

Ukraine's Electric Grid During The Russian Invasion

March 17, 2022

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Research Analyst: Tabor French

Agenda

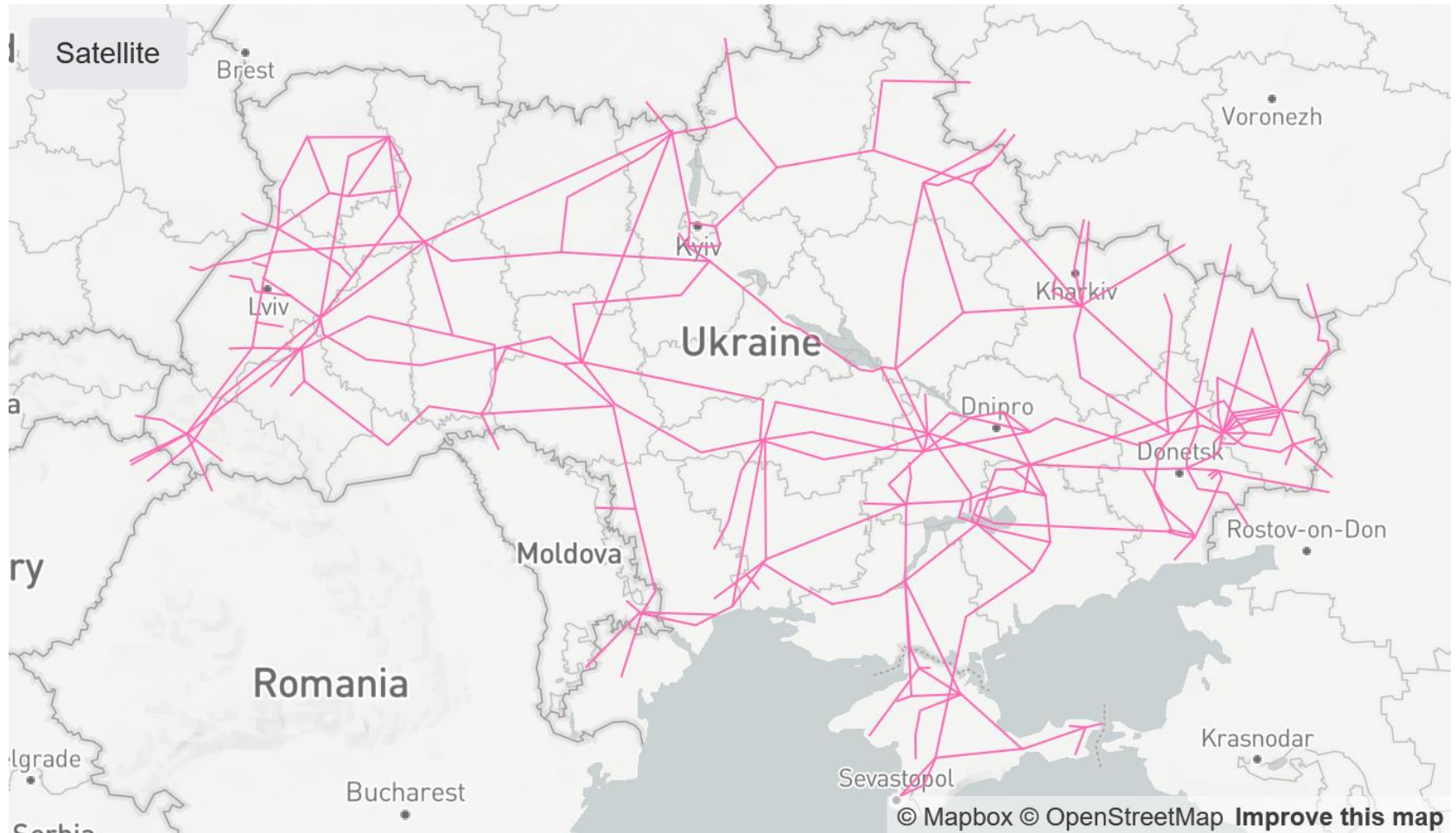
- ❑ Executive Summary
- ❑ Transmission, Control, and Synchronization
- ❑ Generation Plants and Energy Sources
- ❑ Grid Disruptions During the Russian Invasion
- ❑ Indicators of Ukrainian Infrastructure Status
- ❑ Summary Observations

Executive Summary

- **Ukraine Has a Modern, Interconnected, and Synchronized Electric Grid with a System Frequency of 50 Hz**
 - High Voltage Transmission Lines with Transformer Substations
 - Transmission System Operator & Regional Distribution Providers
 - Regulated Wholesale Electricity Market
 - Like All Relay-Protected Grids, Susceptible to Cascading Collapse
 - Synchronized on March 16 with ENTSO-E (Western Europe Grid)
- **Ukrainian Grid Has Wide Diversity of Energy Sources**
 - Nuclear, Coal, Natural Gas, Hydroelectric, and Renewables
- **Continued Electric Reliability During Invasion**
- **Few Attacks on Generation Plants and Substations**
 - Interruption of Cross-Border Natural Gas Pipelines a Disincentive
- **If War Persists, Nuclear Safety & Fossil Fuel Supply Issues**

Transmission, Control, and Synchronization

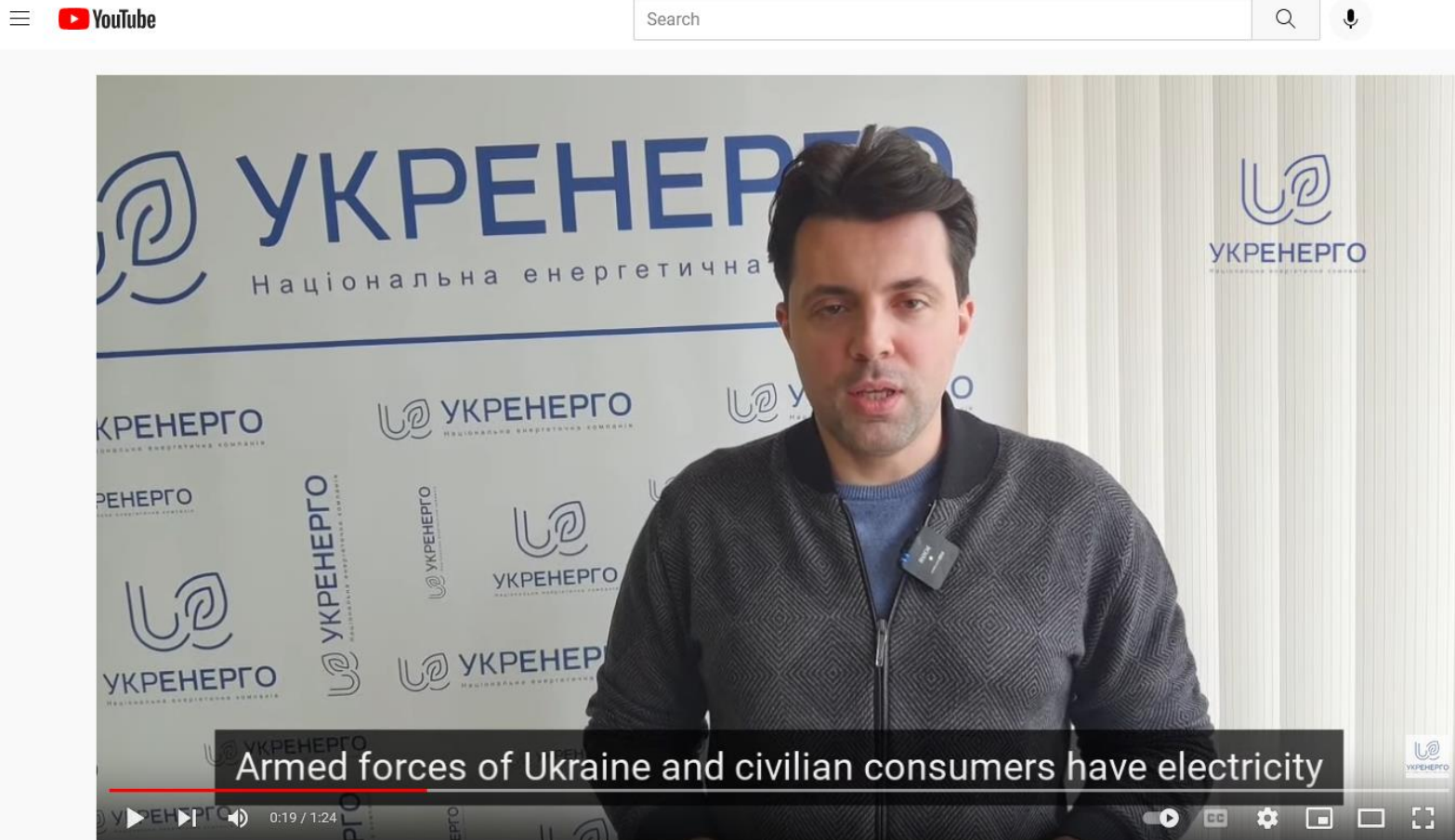
High Voltage Transmission Lines in Ukraine



Ukrenergo Transmission Control Room



Ukrenergo Video Dated March 2, 2022

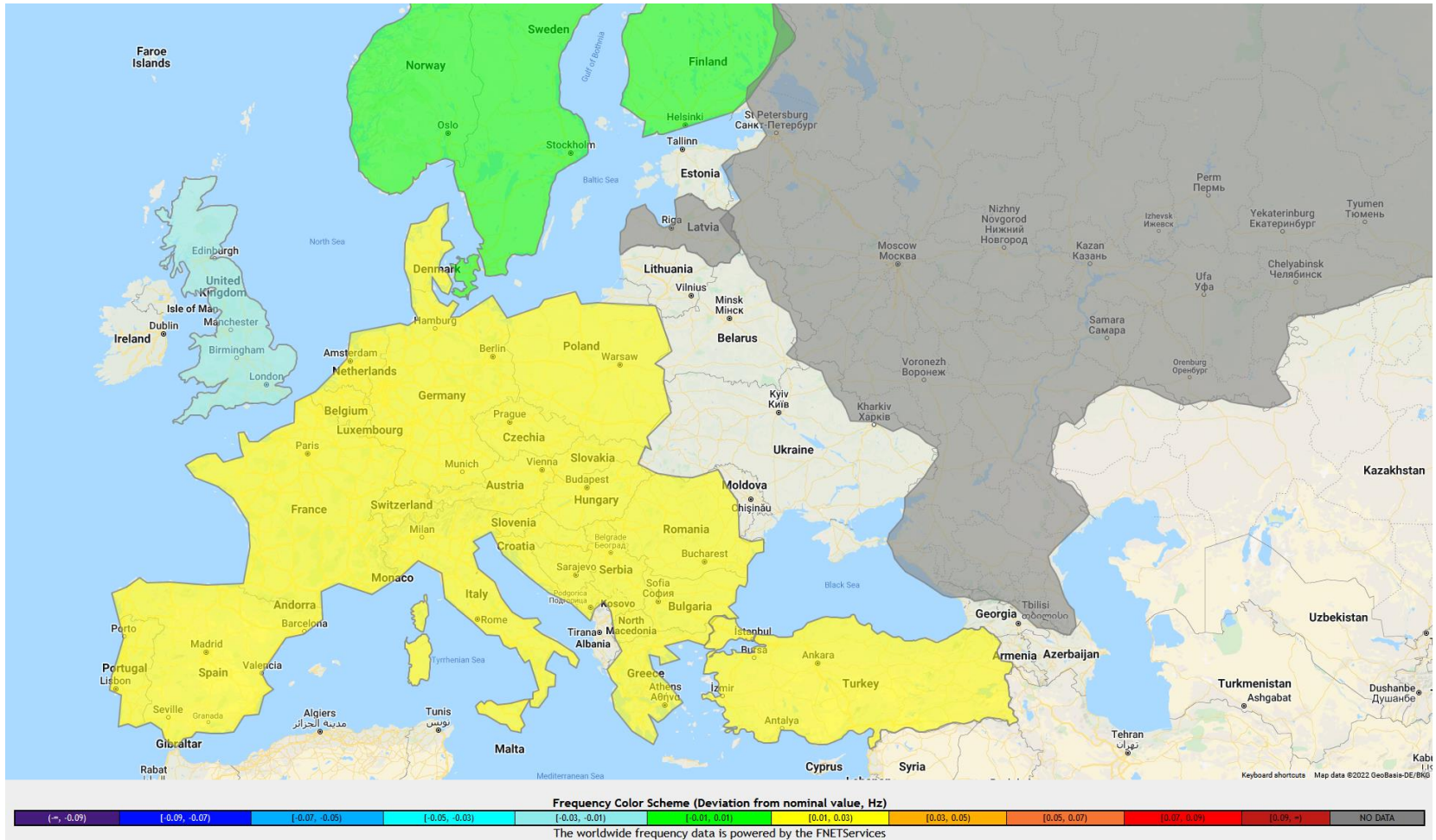


Голова правління «Укренерго» про роботу енергосистеми України на 7-й день війни

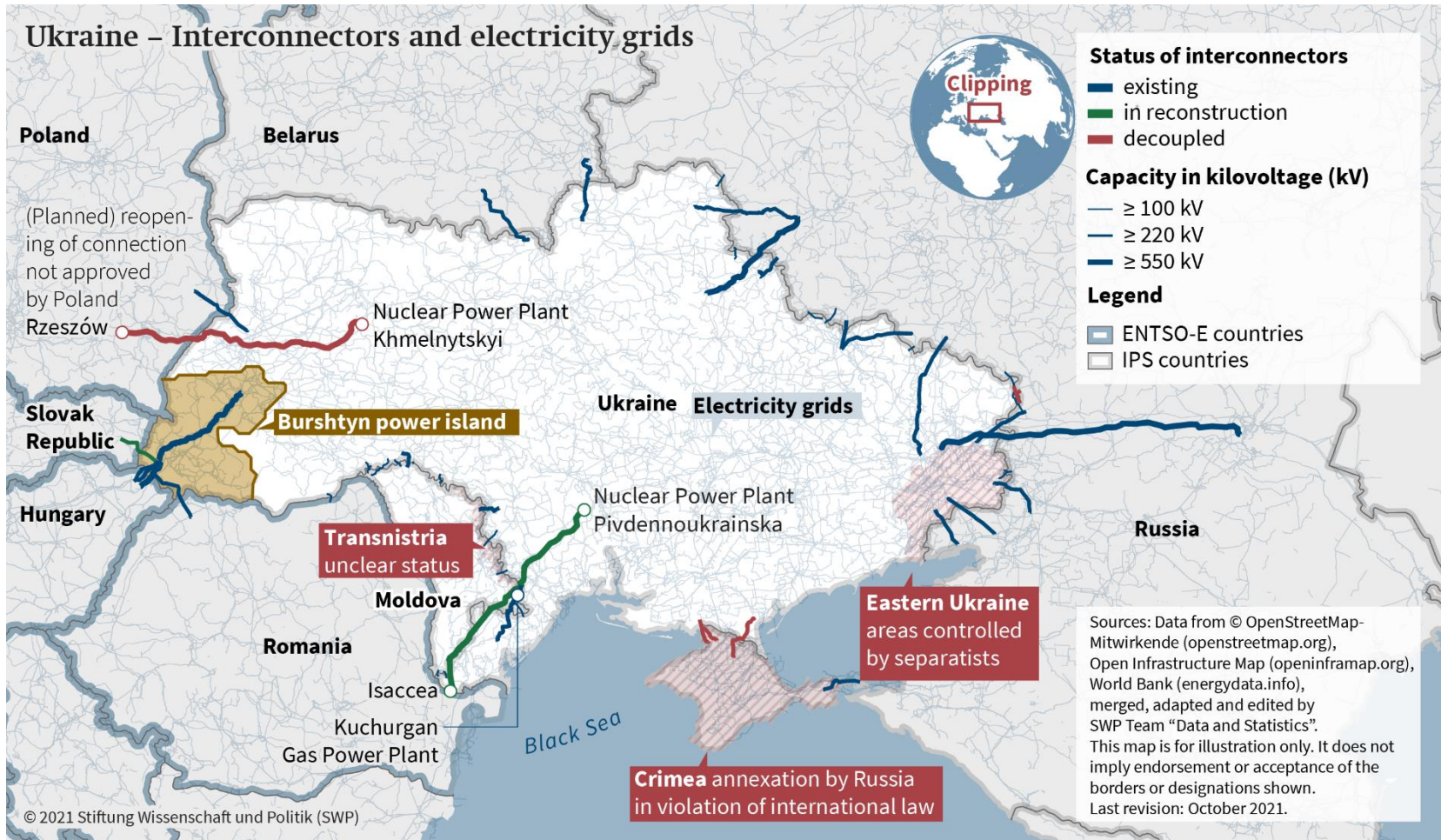
469 views • Mar 2, 2022

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Frequency Map of European Electric Grids

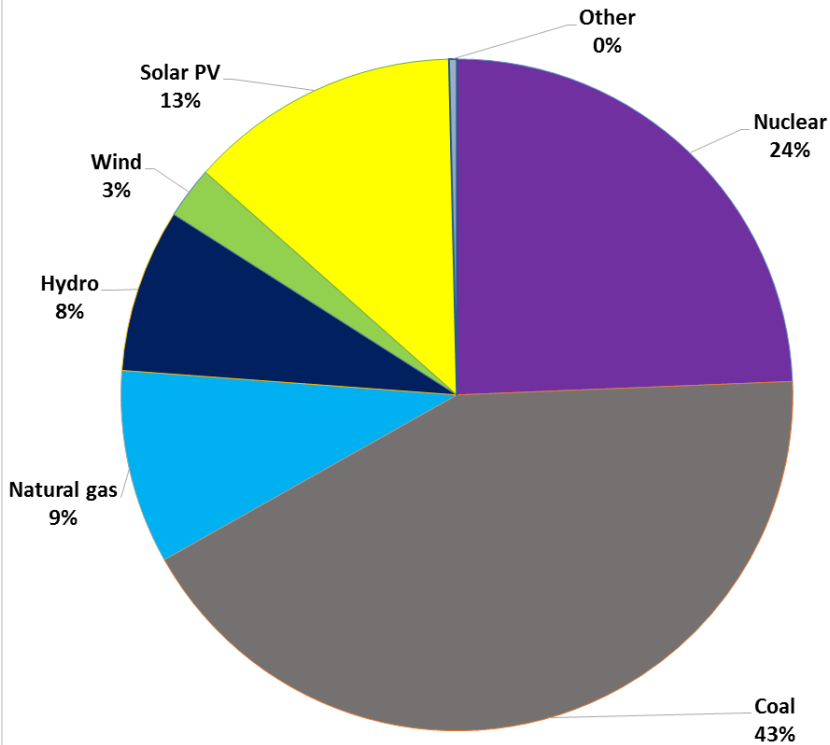


Ukraine Grid Synchronized with ENTSO-E on March 16

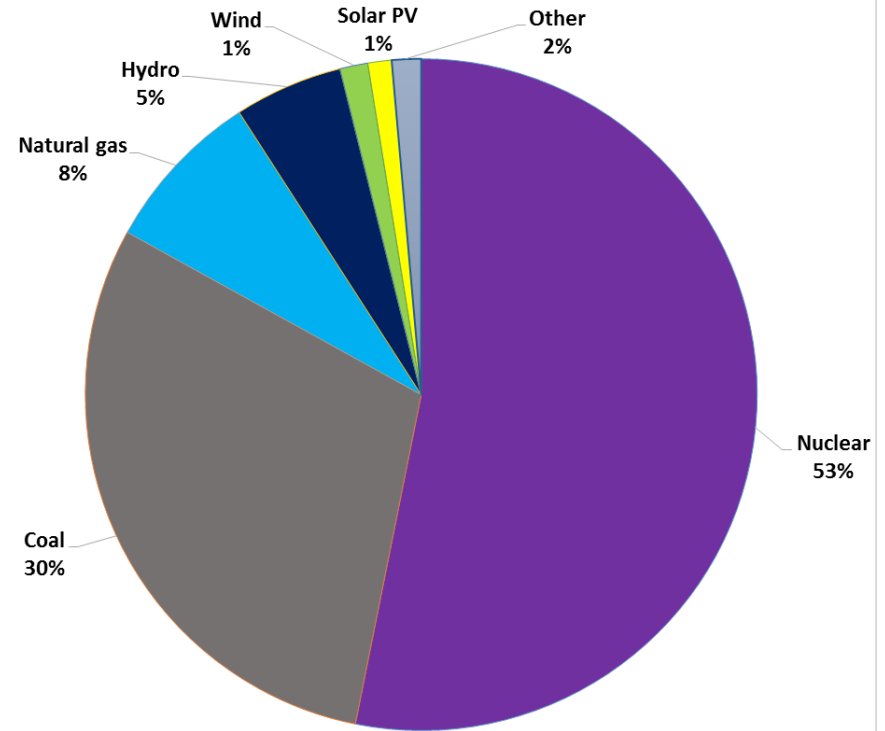


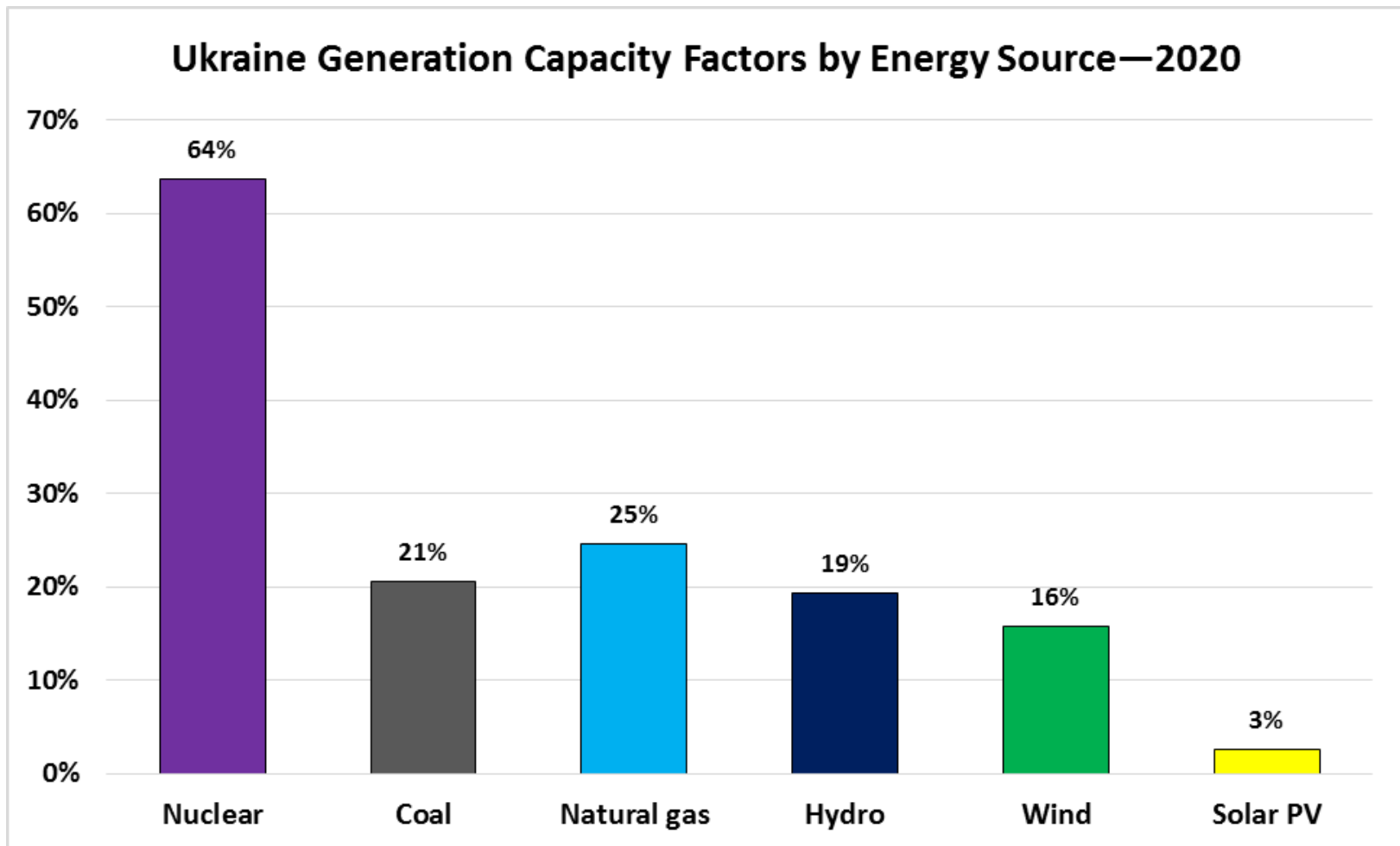
Generation Plants and Energy Sources

Ukraine Generation Capacity By Energy Source
56 GW in 2020



Ukraine Electricity Generation by Energy Source
143,400 GWh in 2020





Ukraine Fossil Fuel Sources

■ Coal

- 45% of coal supply is imported
- Of imported coal, 70% is from Russia
- Russia stopped coal deliveries in November 2021
- Deliveries from South Africa & U.S. in December-January
- On February 28, DTEK estimated 15-20 days of coal reserves

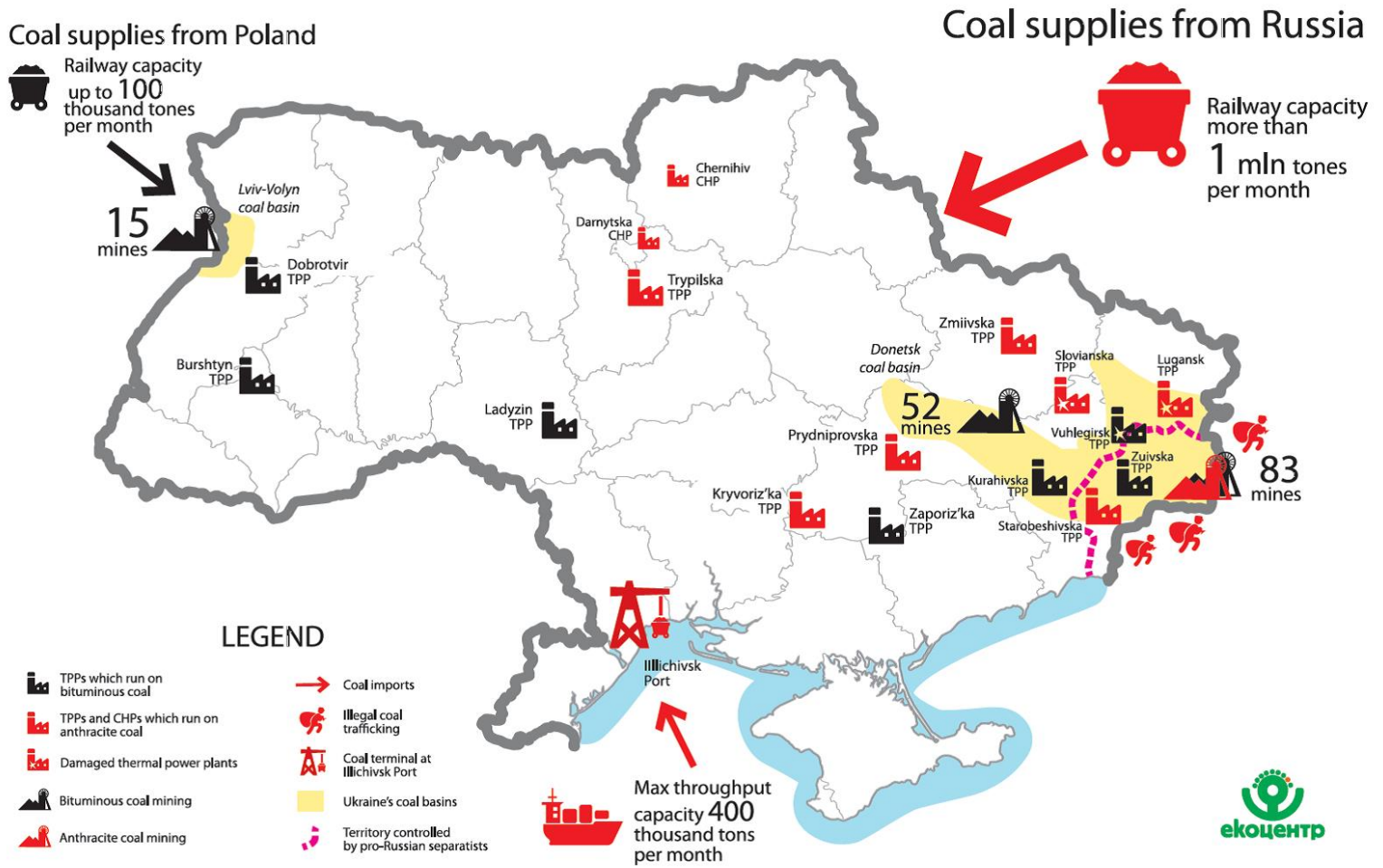
■ Natural Gas

- 30% of natural gas is imported, mainly from “Western Europe”
- Massive natural gas storage facilities of 31 billion cubic meters

■ Refined Petroleum

- 70% supplied from Belarus and Russian refineries
- Kremenchug, west of Karkiv, is sole operating Ukrainian refinery
- Petroleum storage capacity is a Ukraine state secret

Ukraine's Coal-Fired Generation Plants



December 24 “Energy War” Article in Euromaiden Press

Amid Russian energy war, government denies expert warnings that Ukraine may face electricity and heating cuts



Rivne nuclear power plant. Ukrainian nuclear power plants have reached record power generation amid Russian energy war.

2021/12/24 - 21:48 • [REFORMS & POLITICS](#)



About the Source **Bohdan Ben**

Bohdan Ben is a researcher in the field of social and ethical philosophy and in the field of local governance. He was among the winners of the program “Youth will change Ukraine” organized by Bohdan Hawrylyshyn Foundation. Together with his friends, he began the implementation of the project “In the land of Hope” which aims to

Ukraine's Nuclear Power Plants



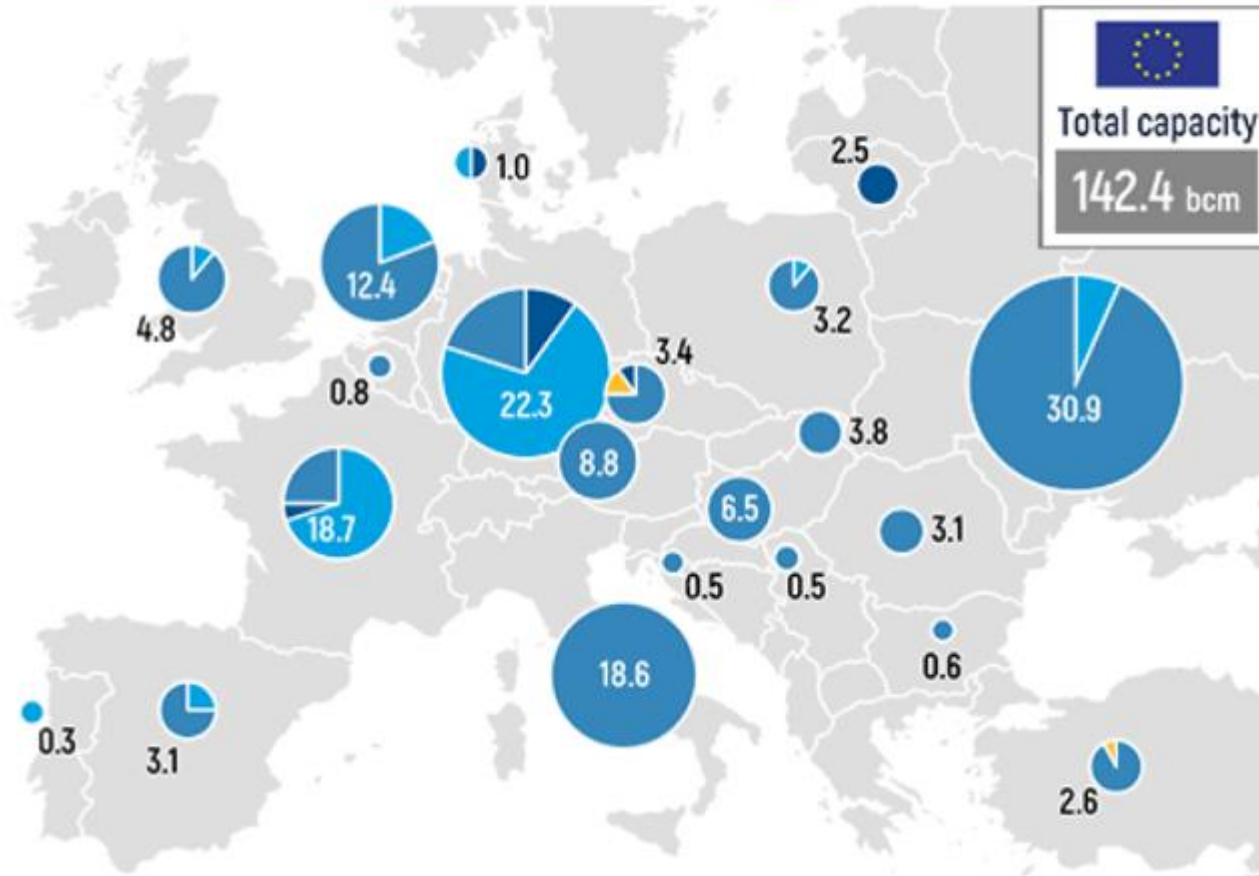
Map: Shyanne Gal/Insider • Source: IAEA

INSIDER

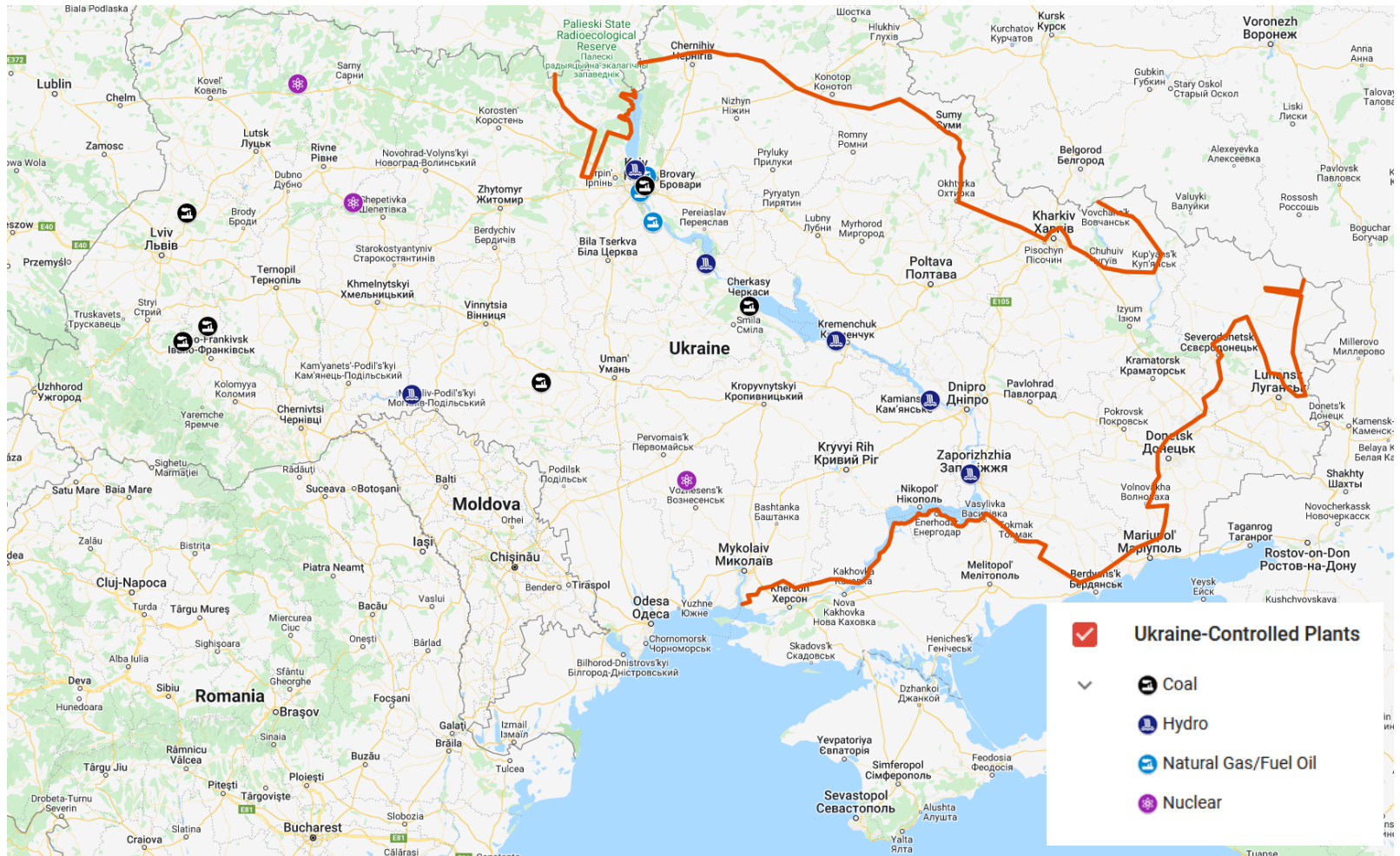
Ukraine's Nuclear Power Plants

- 15 Nuclear Reactors at 4 Plant Locations—13.1 GW
 - 6 Reactors Operating on March 16; Approximately 5 GW
- Soviet-Designed Water-Water Energetic Reactors (VVER)
- Steel and Concrete Containment for Reactors
- Zirconium-Clad Rods Used for Reactors Fuel
 - Fuel Currently Supplied by Russia, Two Year Inventory
 - Pending Transition to Westinghouse Fuel
- Plants Have Spent Fuel Pools Not in Containment
- Spent Fuel Pools Require Electric Power for Cooling
- When Water Boils Off from Spent Fuel Pools, Zirconium Fires and Radioactive Plumes Can Result
- Without Water for Radiation Shielding, Spent Fuel Pools Are Highly Radioactive and Cannot Be Approached

European Union & Ukraine Gas Storage



Energy-Resilient Generation Capacity in Ukraine—March 17



Energy-Resilient Generation Capacity in Regions Controlled By Government of Ukraine—March 17

Rank	Plant Name	Energy Source	Capacity (GW)
1	South Ukraine	Nuclear	2,850
2	Rivne	Nuclear	2,657
3	Burshtyn power station	Coal	1,986
4	Khmelnitski	Nuclear	1,900
5	Dnieper HPP	Hydro	1,579
6	Trypilska power station	Coal	1,225
7	Ladyzhyn power station	Coal	1,200
8	Kyiv CHP-5 power station	Natural Gas/Fuel Oil	800
9	Dniester HPP	Hydro	702
10	Kremenchug HPP	Hydro	700
11	Trypilska power station	Natural Gas/Fuel Oil	600
12	Dobrotvir power station	Coal	510
13	Kaniv HPP	Hydro	500
14	Kyiv CHP-6 power station	Natural Gas/Fuel Oil	500
15	Kyiv HPP	Hydro	440
16	Middle Dnieper HPP	Hydro	388
17	Kalush power station	Coal	200
18	Cherkasy power station	Coal	180
19	Darnytska power station	Coal	160
	Total Capacity		19,077
	Evening Peak Load on March 6, 2022		13,700

Grid Disruptions During the Russian Invasion

Russian Advances Blackout Sumy & Mariupol on March 3

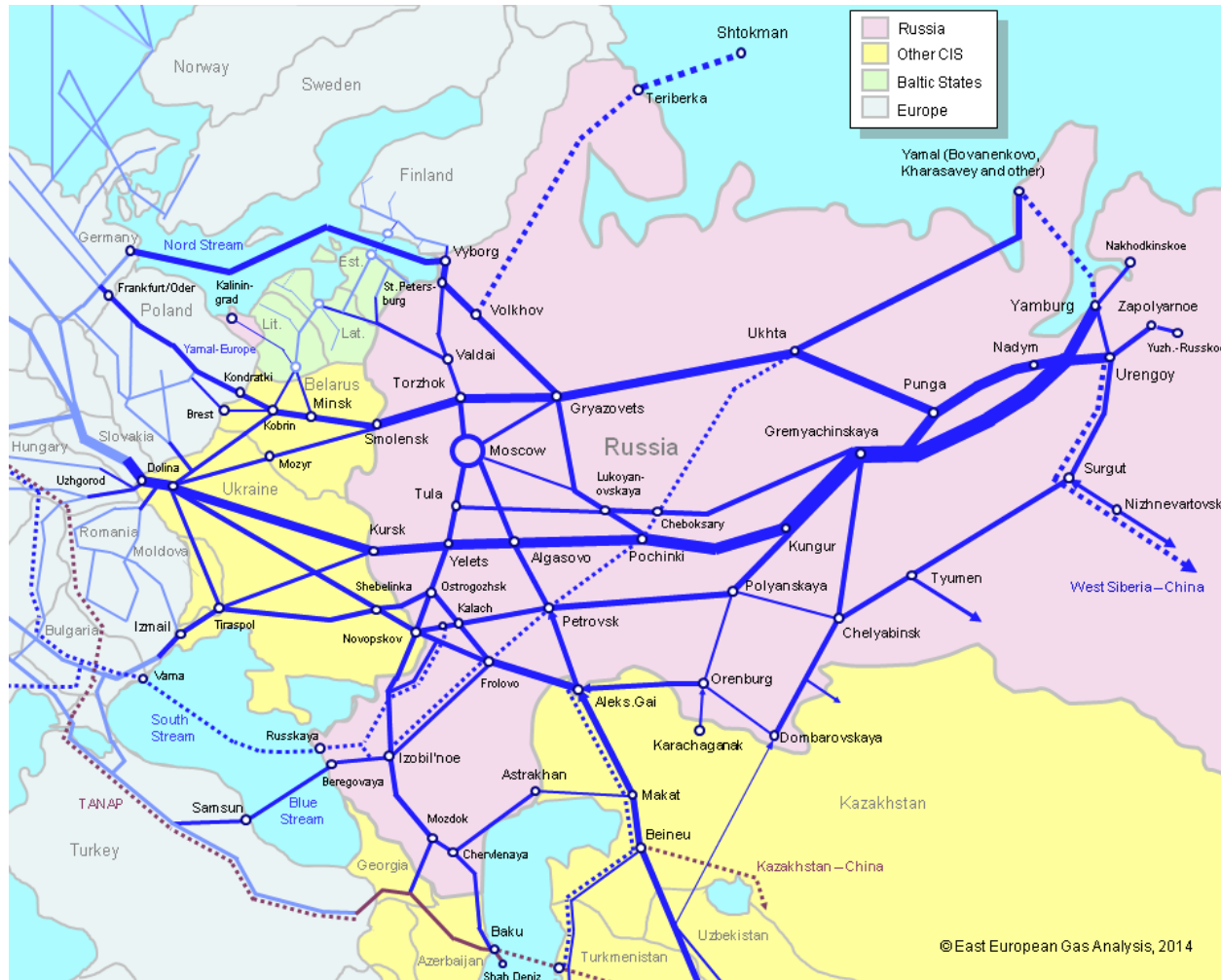


Guardian graphic. Source: Rochan Consulting, The Institute for the Study of War with AEI's Critical Threats Project. Note: latest data at 1700 GMT 5 March

Attack on Zaporizhzhia Nuclear Power Plant on March 3

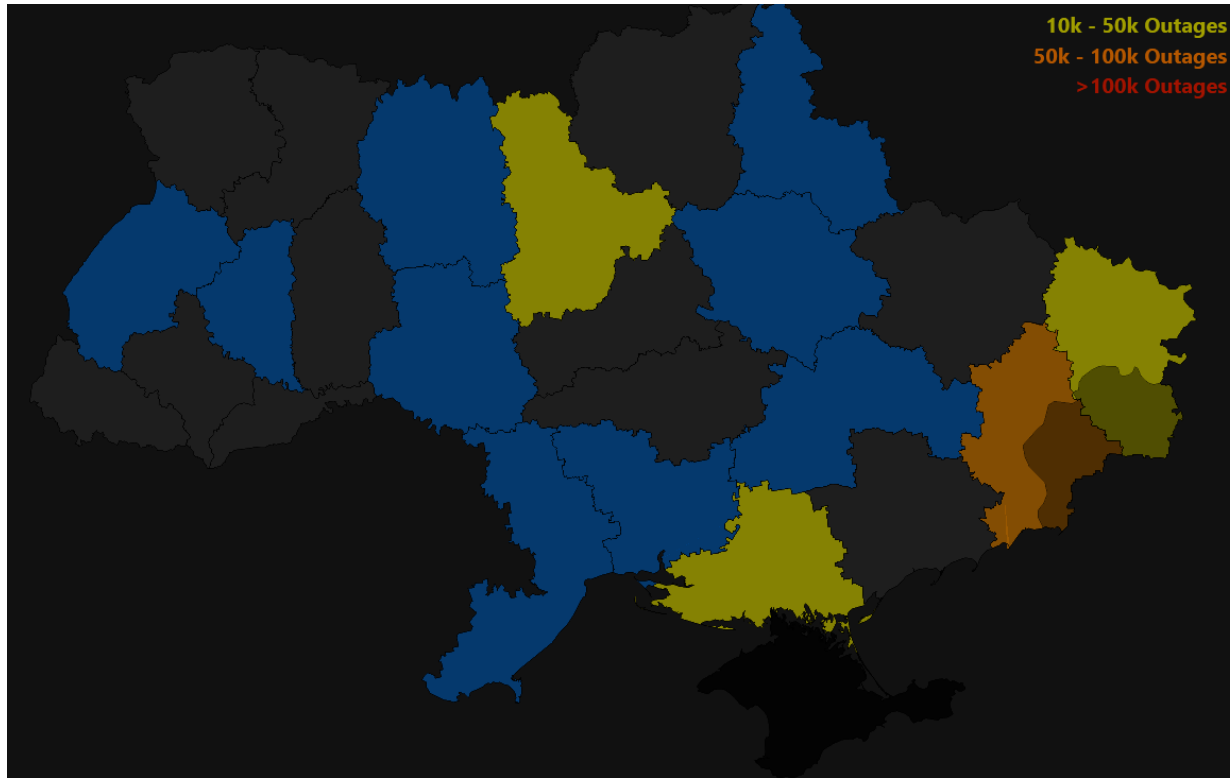


Interdependence of GazProm and UkrTransGas Pipelines



Indicators of Ukrainian Infrastructure Status

Ukraine Electric Grid Outages on March 17



Oblasts

Oblast	Outages
Donetsk	92,189
Kyiv	34,467
Kherson	17,911
Luhansk	16,425
Lviv	6,103
Sumy	5,412
Poltava	3,405
Mykolaiv	2,744
Zhytomyr	2,158
Dnipropetrovsk	1,205
Cherkasy	0
Chernihiv	0
Chernivtsi	0
Ivano-Frankivsk	0
Kharkiv	0
Khmelnyskyi	0
Kirovohrad	0
Odessa	0
Rivne	0
Ternopil	0
Vinnytsia	0
Volyn	0
Zakarpattia	0
Zaporizhzhia	0

Welcome! This is an ongoing project created to track, record, and aggregate power outages across Ukraine. Find out more on our [About](#) page. Click on an oblast to see more information. Data is updated site wide approximately every ten minutes.

Helpful Definitions:
Oblasts are the same as a state or province
Raions are the same as a county or region
Oblenergo means electric distribution utility

Oblasts by Outages

Donetsk	92,189
Kyiv	34,467
Kherson	17,807
Luhansk	16,425
Lviv	6,543
Last Updated	
3/17/2022, 09:14:59 AM	



Main > News > Press Releases > DTEK Donetsk Grids has returned electricity to almost 5,000 families in the Donetsk region

DTEK Donetsk Grids has returned electricity to almost 5,000 families in the Donetsk region

Thermal power generation 10 March 2022

On March 9, DTEK Donetsk Grids repair crews fully or partially restored electricity for 4.9 thousand families living in 13 cities and villages of Maryinskyi, Dobropilskyi, Konstantynivskyi, Oleksandrivskyi, and Yasynuvata districts. Emergency repair works in the region will continue as soon as the company's specialists are able to perform them safely.

As of March 10, DTEK Donetsk Grids repair crews restored electricity to the villages: Solodke, Stepove, Slavne, Uspenivka, Annivka, Bohoiavlenka, Ostrivske, Katerynivka, Kostiantynivka, Illinka, Antonivka, Yelyzavetivka, Yakovlivka, Mykhailivka, Lvivka, Dmytrivka.

In total, the DTEK crew restored electricity for 4.9 thousand families in 5 districts of the region.

Residents of 148 settlements in the Donetsk region are left without electricity. The most difficult situation remains in Mariupol, where due to regular shelling and the inability to repair power grids, more than 200,000 families remain in the city without electricity. The situation is complicated by active hostilities in the city, which had no break for more than a week.

DTEK Donetsk Grids is continuously working and doing everything possible to promptly restore electricity supply to settlements affected by the fighting. The company cooperates with the Armed Forces of Ukraine to gain safe access to places with damaged power lines.

SEE ALSO

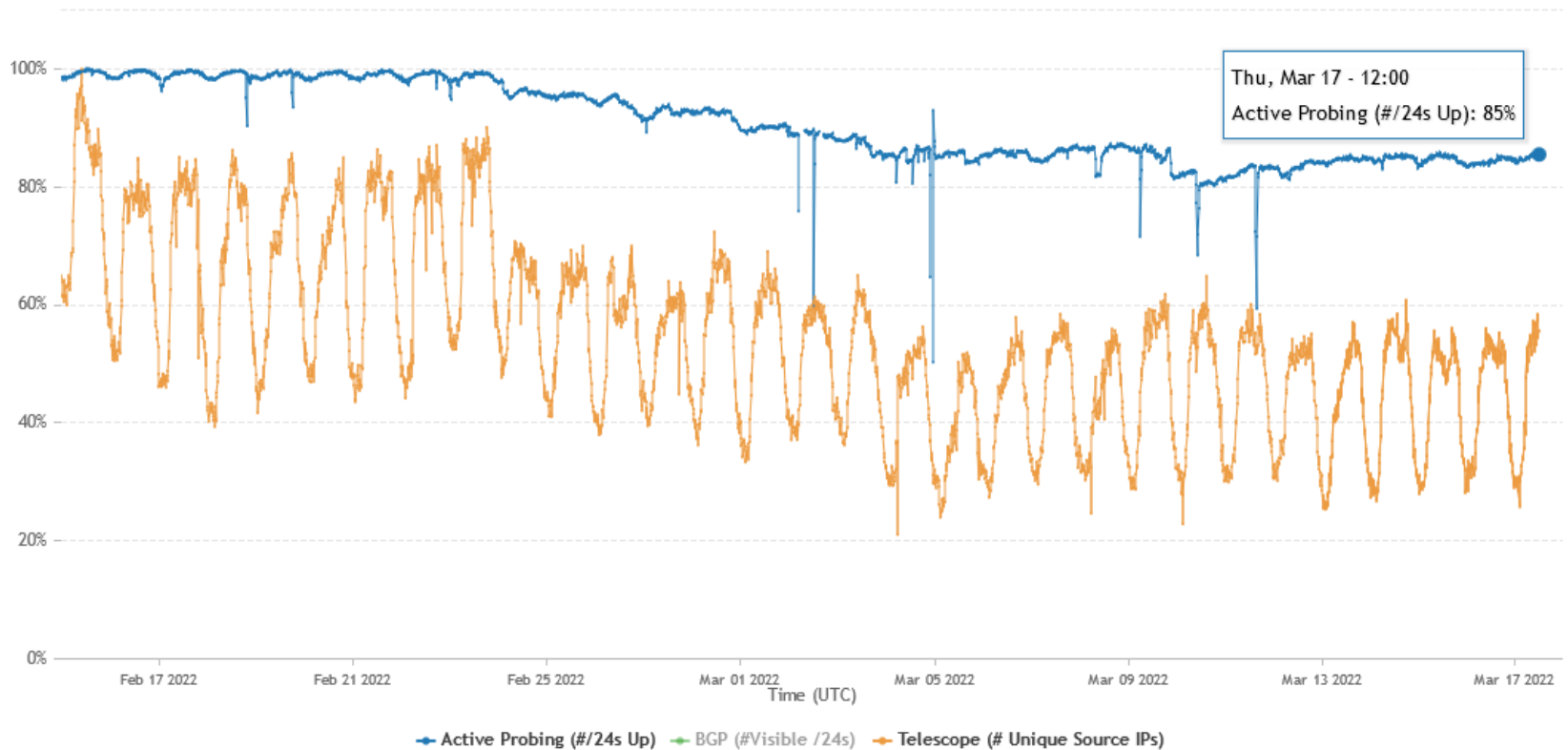
- 16 March 2022** **Thermal power generation**
DTEK Odessa Grids restored power supply in two villages of the Bilhorod-Dnistrovskyi district affected by the hostilities
- 10 March 2022** **Thermal power generation**
DTEK Kyiv Regional Grids restored service to another 8,900 families in the Kyiv region
- 27 February 2022** **Thermal power generation**
DTEK repair crews are doing whatever is needed to restore power after hostilities
- 22 February 2022** **Thermal power generation**
DTEK Odessa Grids and State Architectural and Construction Inspectorate of Odessa mediate problems of power supply to apartment buildings

IODA Monitoring of Ukrainian Internet Traffic

IODA Signals for Ukraine ?

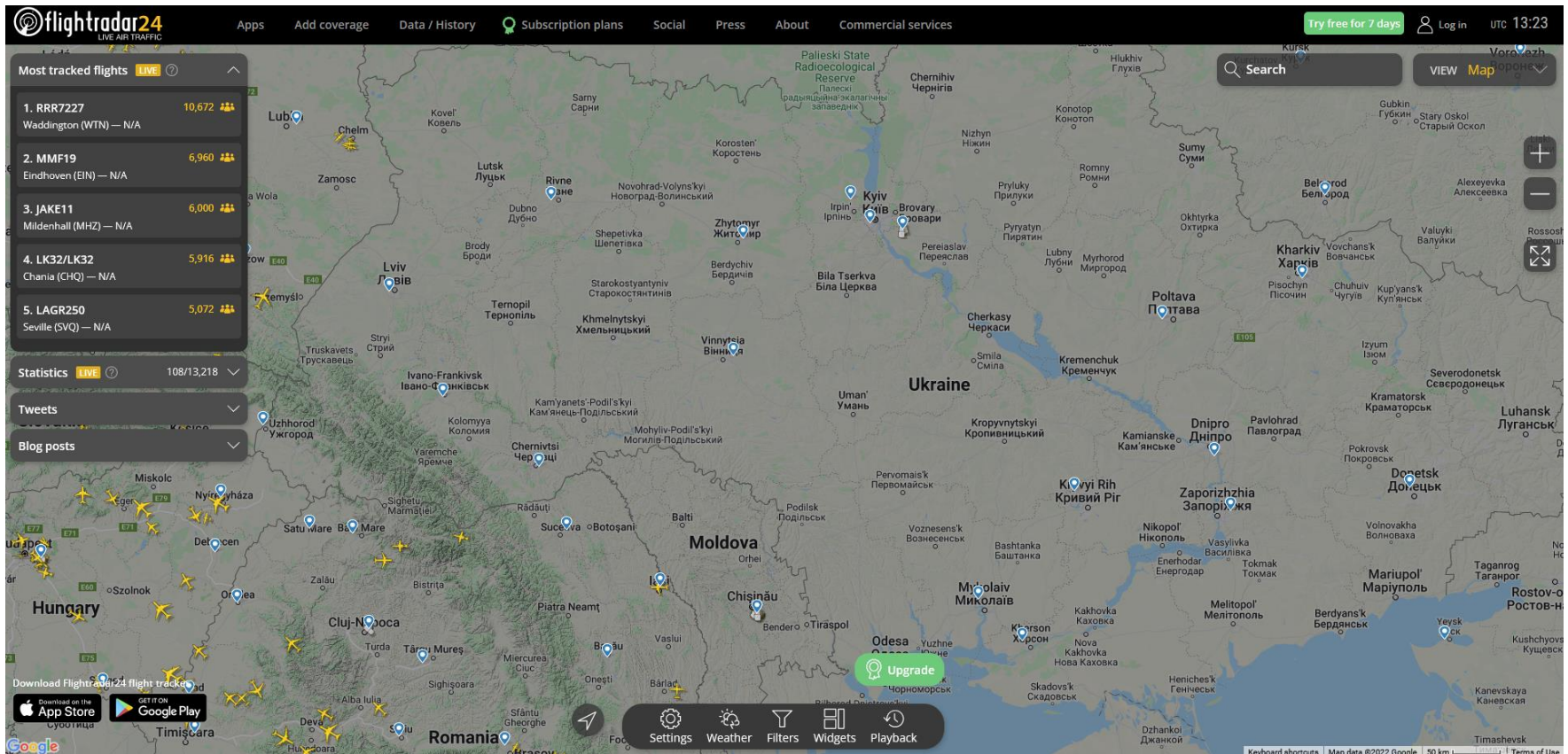
Alert Bands OFF

Normalized Values ON



February 15, 2022 00:00am – March 18, 2022 00:00am

FlightRadar24 Ground Stations on March 17



Summary Observations

- **Russia's Attack on Ukraine Unprecedented in Modern Era**
 - Besieged Country with Wide-Area, Synchronized Electric Grid
 - Nuclear Power Sector Supplied Over 50% of Electricity
 - Telecommunications Interdependent with Electric Grid
 - Cross-Border Natural Gas Pipelines Also Interdependent
- **Not Yet The Society-Wide "Total War" of World War II**
 - Few Attacks on Electric Grid and Continued Reliable Operation
- **Russian Incentives To Preserve Grid Infrastructure**
 - Continued Transmission of Russian Gas to European Customers
 - Prevention of Cascading Grid Collapse and Risky Blackstart
 - Avoided Long Lead-time Replacement of Critical Grid Components
 - Averted Humanitarian Disaster in Country of 44 Million