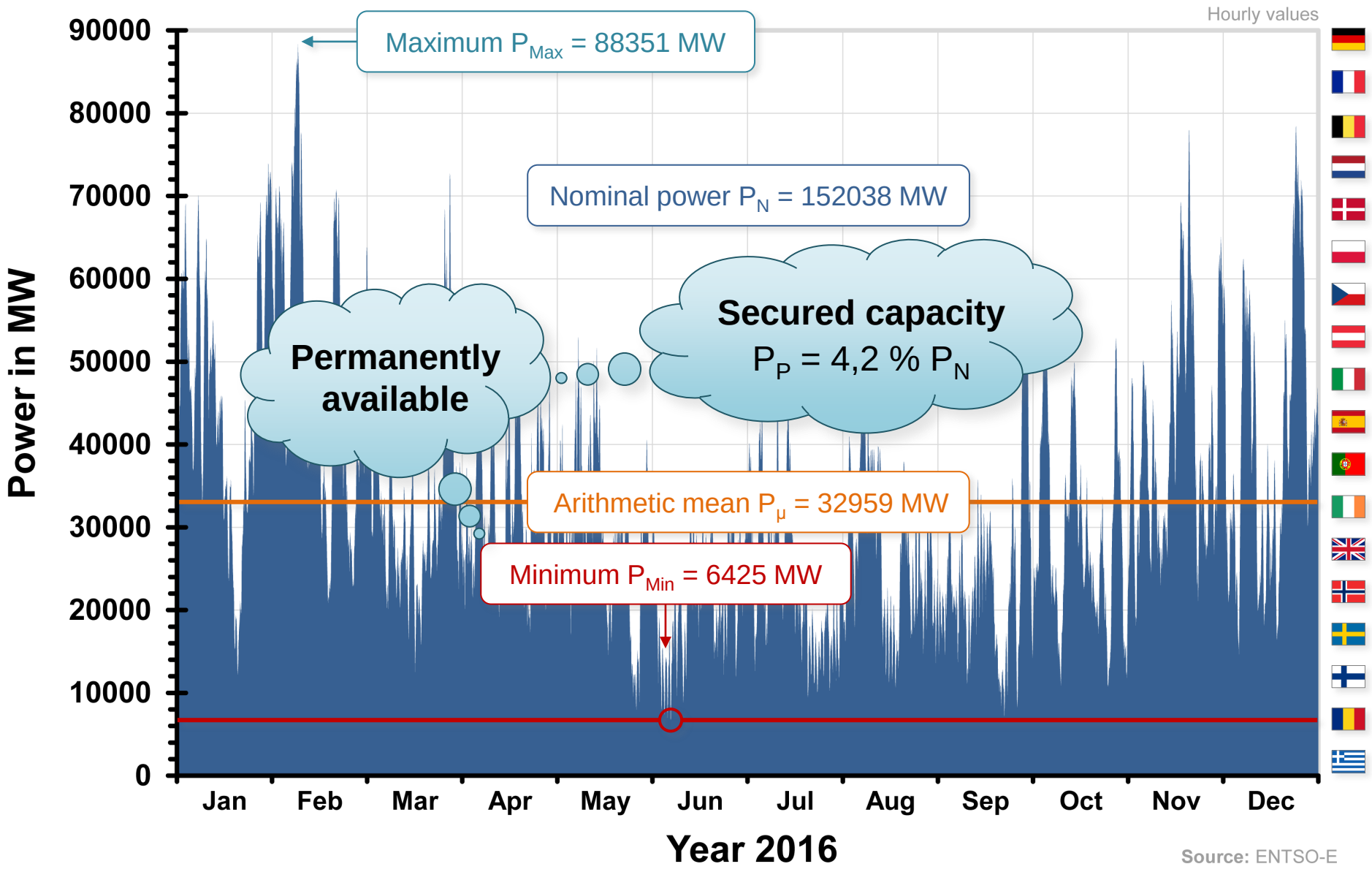

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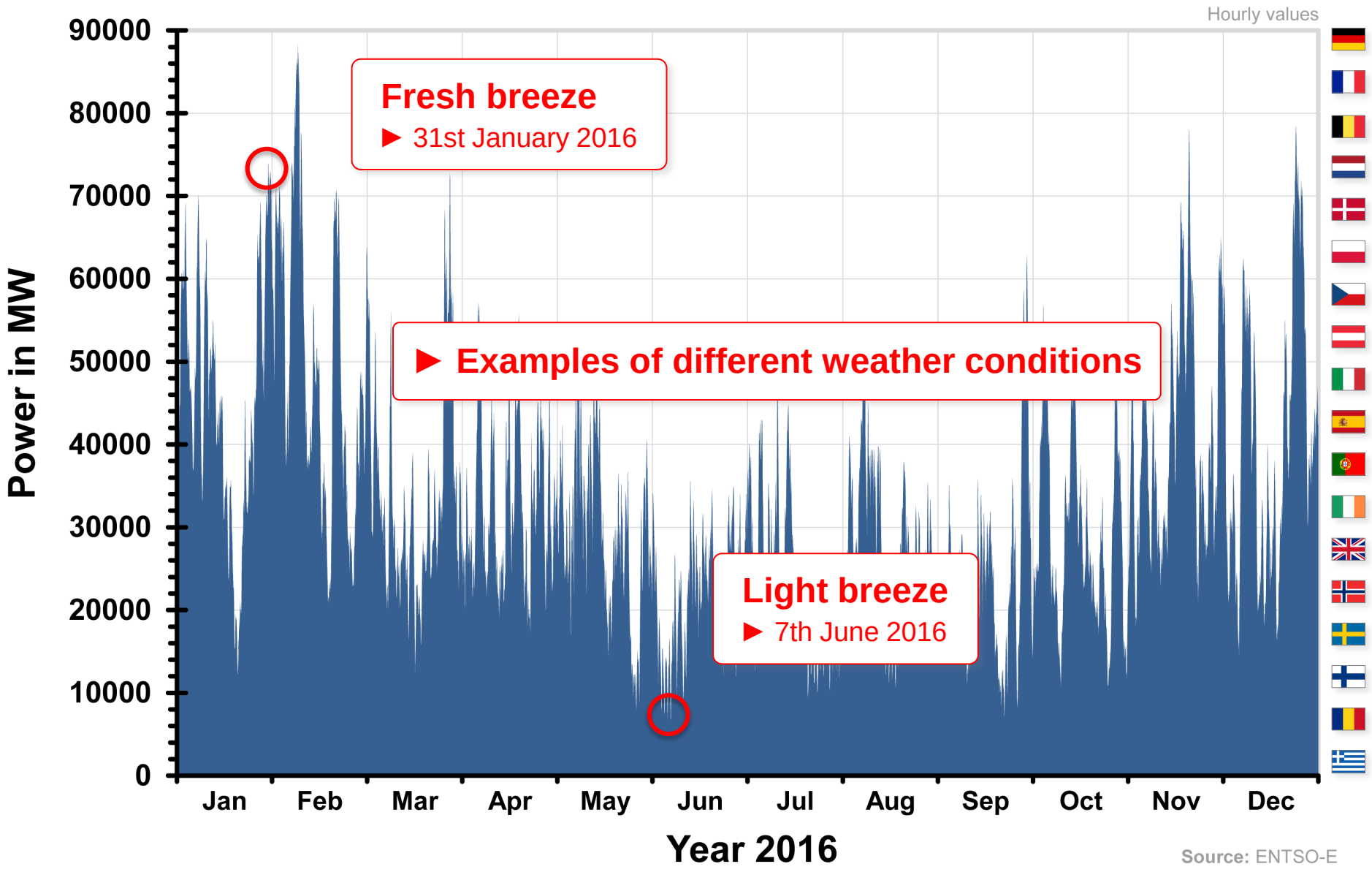
Europe: Wind regimes at different weather conditions



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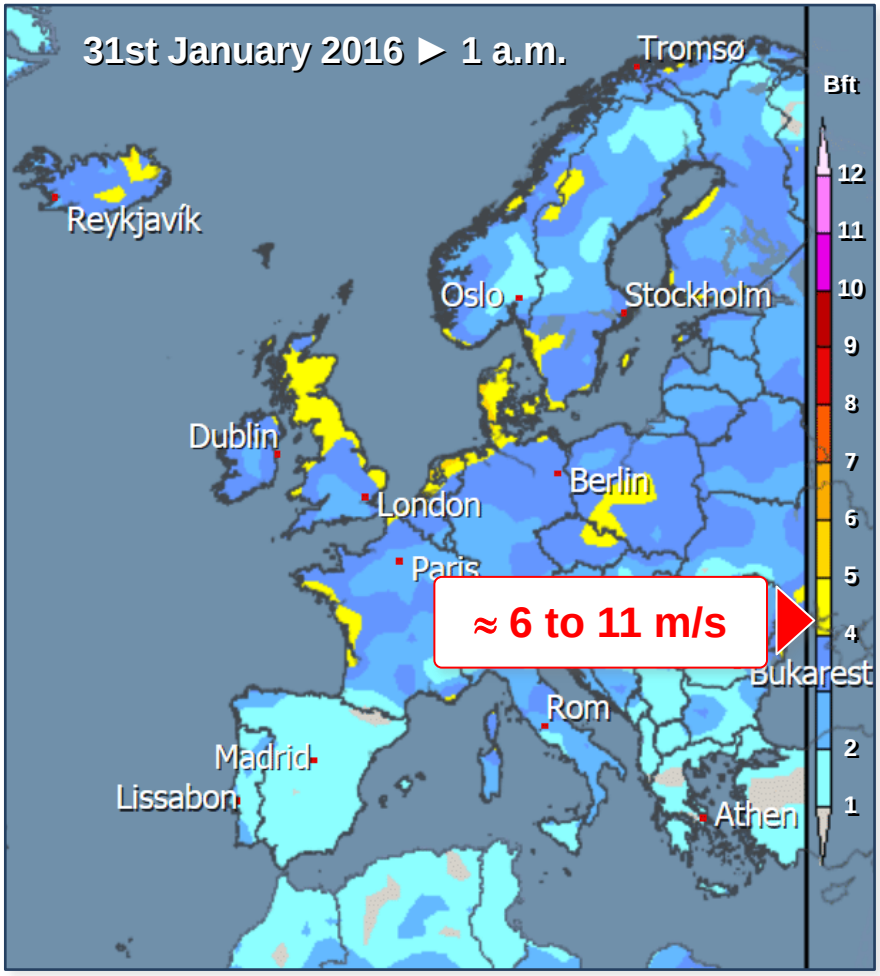
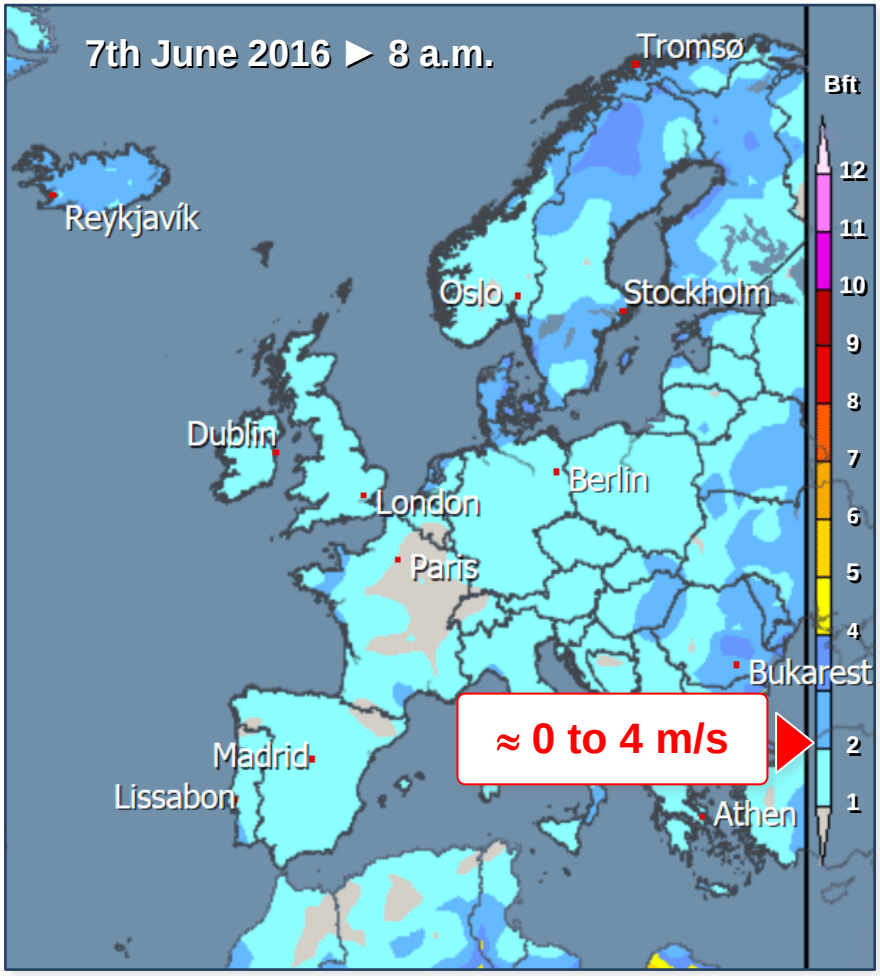
Fresh breeze



Source: www.wetter.info

Light breeze



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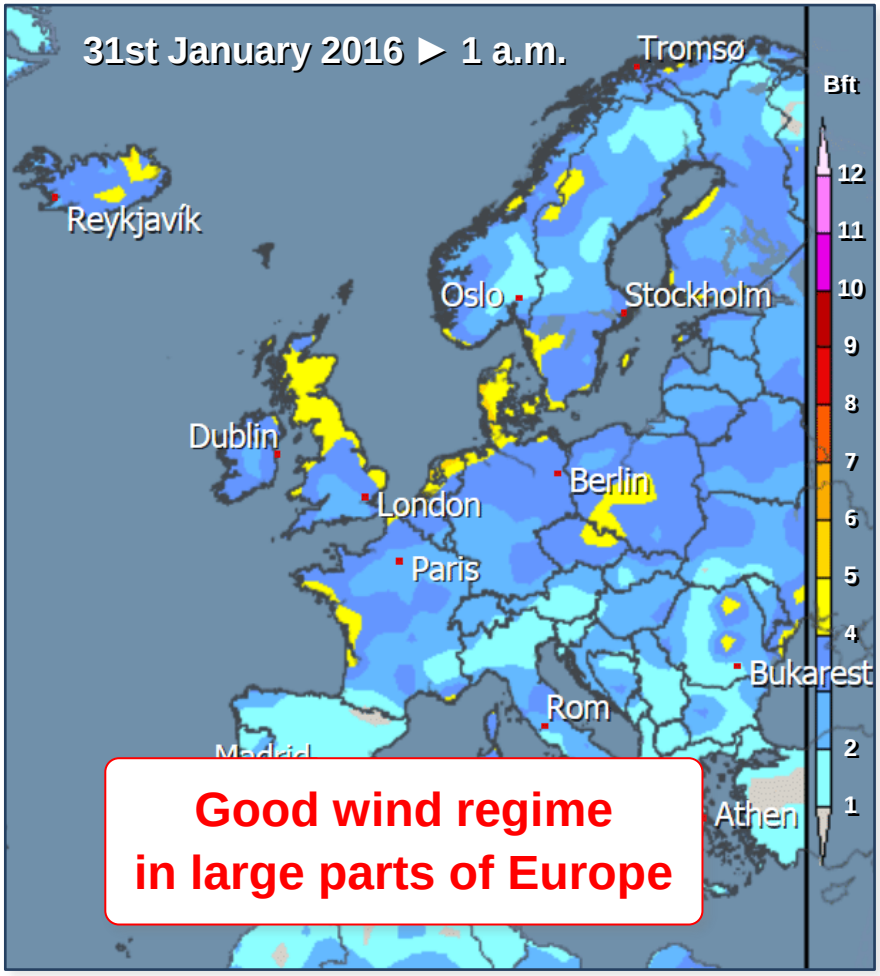

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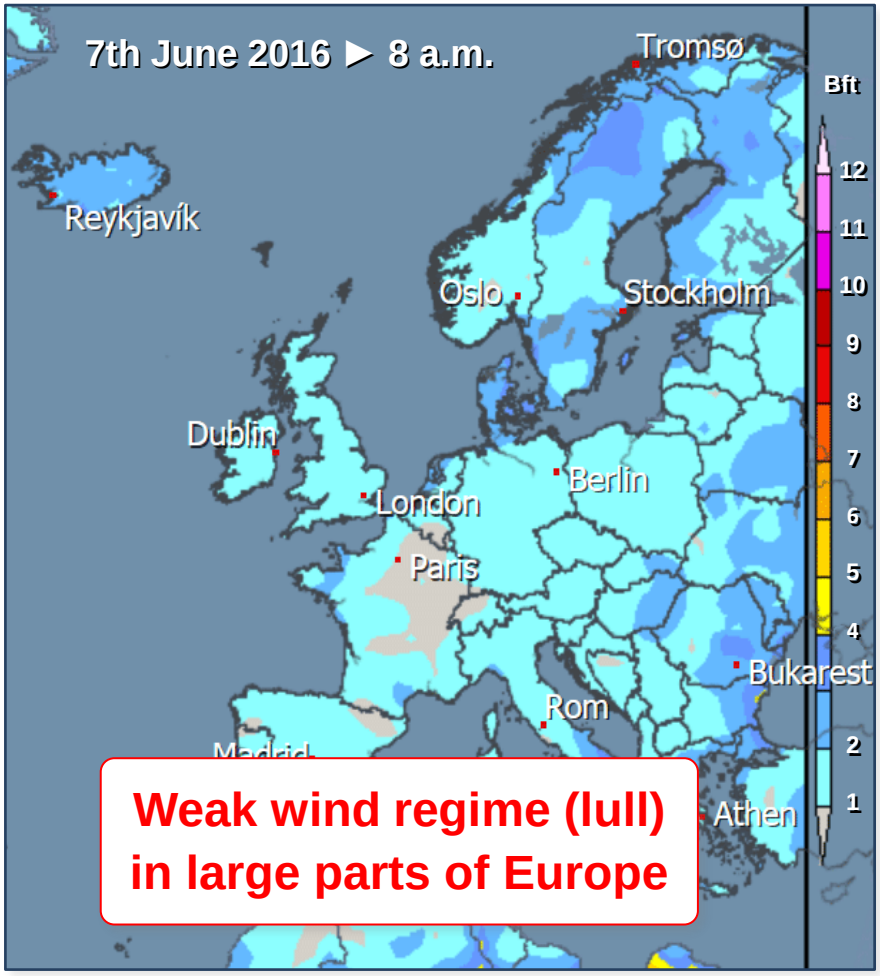

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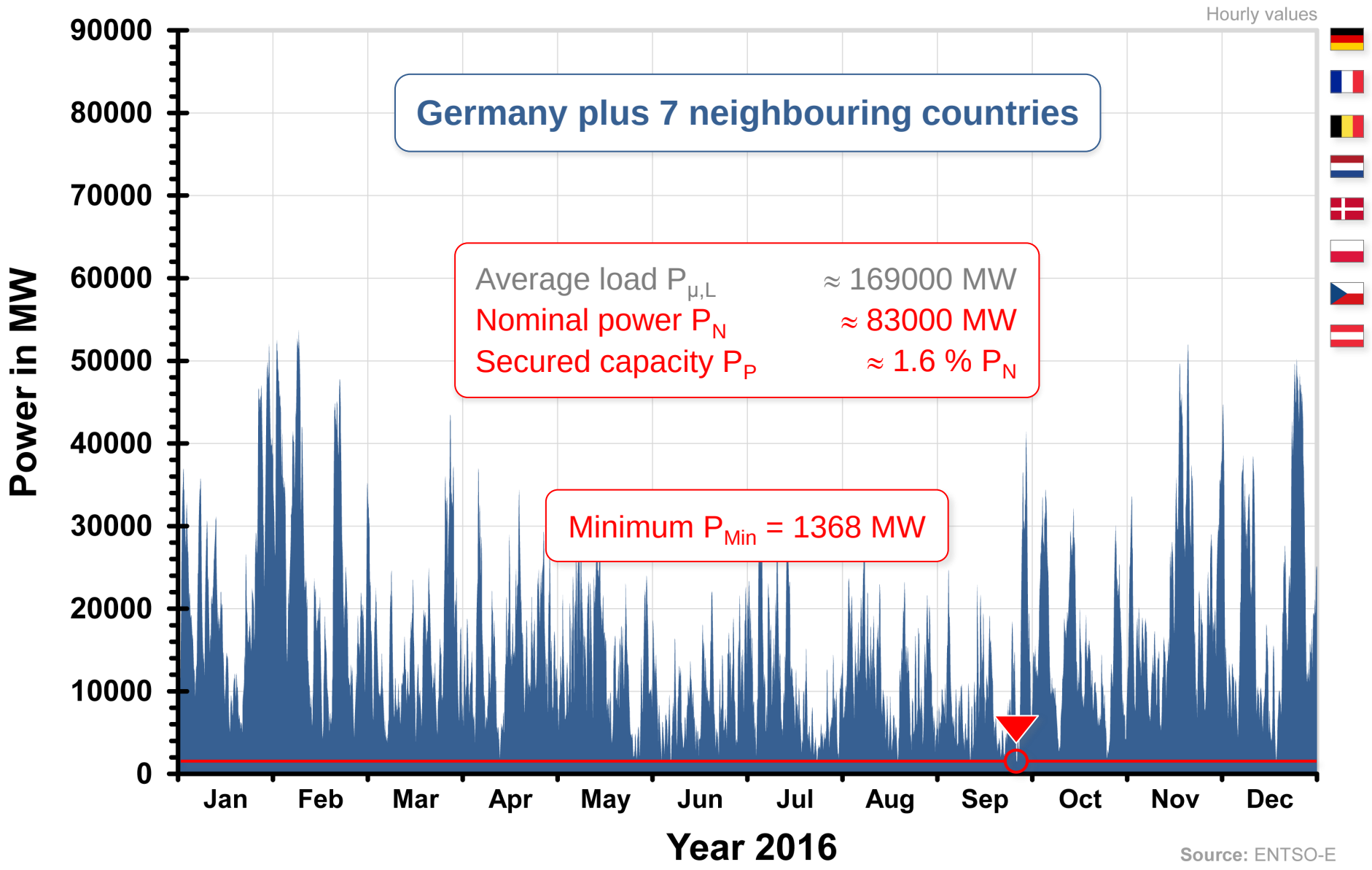
Europe: Minimum power at European network level



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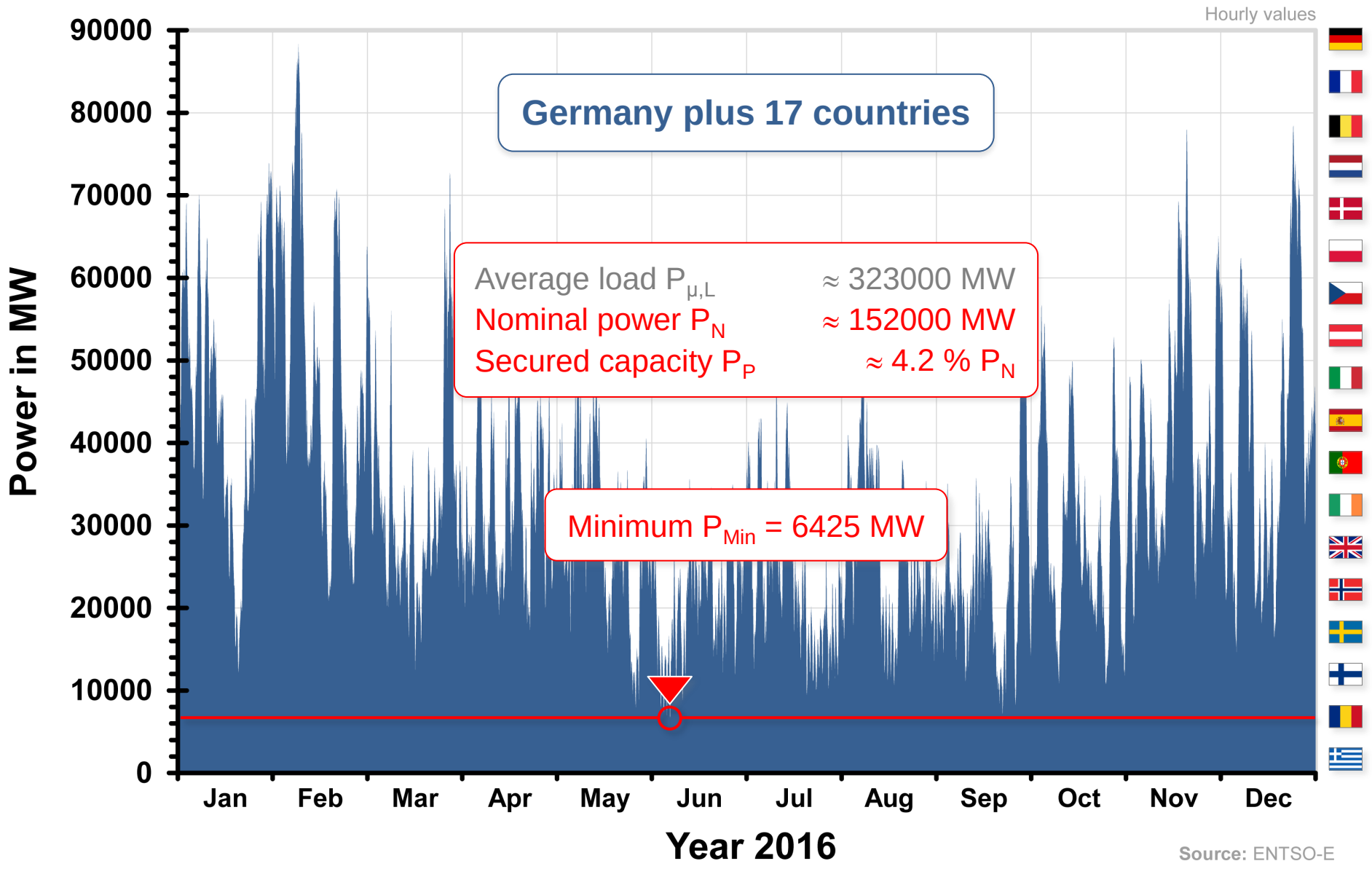

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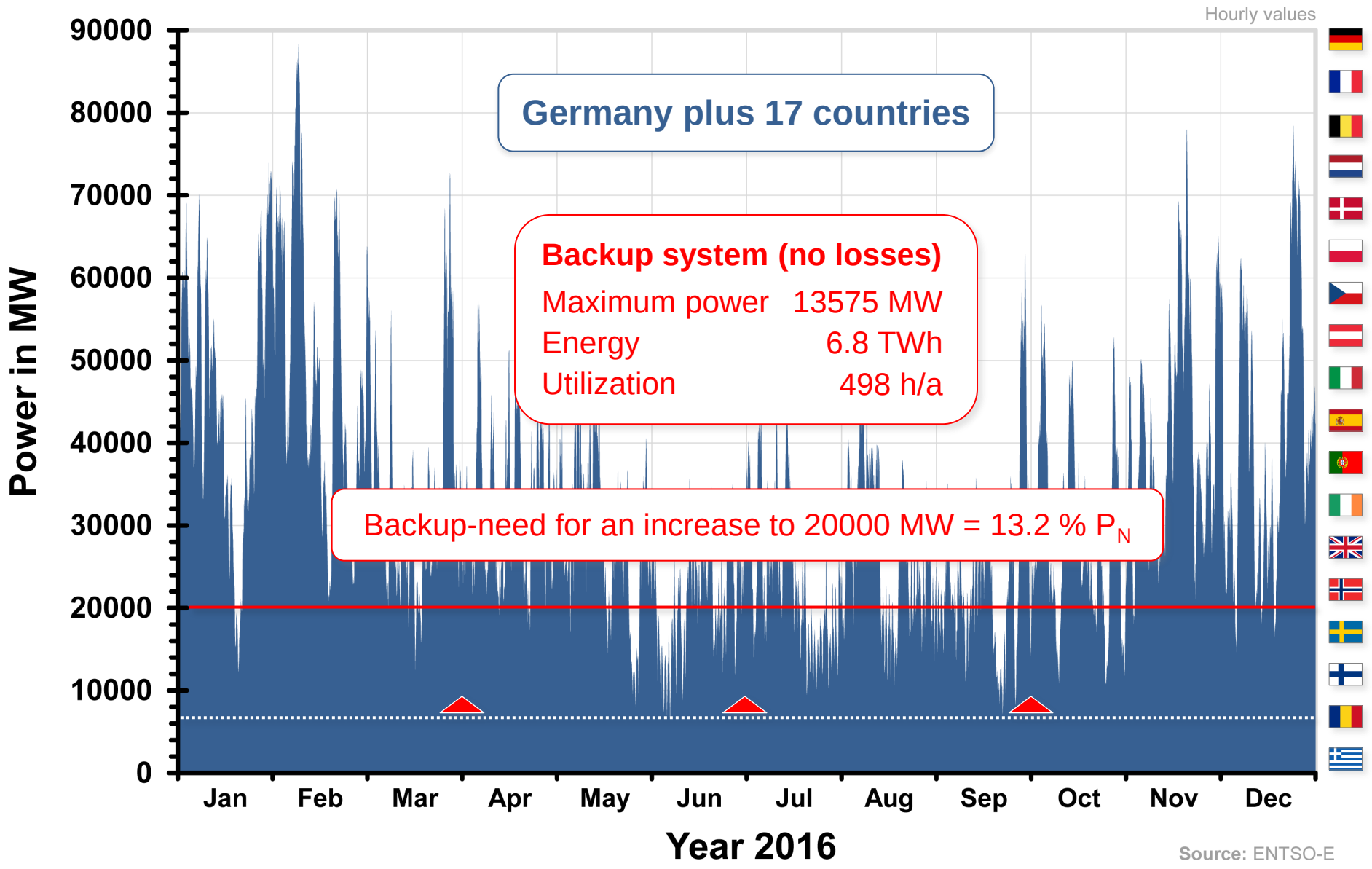

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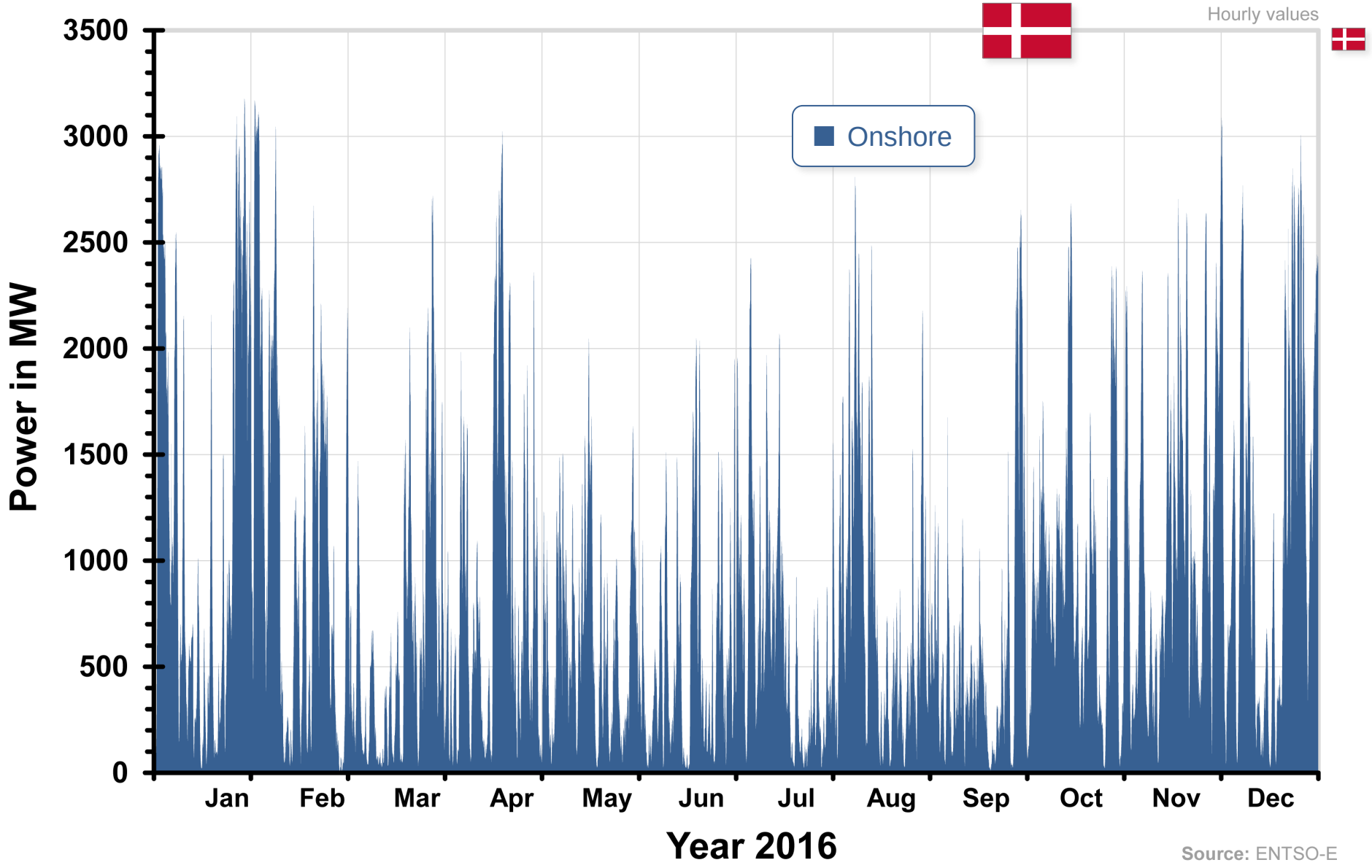
Denmark: Wind power production in 2016



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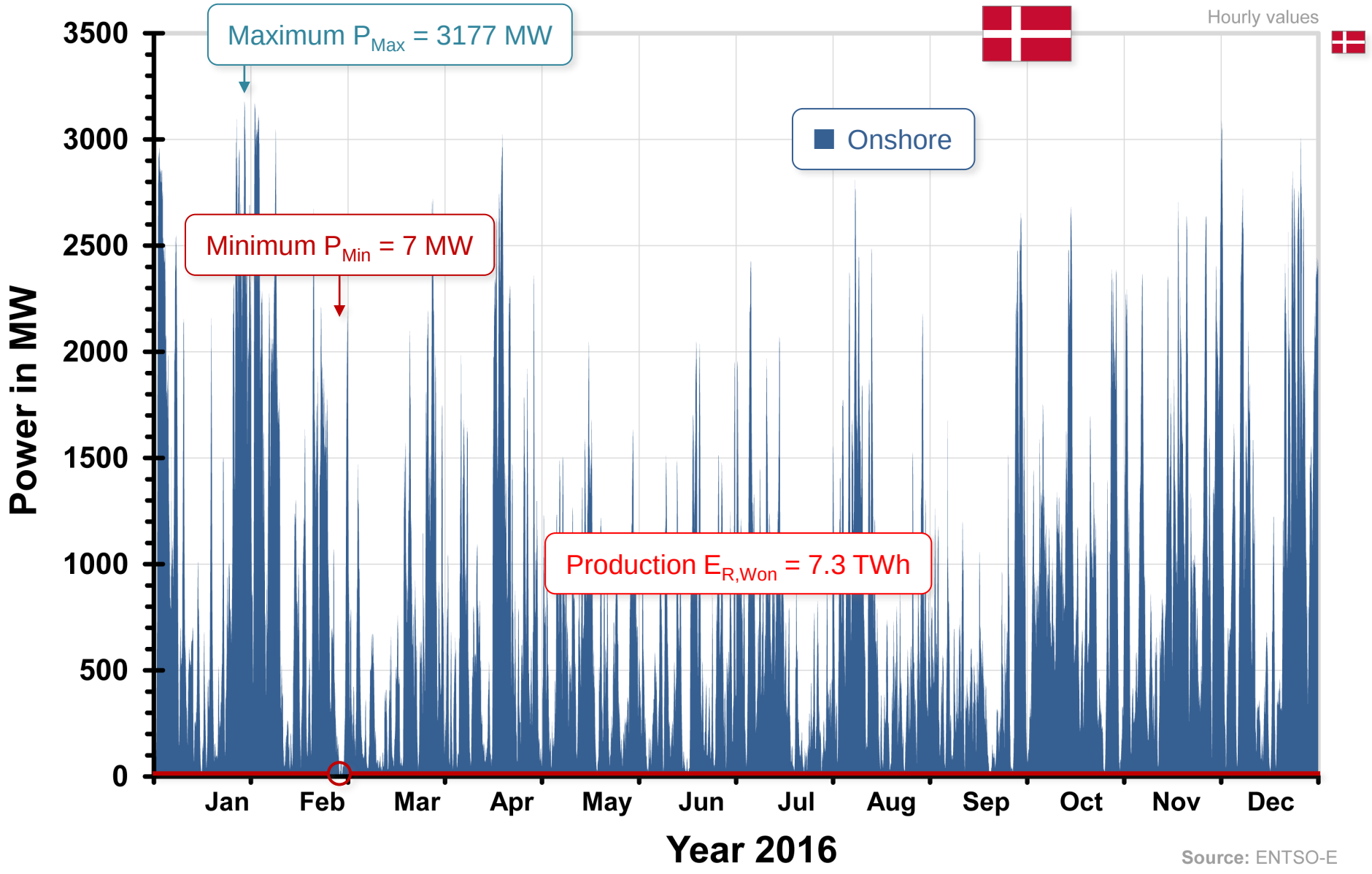

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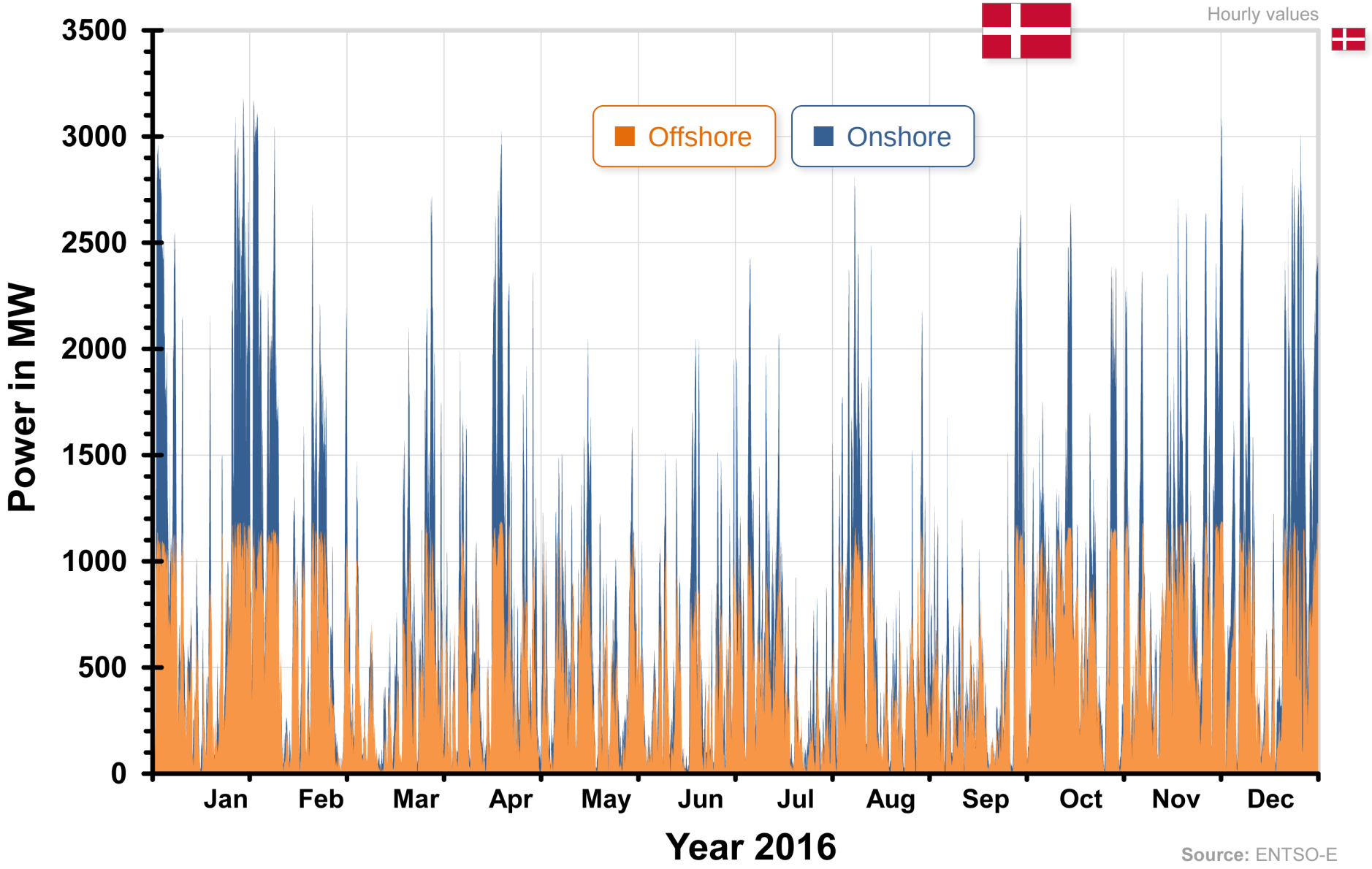

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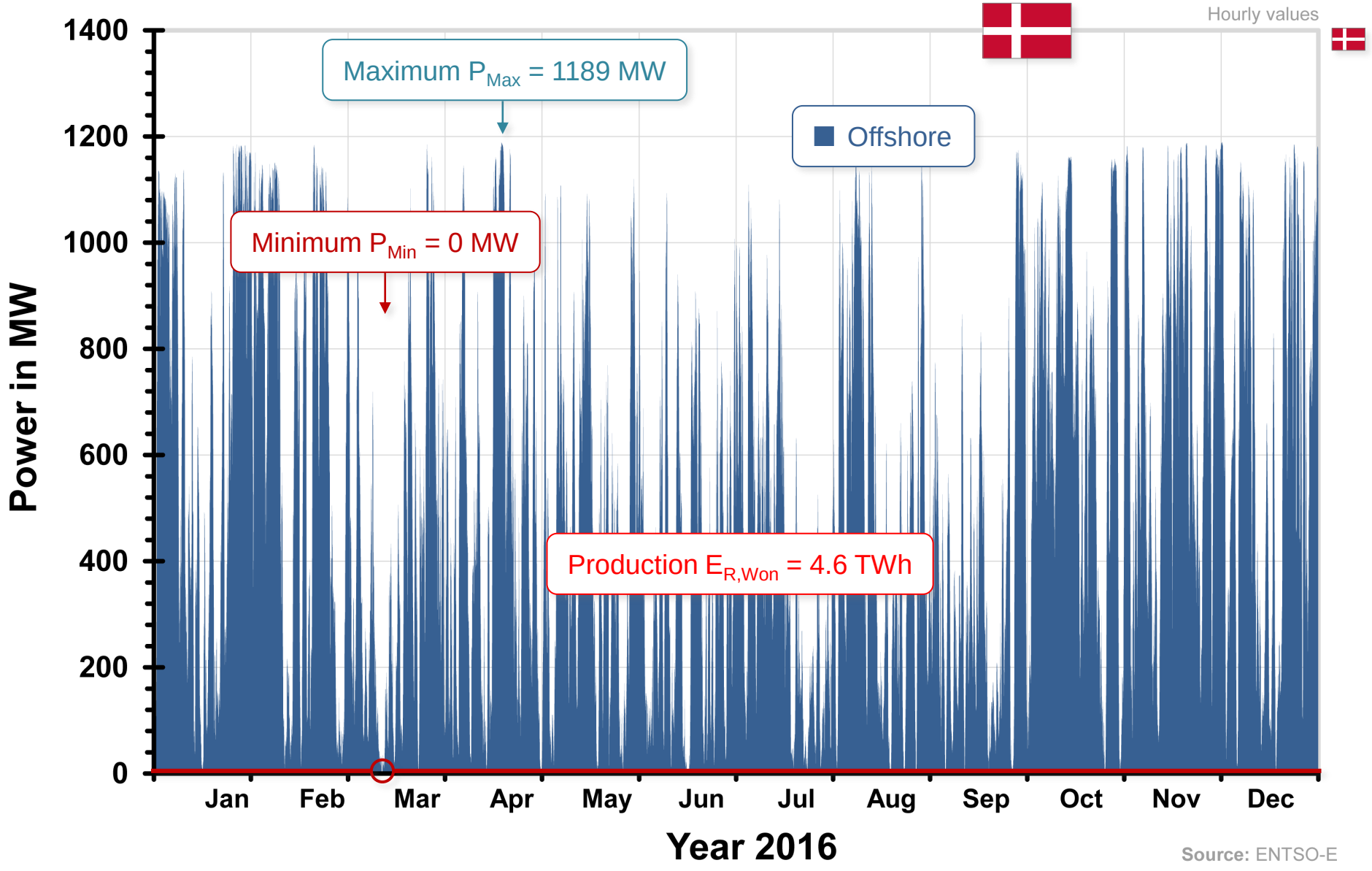

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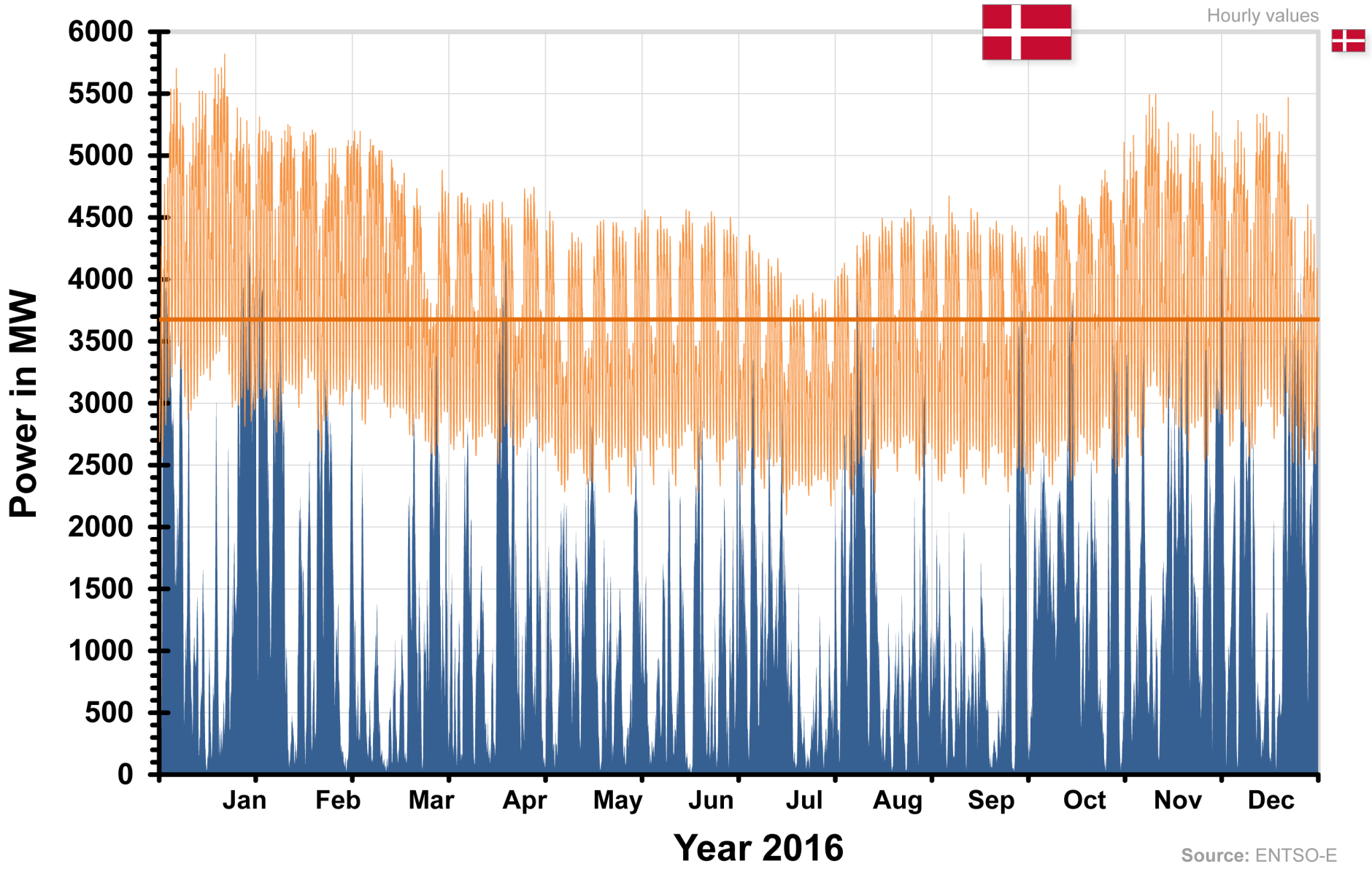
Denmark: Wind power production and load in 2016



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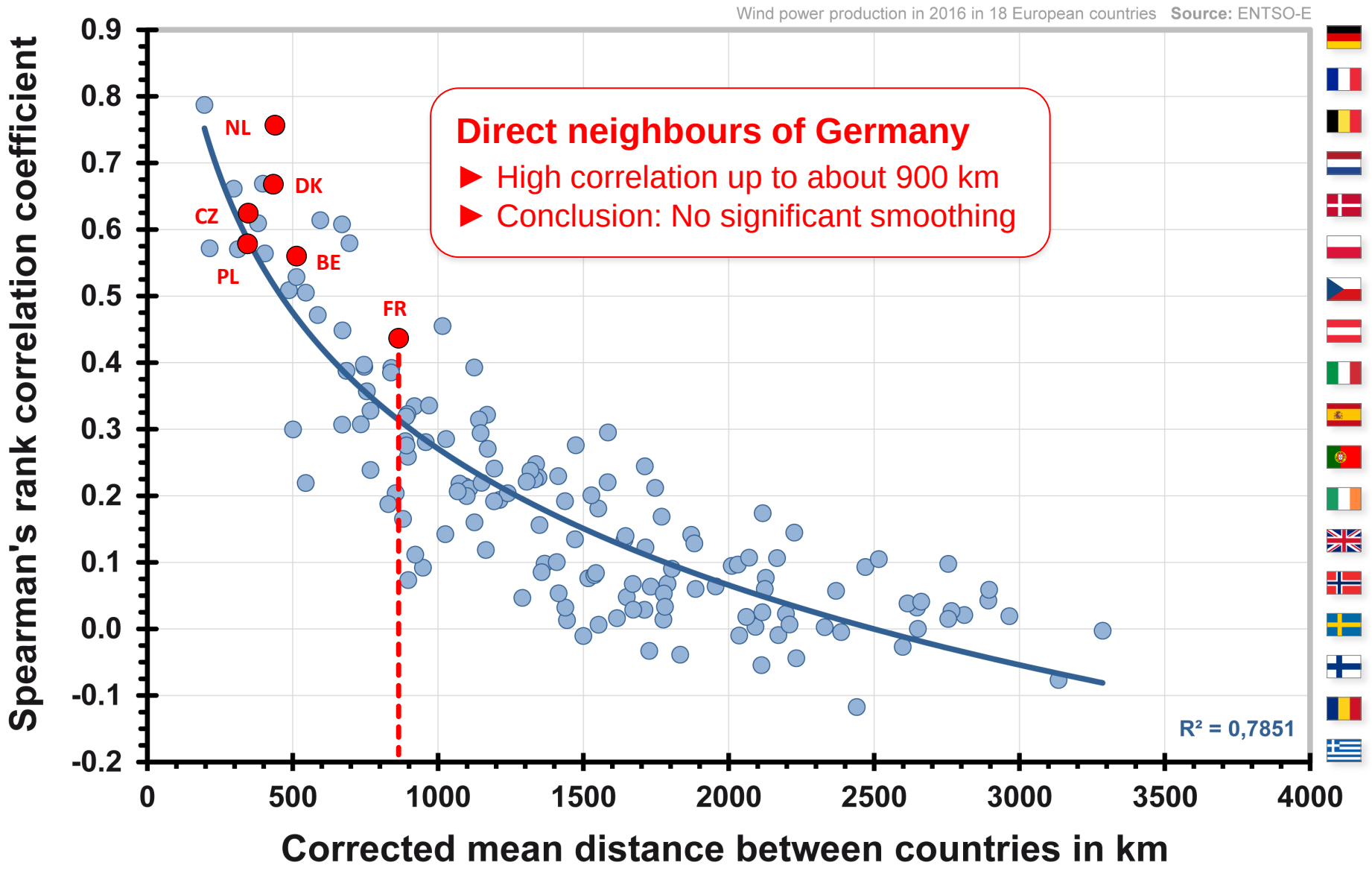
Europe: Spatial correlation of power time series



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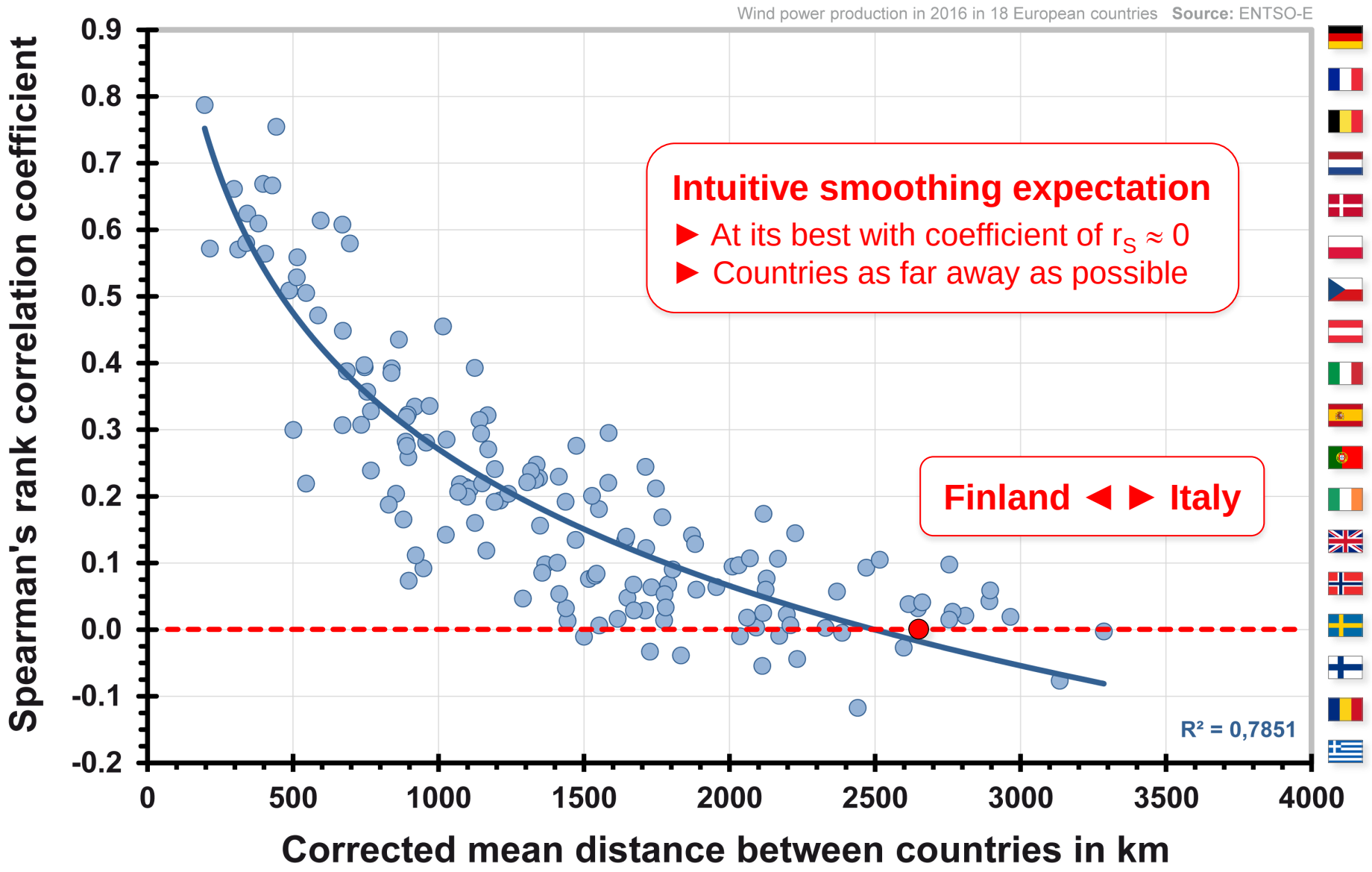

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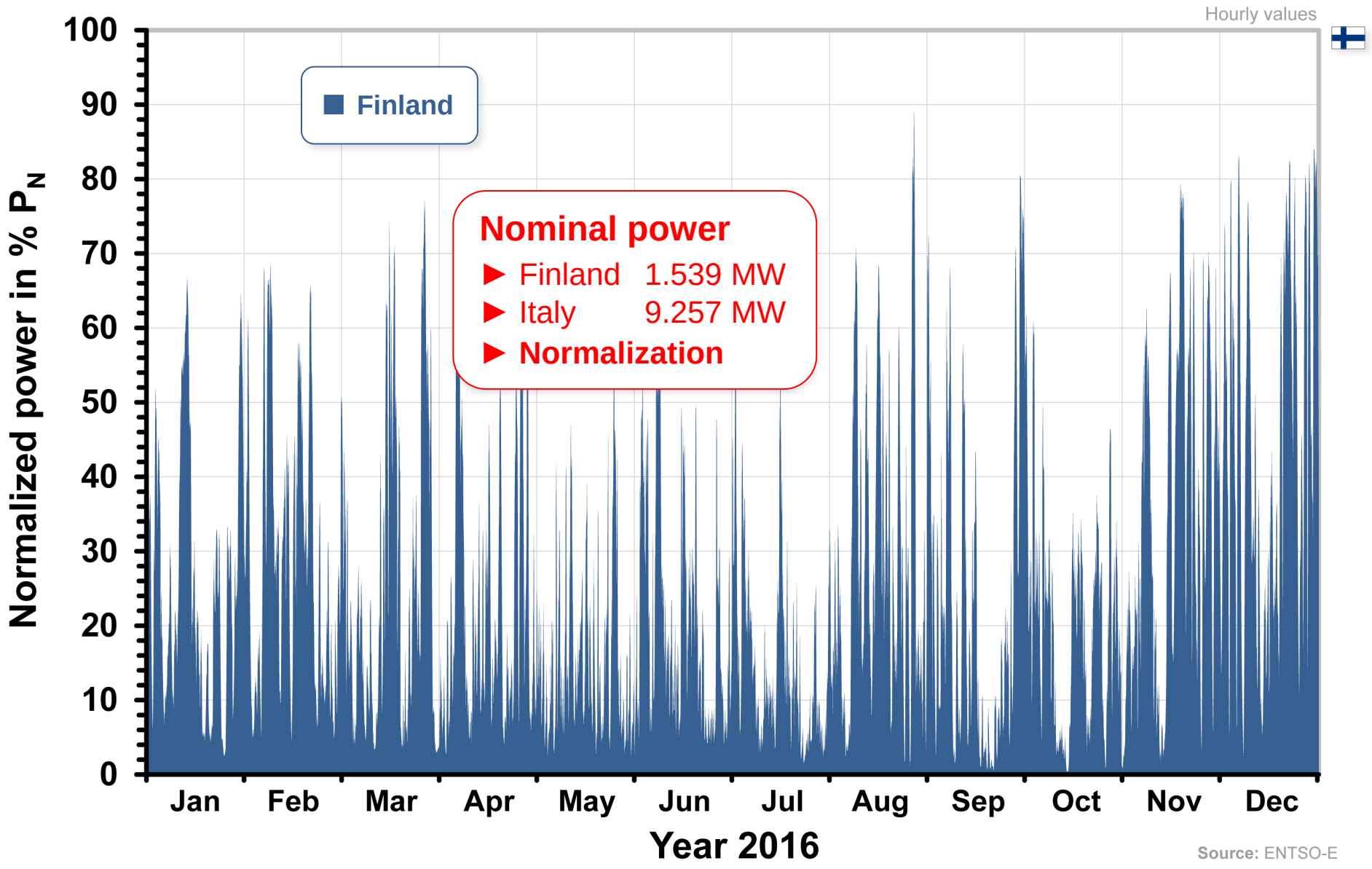

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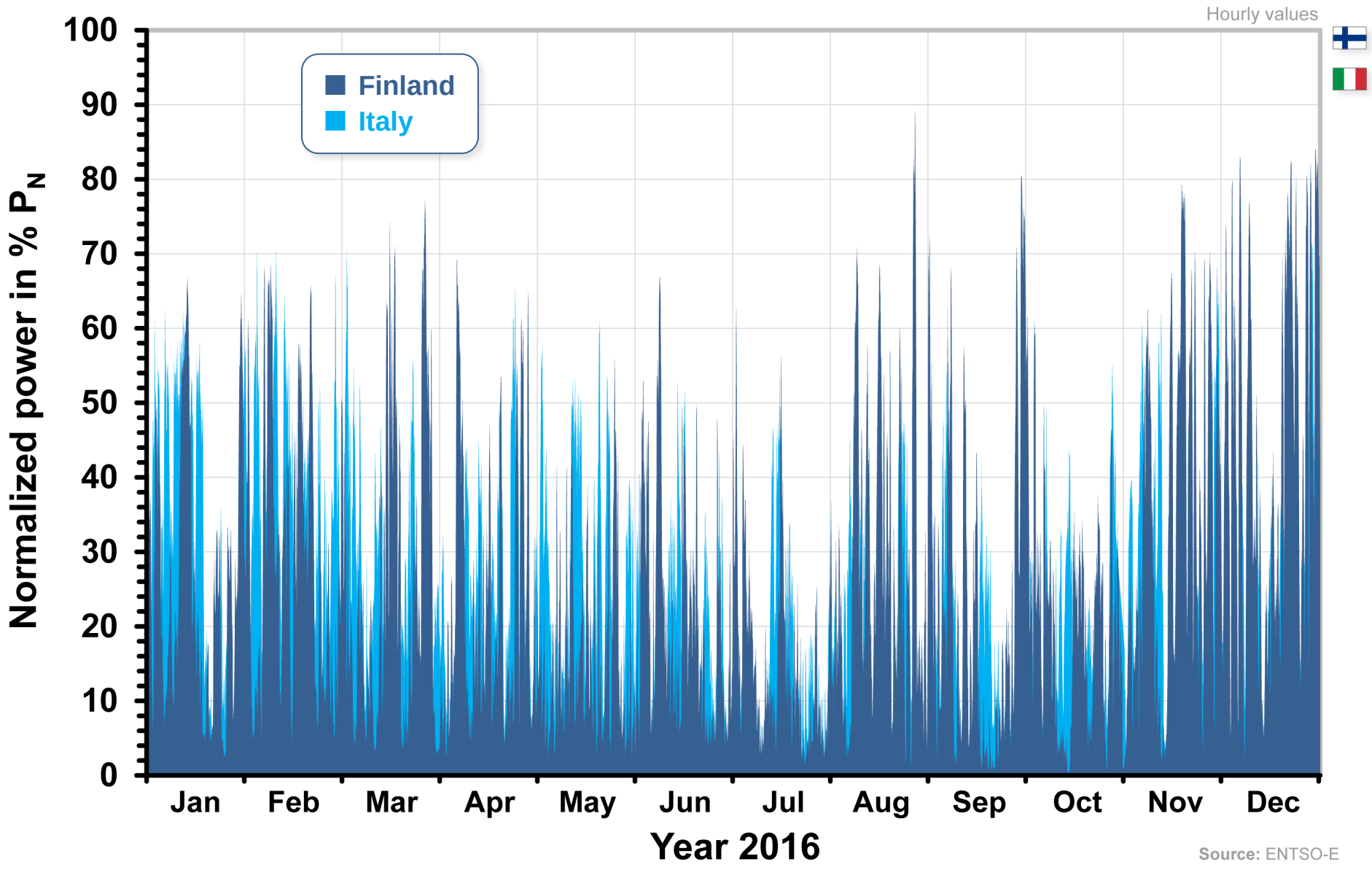

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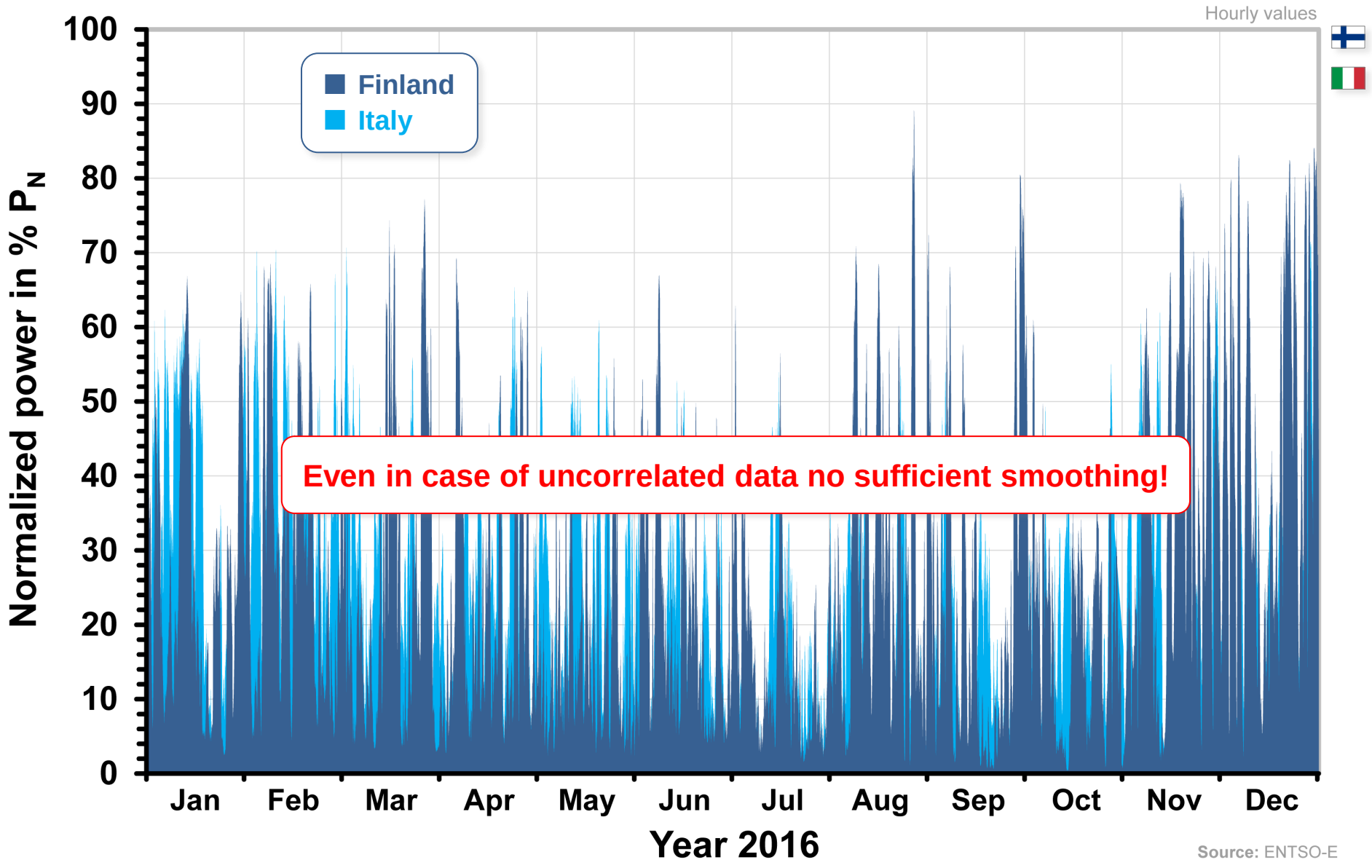
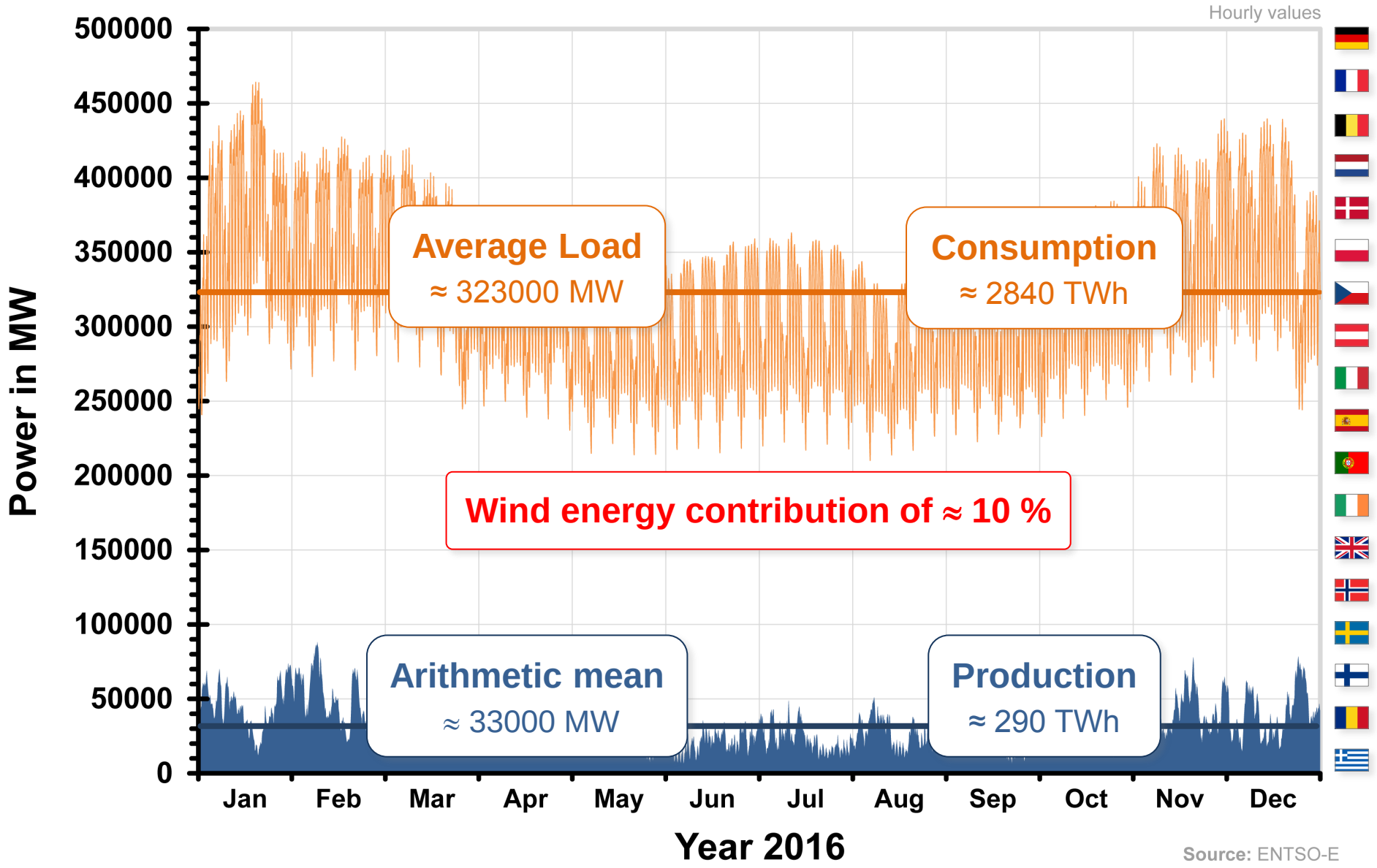
Europe: Spatial correlation of power time series



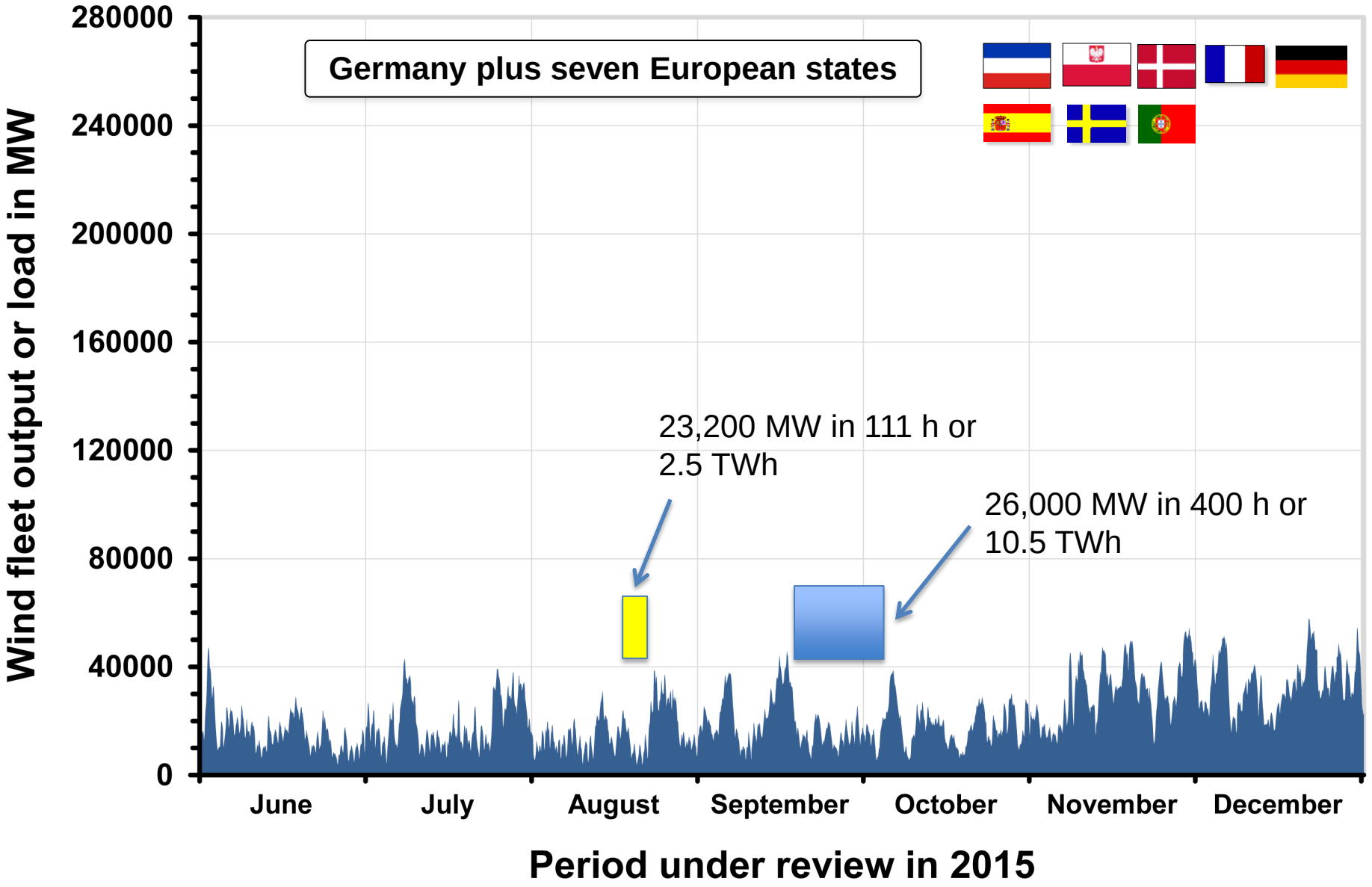
based on a Wind Study by Thomas Linnemann and Guido Vallana, VGB PowerTech e.V.

Europe: Wind power production versus demand



based on a Wind Study by Thomas Linnemann and Guido Vallana, VGB PowerTech e.V.

European perspective: Need for storage or fossil generation



Source: ENTSO-E

based on a Wind Study by Thomas Linnemann and Guido Vallana, VGB PowerTech e.V.

Decommissioning of existing plants

Kraftwerksstilllegungsanzeigenliste der Bundesnetzagentur

Stand: 20.02.2017

Die nachstehende Kraftwerksstilllegungsanzeigenliste (kurz: KWSAL) enthält die bei der Bundesnetzagentur zum oben genannten Datumsstand eingegangenen Stilllegungsanzeigen.*

Kraftwerks-nummer BNetzA	Kraftwerksbetreiber	Kraftwerksblock	Netto-Nenn-leistung in MW laut KW-Liste	Stilllegungsanzeigentyp	Systemrelevanz von zur Stilllegung angezeigten KW-Blöcken gemäß ÜNB
BNA0574	Statkraft Markets GmbH	Gaskraftwerk Robert Frank, Landesbergen	500	Geplant vorläufig	
BNA1044	RWE Generation SE	Gersteinwerk F2 (Dampfteil)	355	Geplant vorläufig	
BNA1045	RWE Generation SE	Gersteinwerk G2 (Dampfteil)	355	Geplant vorläufig	
BNA1043	RWE Generation SE	Gersteinwerk Block I2 (Dampfteil)	355	Geplant vorläufig	
BNA0680	Mitteldeutsche Braunkohlengesellschaft mbH	Mumsdorf	60	Geplante endgültige Stilllegung und mittlerweile endgültig stillgelegt	
BNA0268	Mark-E Aktiengesellschaft	Pumpspeicherkraftwerk Rönkhausen	138	Geplant vorläufig	
BNA1035	Mark-E Aktiengesellschaft	Kraftwerk Werdohl-Elverlingsen E3	186	Geplante endgültige Stilllegung und mittlerweile endgültig stillgelegt	

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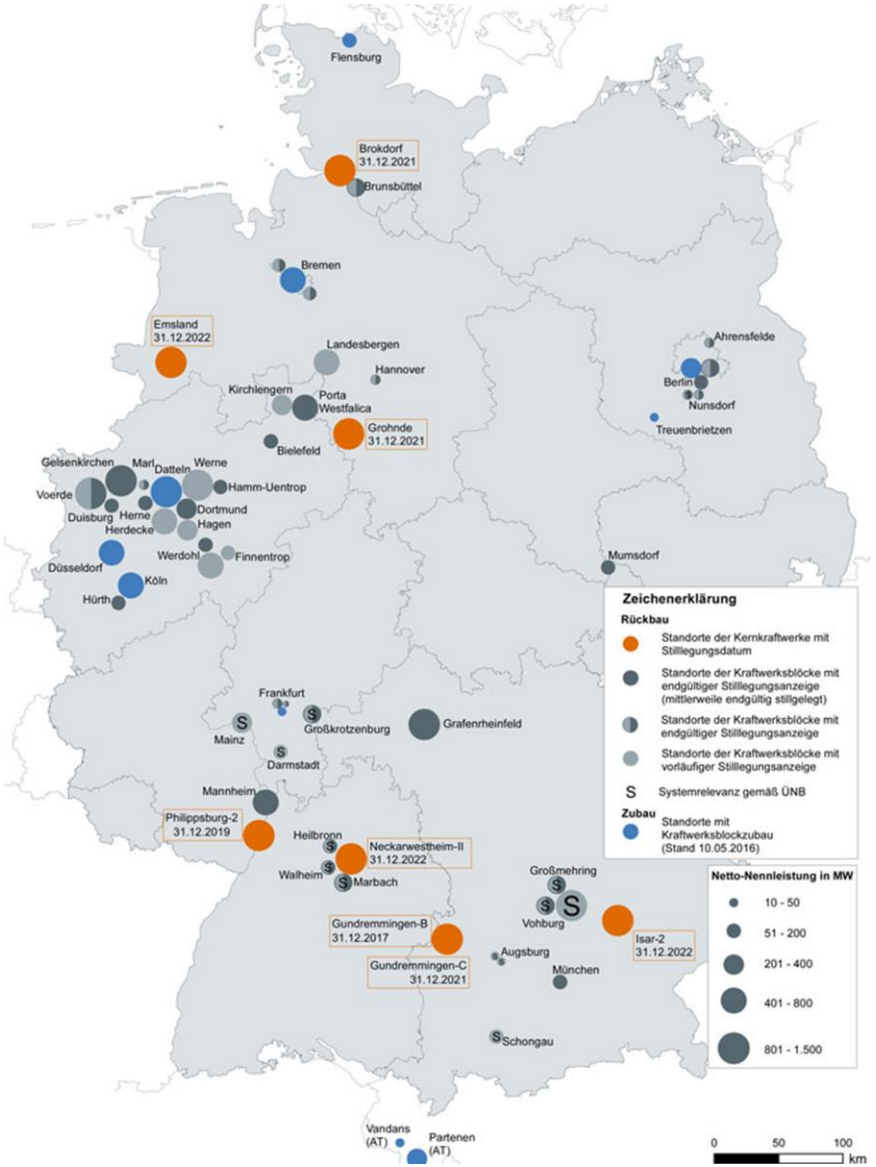
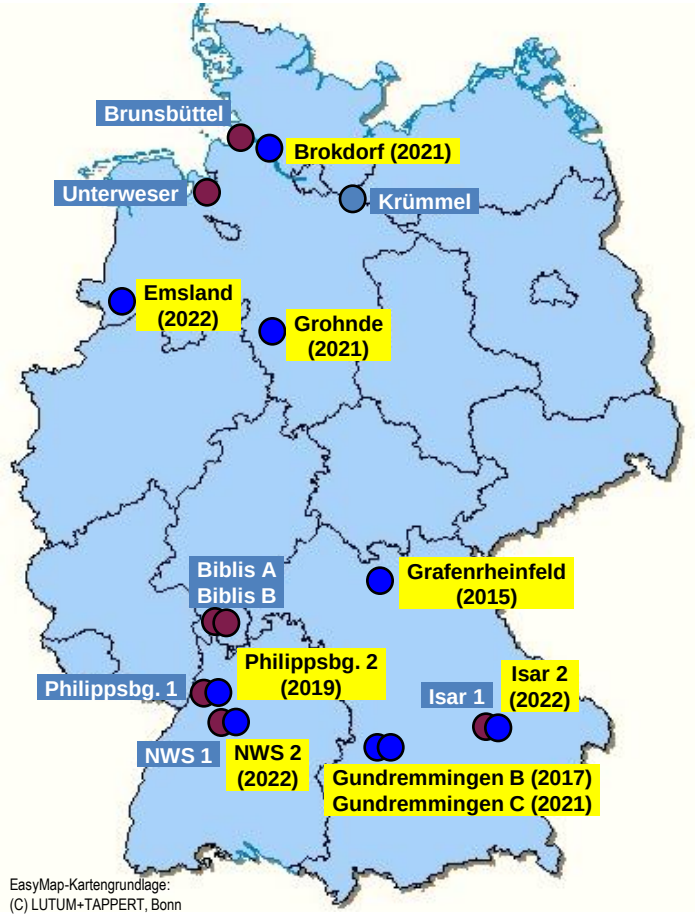


Listed for decommissioning:

- 88 plants (19,132 MW) incl. Grafenrheinfeld
- 29 plants (5,689 MW) have been decommissioned
- **26 plants (6,511 MW) classified as system critical**
- **New plants “not in the money”**

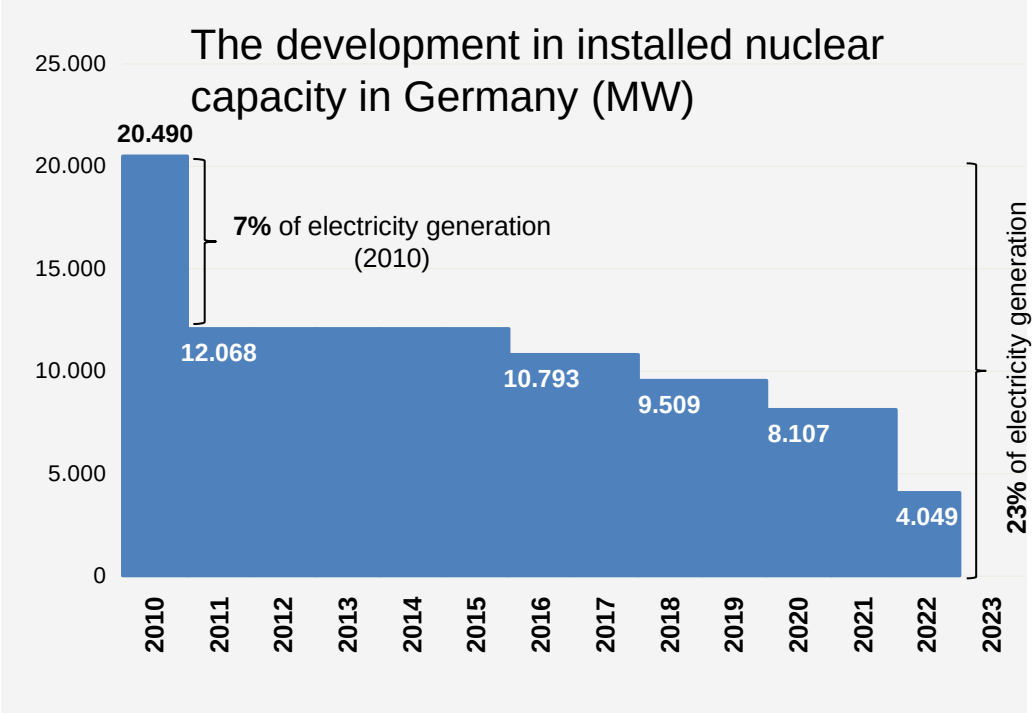
http://www.bundesnetzagentur.de

Phase-out of nuclear



Closed 2011

Closed 2015-2022*

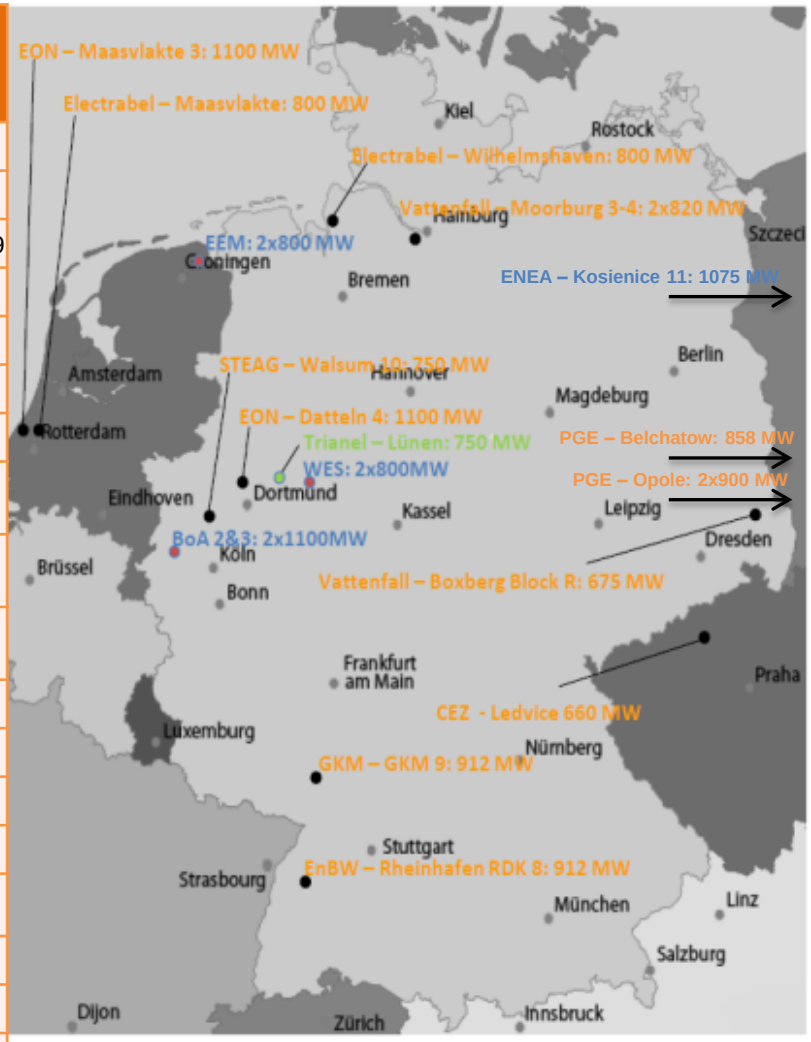


* bei Erreichen der in Anlage 3 AtG festgelegten Reststrommengen, spätestens jedoch mit Ablauf des 31.12. des jeweiligen Jahres

Source: Atomgesetz (ATG) §7

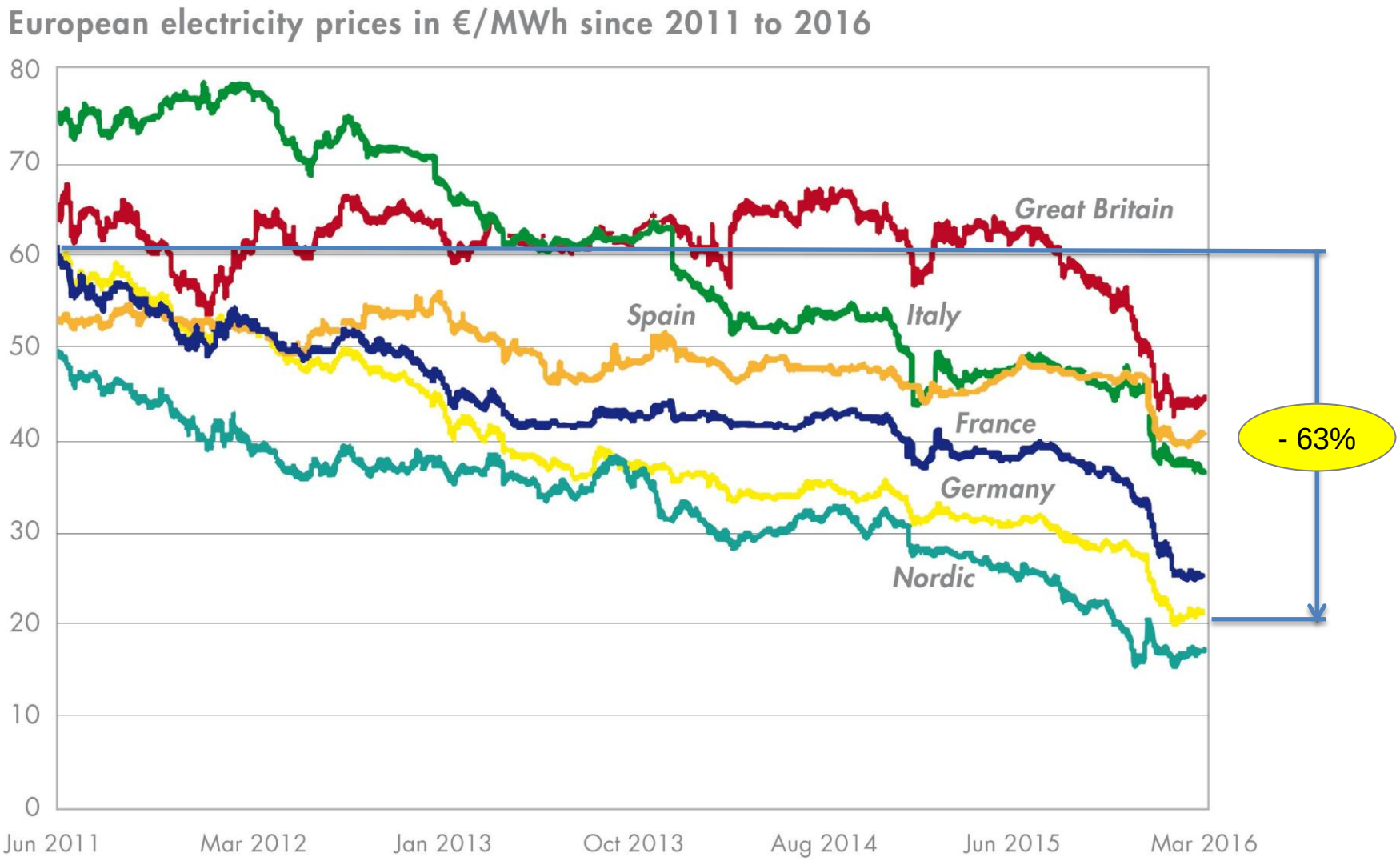
Status quo: recent USC coal fired power plants in Central Europe

Plant	Operator	Site	No. Units	Unit Cap. MW (gr.)	Main Fuel	COD
Turow	PGE	Turow	1	450	LIG	*2018*
Kosienice 11	ENEA	Kosienice	1	1075	HC	2017
Opole 5 & 6	PGE	Opole	2	900	HC	2018/2019
Belchatow 13	PGE	Belchatow	1	858	LIG	2011
Ledvice 4	CEZ AS	Ledvice	1	660	LIG	2014
Neurath F&G	RWE Power	Neurath	2	1100	LIG	2012
Datteln 4	E.ON	Datteln	1	1100	HC	*2019*
Moorburg A-B	Vattenfall Europe	Hamburg-Moorburg	2	820	HC	2015
Boxberg R	Vattenfall Europe	Boxberg	1	675	LIG	2012
GKM 9	Grosskraftwerk Mannheim AG	Mannheim	1	911	HC	2015
RDK8	EnBW	Karlsruhe	1	912	HC	2014
Walsum 10	STEAG/EVN	Duisburg	1	725	HC	2013
Lünen	Trianel	Lünen	1	750	HC	2014
Wilhelmshaven	GDF Suez	Wilhelmshaven	1	800	HC	2014
Westfalen D&E	RWE Generation	Hamm	2	800	HC	2014
Eemshaven	RWE Power	Eemshaven	2	800	HC	2015
Maasvlakte	Electrabel	Rotterdam	1	750	HC	2013
Maasvlakte 3	E.ON Benelux	Maasvlakte	1	1100	HC	2015



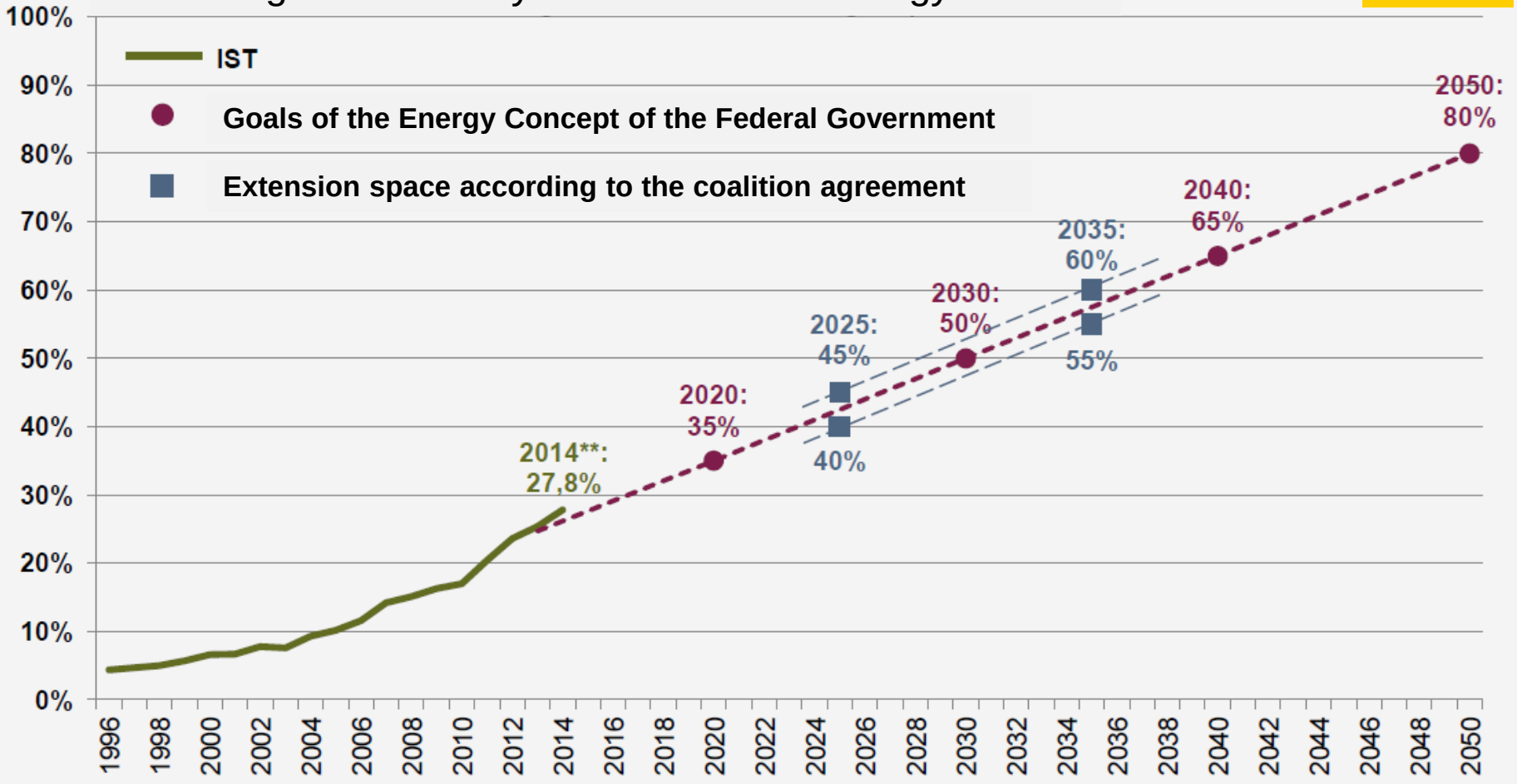
23 plants totaling 19,600 MW

Content


European electricity prices in €/MWh since 2011 to 2016
80
70
60
50
40
30
20
10
0
Jun 2011
Mar 2012
Jan 2013
Oct 2013
Aug 2014
Jun 2015
Mar 2016
Great Britain
Spain
Italy
France
Germany
Nordic
- 63%

Platts

Contribution and goals of renewable energies in Germany



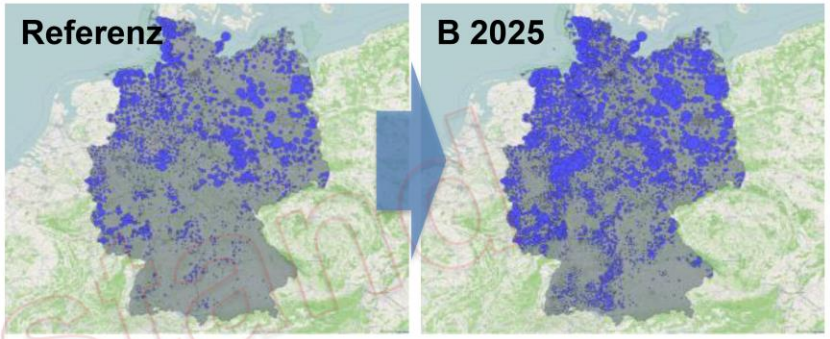
* Based on the gross national electricity consumption in Germany

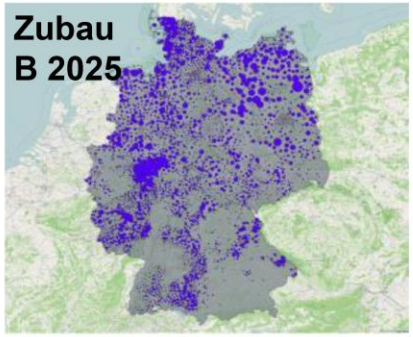
** Preliminary

Source: BDEW, status 02/2015

Szenariorahmen zum NEP 2025
Regionalisierung: Entwicklung der Windenergie in B1 2025/B2 2025

Installierte Leistung [GW]	Referenz	Zubau	B 2025
Deutschland	**33,8**	**+30,0**	**63,8**
Baden-Württemberg	0,6	+2,3	2,9
Bayern	1,0	+1,7	2,7
Berlin	0,0	+0,0	0,0
Brandenburg	5,1	+2,4	7,5
Bremen	0,2	+0,1	0,3
Hamburg	0,1	+0,1	0,1
Hessen	0,9	+1,6	2,5
Mecklenburg-Vorpommern	2,1	+3,3	5,4
Niedersachsen	7,6	+4,4	12,0
Nordrhein-Westfalen	3,4	+4,7	8,1
Rheinland-Pfalz	2,3	+2,3	4,6
Saarland	0,2	+0,3	0,5
Sachsen	1,1	+0,9	2,0
Sachsen-Anhalt	4,1	+1,3	5,4
Schleswig-Holstein	3,8	+3,7	7,5
Thüringen	1,1	+0,9	2,0

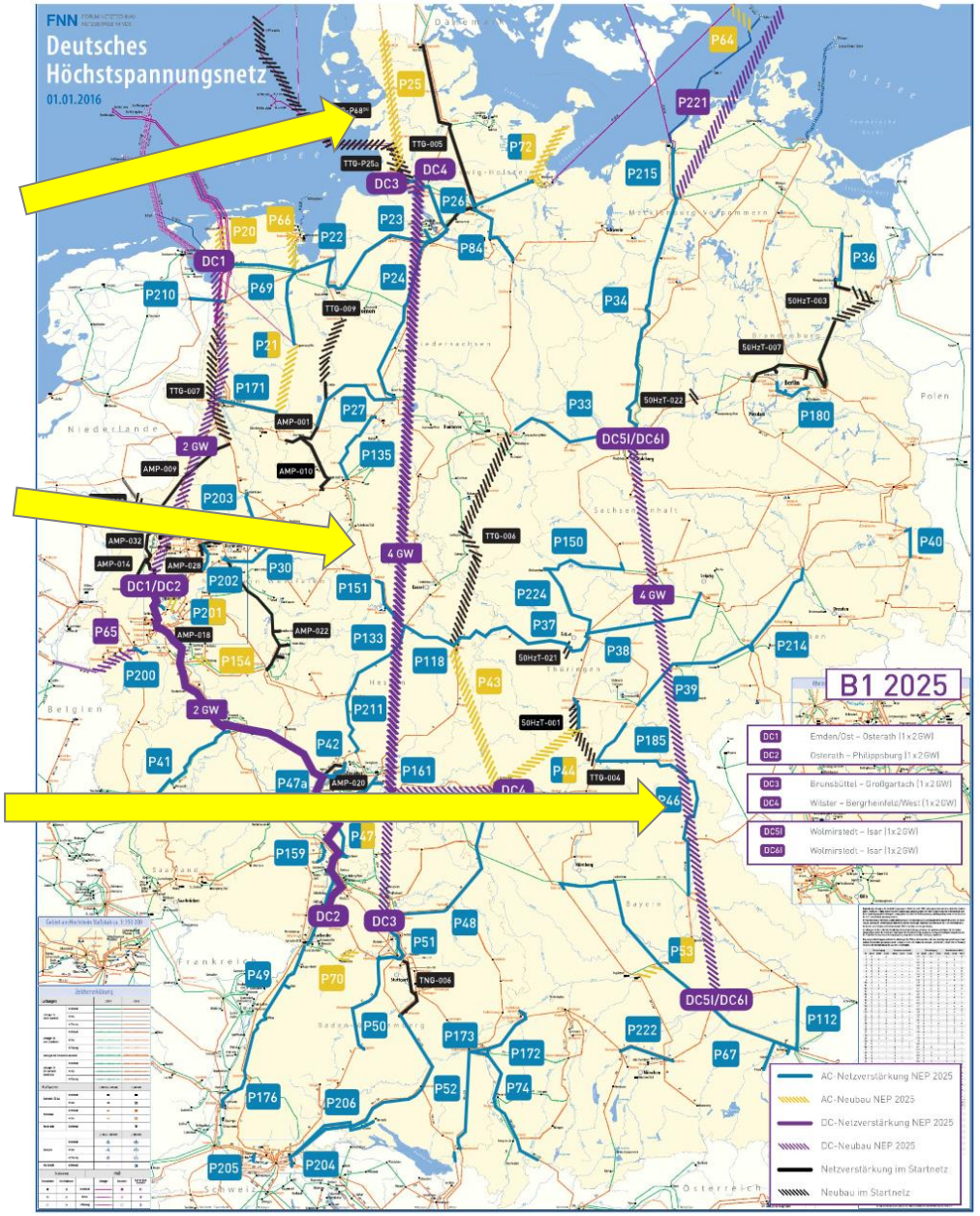




Pipeline Westcoast:
138 km, 380 kV
Commissioning 2021

Südlink:
770 km, 500 kV DC, 4 GW
Target 2025

Südostlink:
580 km, 500 kV DC, 2 GW
Target 2025



http://www.netzentwicklungsplan.de

Content

- **No**, right now there is abundance of capacity.
- **But**, we need to react within next few years!
- Passivity is also a decision.

And then:
“The ‘secured’ generation capacity will - with the highest probability in all scenarios - be under the yearly need for peek capacity.“

(BNetzA: Szenariorahmen 2025, p. 56)

Content

Options for future basic electricity supply

- **Nuclear energy** — Politically undesirable
- **Coal** — Politically undesirable
  Even valid for CCS technologies
- **Gas** — Bridge technology
  Import dependence
- **Biomass** — Limited availability
  Competition to food production
- **Hydropower** — Limited availability
  Practically extensively exhausted
- **Photovoltaics** — Complementary technology required
  Contribution at night: Zero
- **Wind energy** — Complementary technology required
  Intermittent availability, large correlation lengths of power production

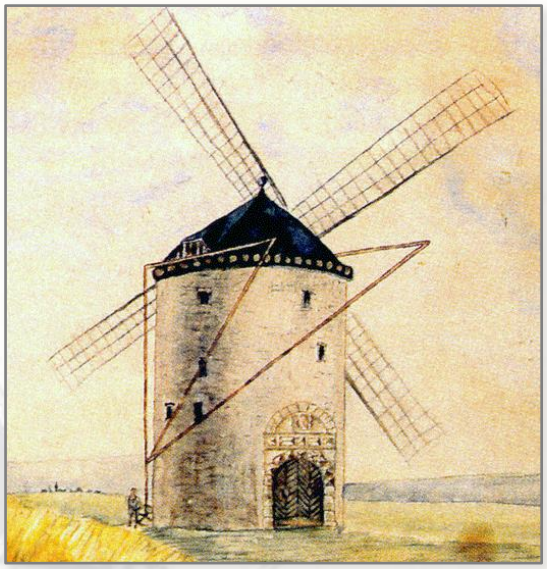


Illustration: www.kultur-denkmal-merzenich.de

CCS: Carbon capture and storage

based on a Wind Study by Thomas Linnemann and Guido Vallana, VGB PowerTech e.V.

- We still need “plannable generation capacity“ up to close to 100% of demand side peek!
- Demand side management
- **Storage:** **need for much more R&D**
- Fossil / Nuclear: need to retain capacity for 20 years +
- But no business case for either!!

Thank you for your interest!

Contact:
Erland Christensen
Executive Managing Director

VGB PowerTech e.V.
Deilbachtal 173
45257 Essen / Germany
Tel.: +49 201 8128 222
erland.christensen@vgb.org
www.vgb.org