COLLEGE OF ENGINEERING
BRADLEY DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
VIRGINIA TECH™

CPES
Center for Power Electronics Systems

Moving Towards a Carbon-Free World by 2050

Intergrid for Sustainable Energy Abundance

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Three Corners Power Electronics Extended Collaboration (3C-PEEC) Workshop

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Switching from Fossil Fuels to 100% Renewable Energy Supply?

- Earth receives about 14 thousand EJ of energy each day from Sun.
- About 10,000 times more than humankind's total primary energy consumption.

SUSTAINABLE ENERGY ABUNDANCE:

Total daily energy consumption of 10 billion humans, using per capita twice as much energy as an average American today, 30 years from now, will still be only about 0.1% of energy that is continuously received by Earth from Sun every day.

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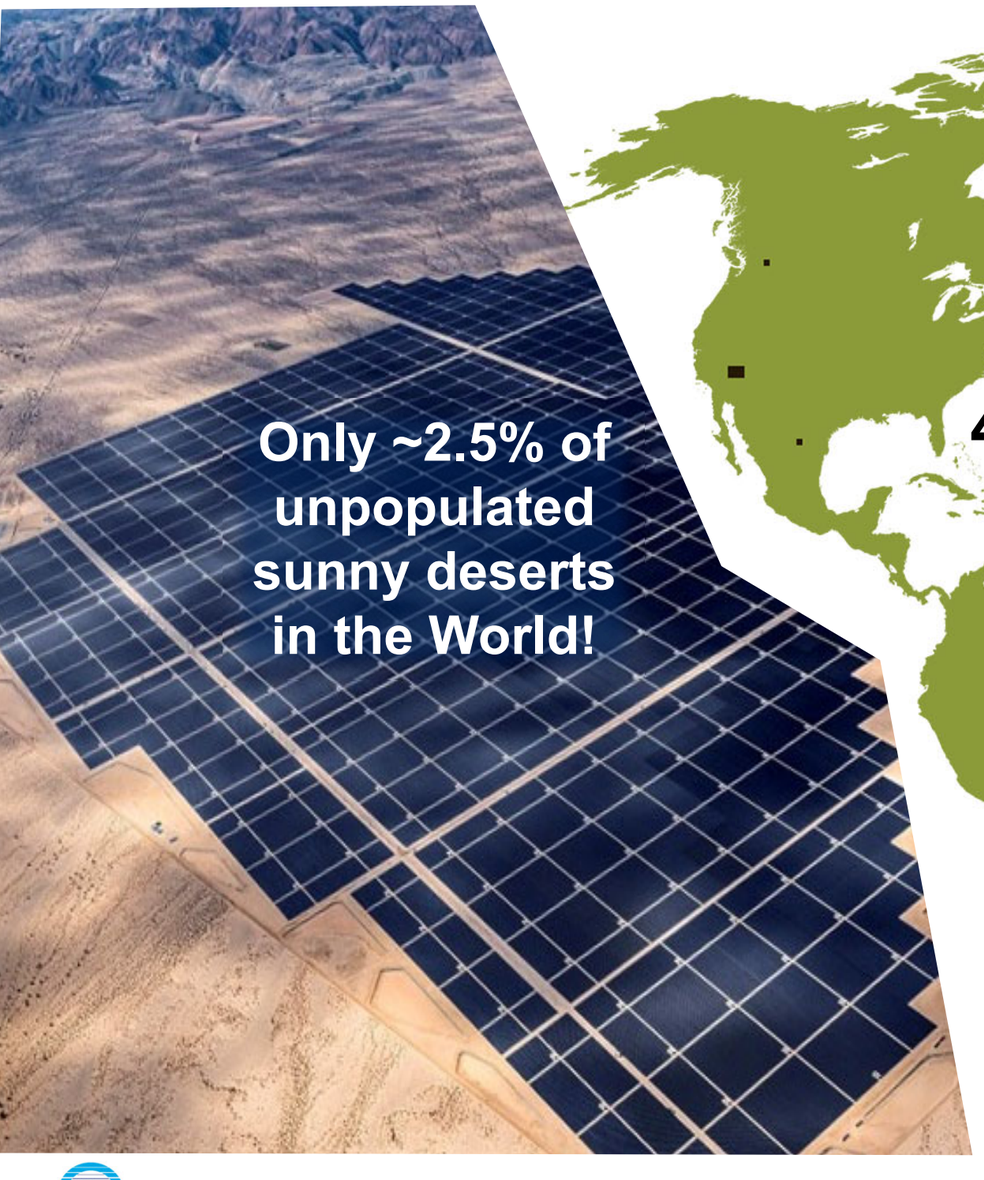
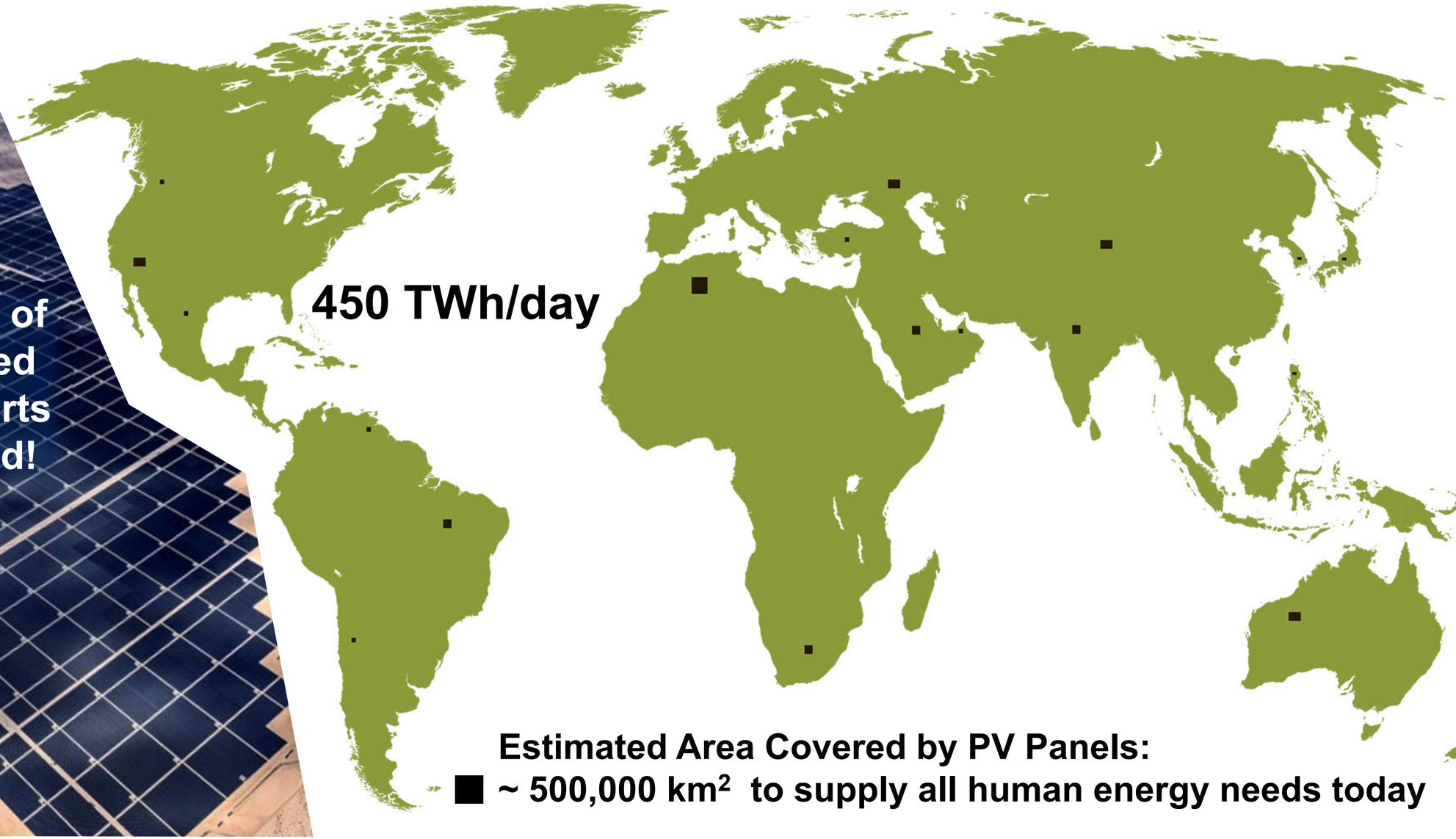
Even if the World is Powered only by Solar





Estimated Area Covered by PV Panels:

■ **~ 500,000 km^2 to supply all human energy needs today**

Assumed insolation of 1000 W/m^2 for 5 h/day and efficiency of 18%

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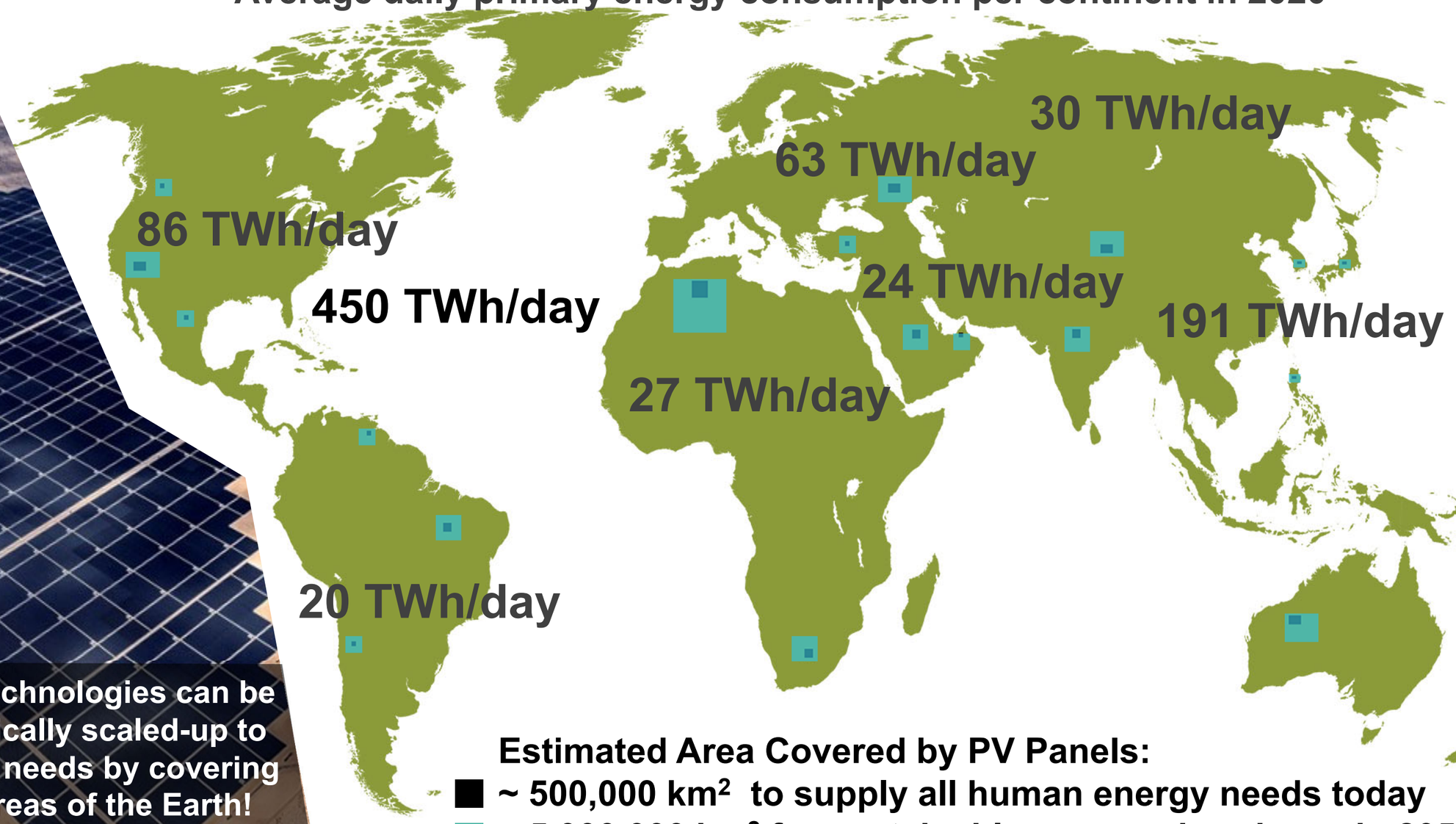
Even if the World is Powered only by Solar

The existing renewable technologies can be sustainably and economically scaled-up to provide all human energy needs by covering < 20% of unpopulated areas of the Earth!

Average daily primary energy consumption per continent in 2020



Estimated Area Covered by PV Panels:

- **~ 500,000 km^2 to supply all human energy needs today**
- **~ 5,000,000 km^2 for sustainable energy abundance in 2050**

Assumed insolation of 1000 W/m^2 for 5 h/day and efficiency of 18%

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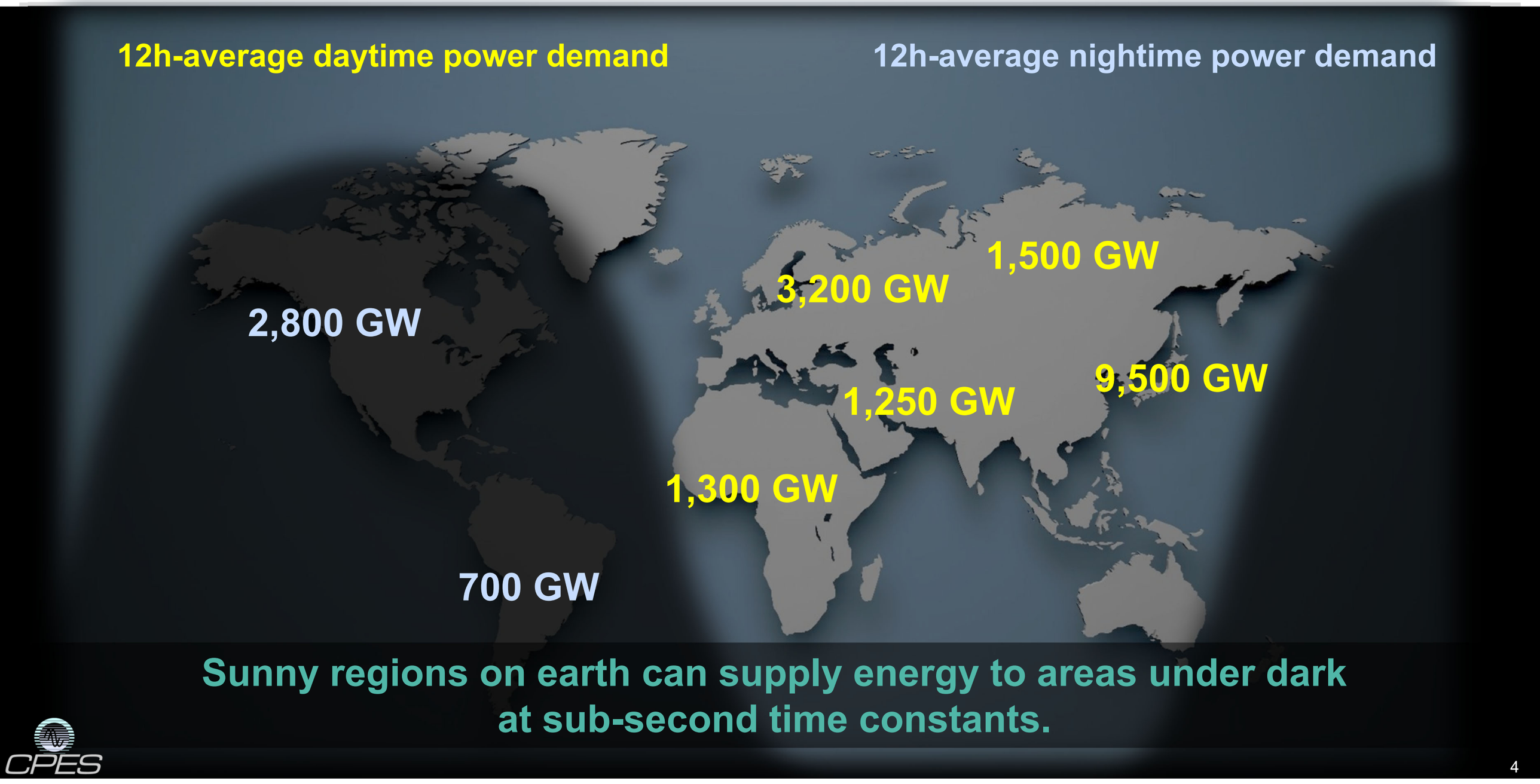
Balancing Global Varying Generation with Varying Consumption



Sunny regions on earth can supply energy to areas under dark at sub-second time constants.

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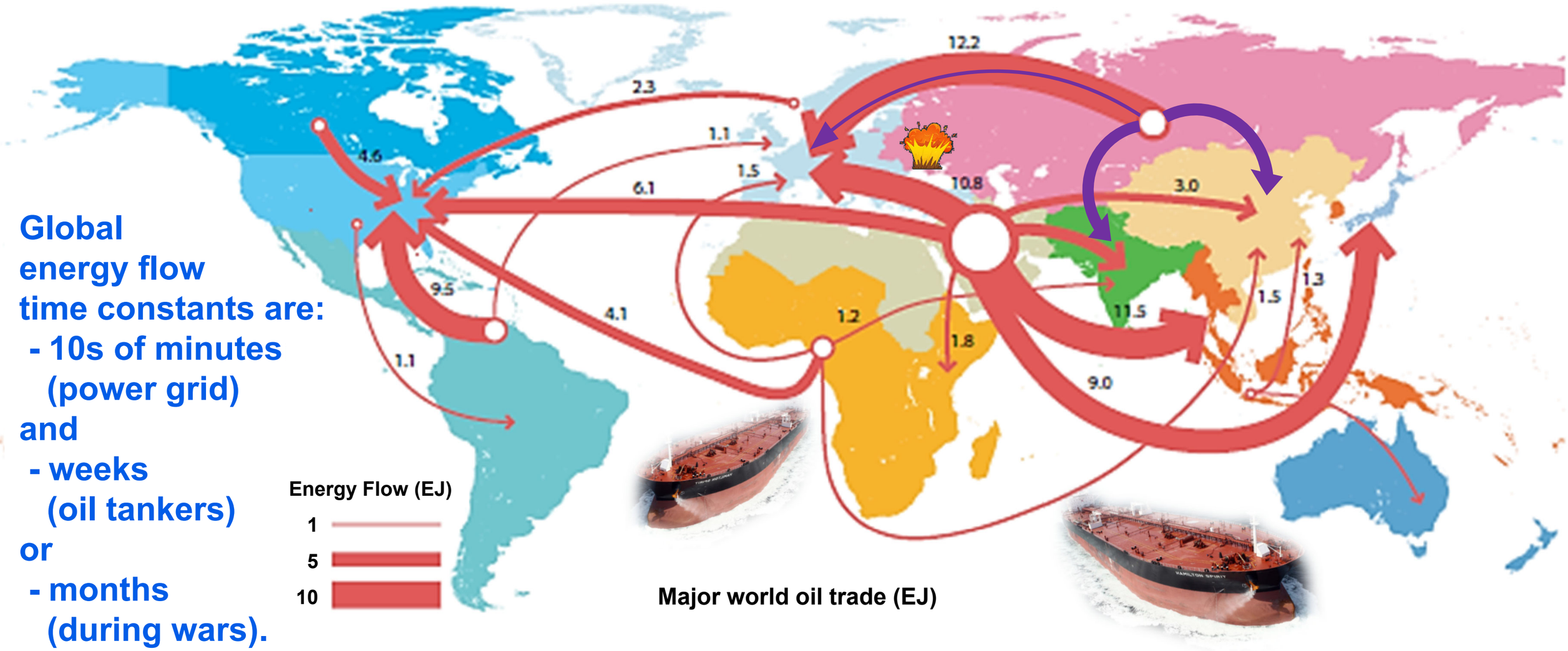
Energy Supply Has Been Global Since 1900's

Over 1/3 of world primary energy is traded internationally!

Global energy flow time constants are:
- **10s of minutes (power grid)**

and
- **weeks (oil tankers)**

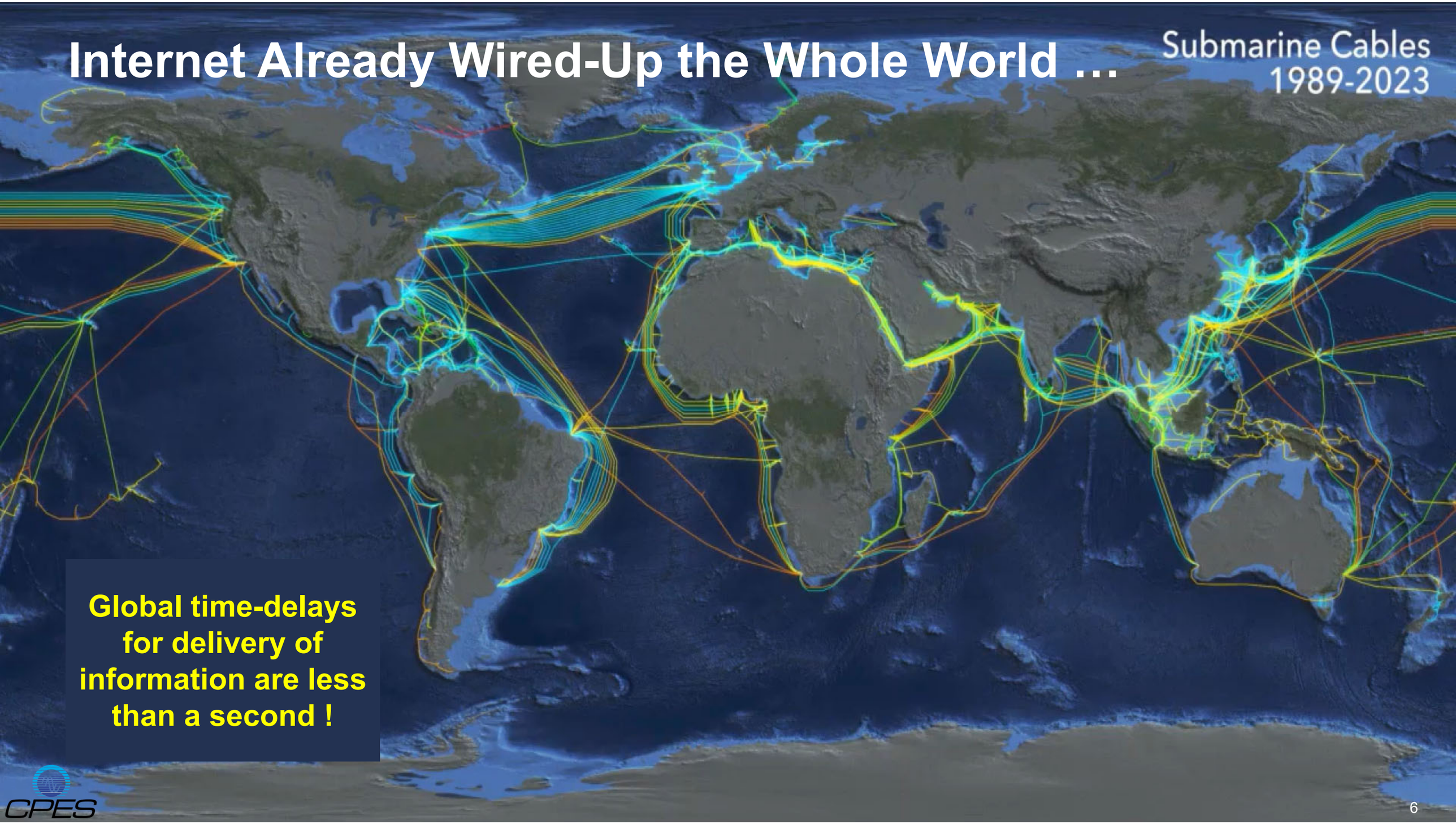
or
- **months (during wars).**



Major world oil trade (EJ)

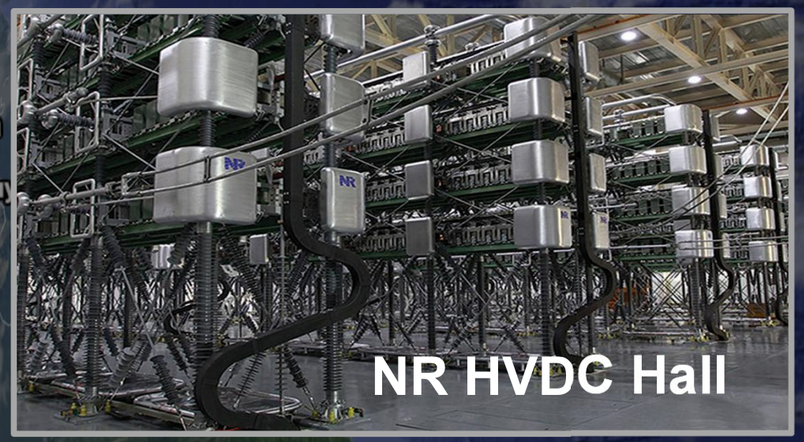
COVID-19 pandemic has taught us that global problems must use global solutions!

Internet Already Wired-Up the Whole World …



Global time-delays for delivery of information are less than a second !

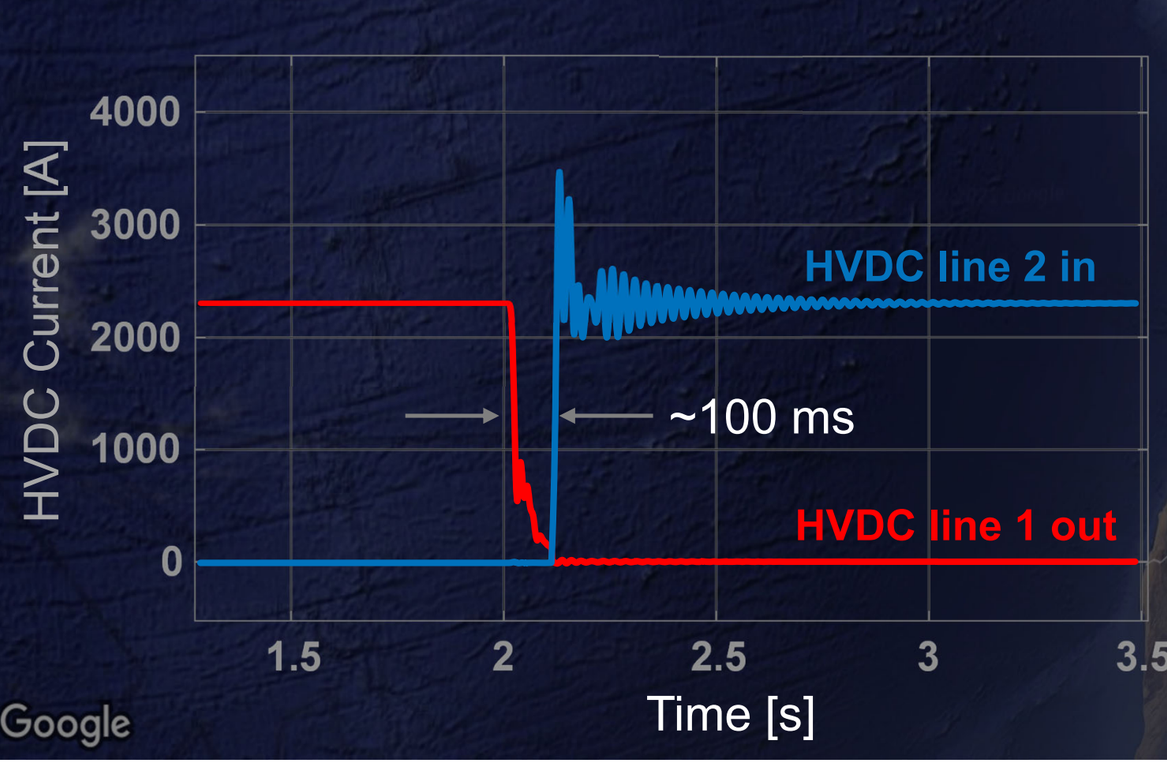
Uninterruptible Intercontinental Energy Delivery



3 GW

±640 kV

~4,000 km



Guinea-Bissau
Burkina Faso
Chad
Benin
Sierra Leone
Côte d'Ivoire
Togo
Nigeria
Liberia
Ghana
Cameroon
Gulf of Guinea
Equatorial Guinea
Gabon
Brazil
Angola
olivia
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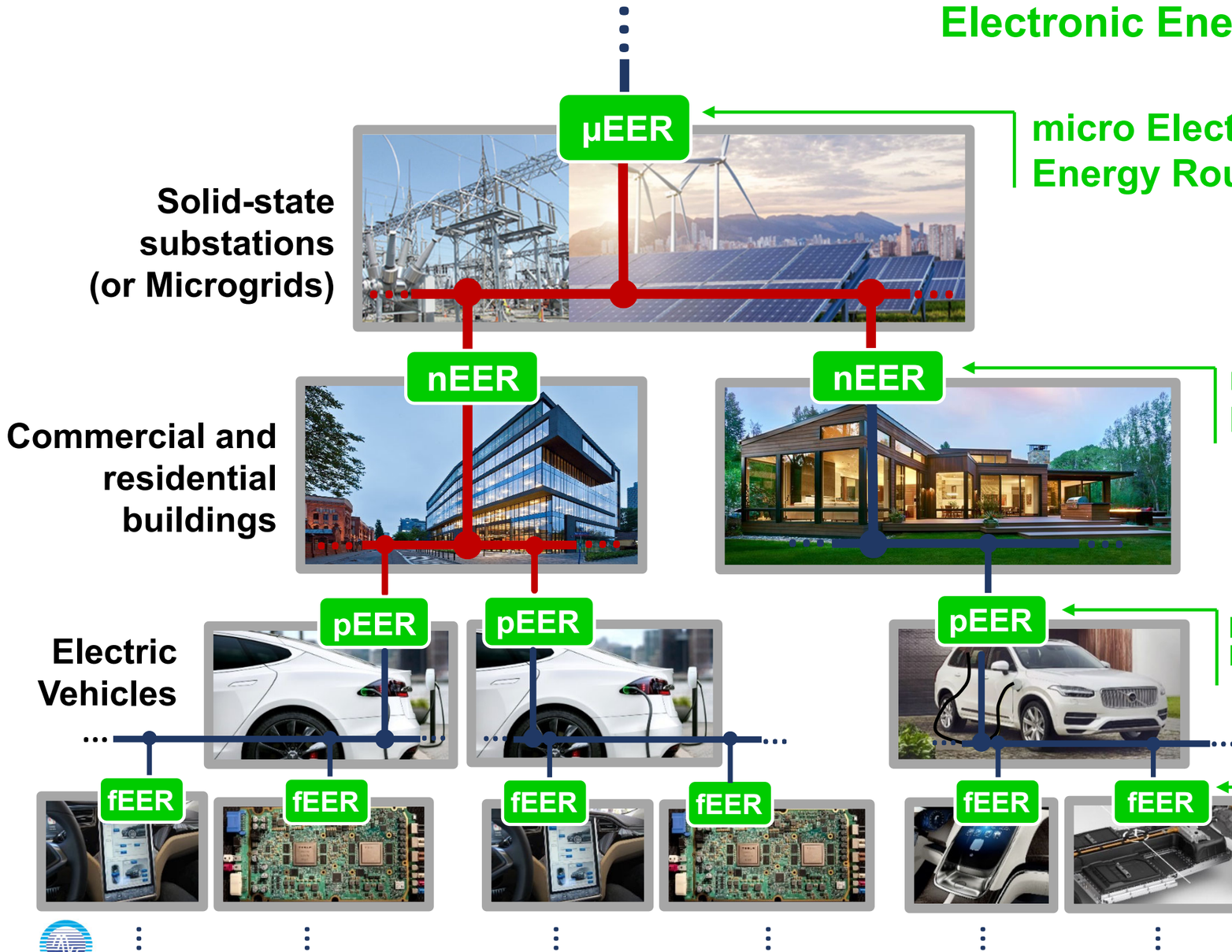
Intergrid

Hierarchical network of dynamically-decoupled, electronically-interconnected, sub-networks



= Bidirectional power converters for point-to-point energy flow control and integral protection;

- Every *x*-GRID is connected to a higher level by *x*-EER;
- Distributed energy generation and storage;
- Ability to operate in islanded mode;
- No thermo-mechanical switchgear;
- Step-up/down and isolation functions provided by the power converters (no low-frequency transformers);
- Extensive communication and control capabilities;
- **Standardized energy transfer & interconnection protocols are needed!**

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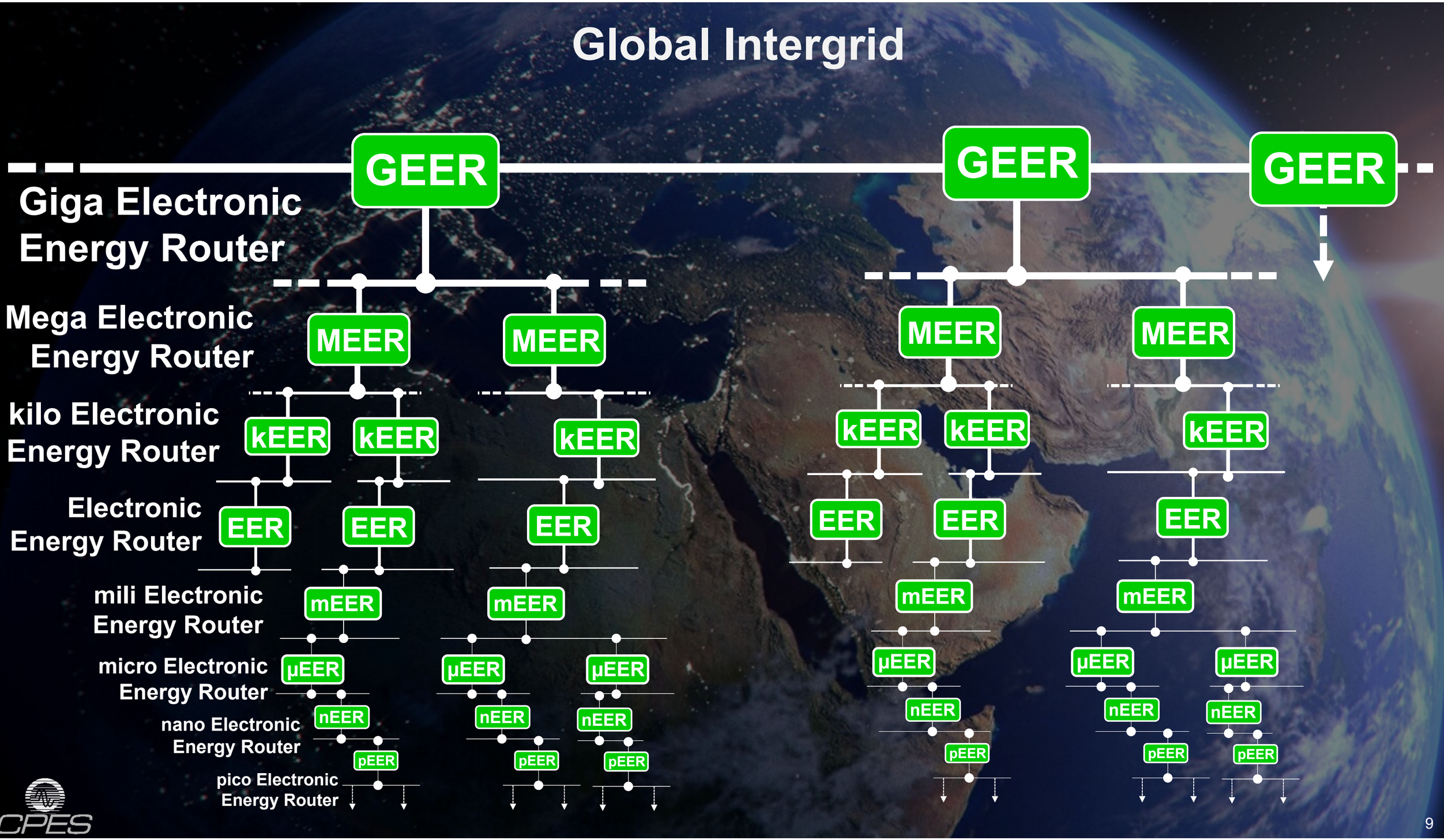
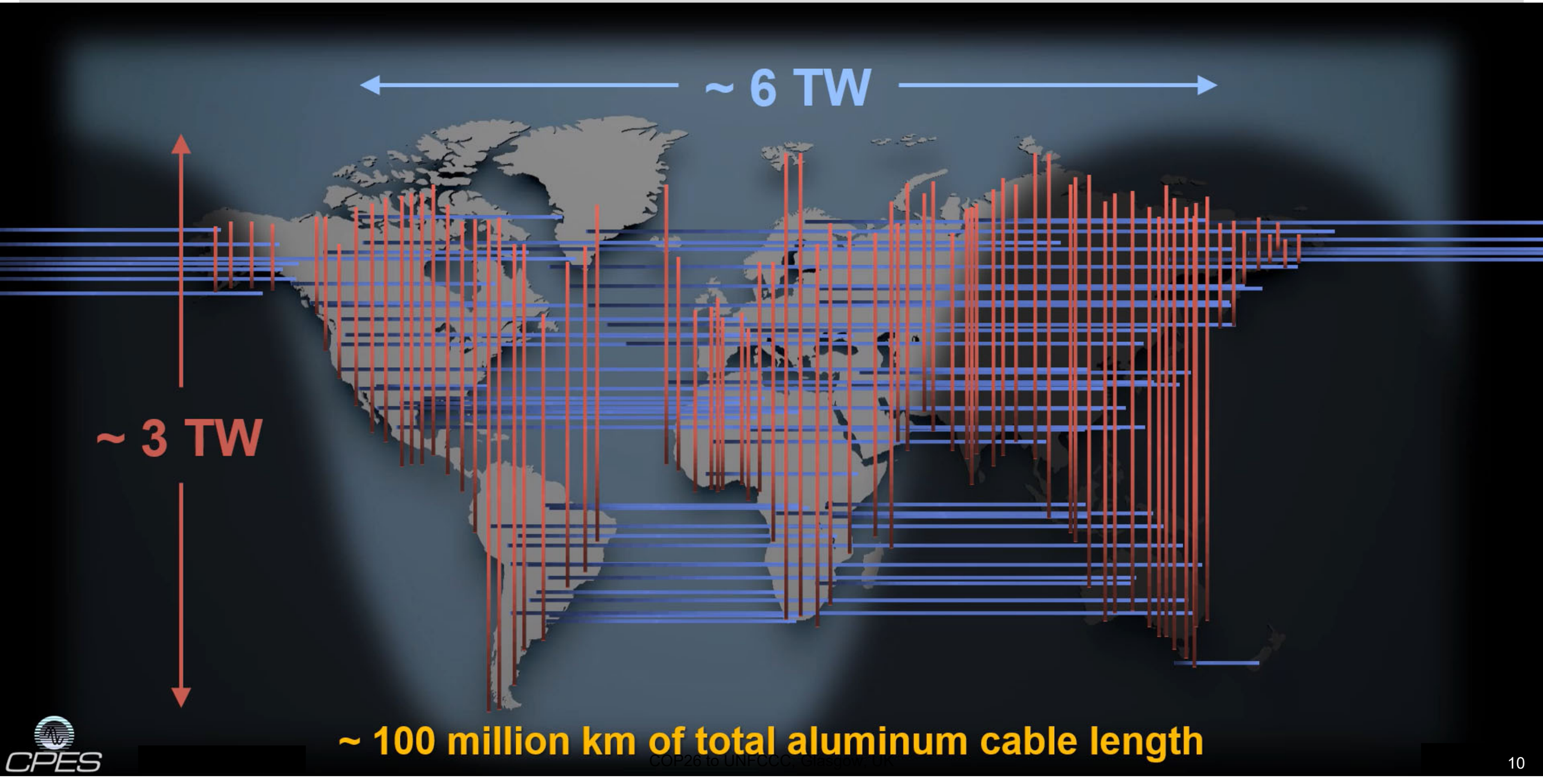
Global Intergrid



Balancing Global Varying Generation with Variable Consumption



Global Intergrid for Sustainable Energy Abundance

“Packets of electrical energy” can be sent at the speed of light between any two points on the Earth connected by electrical conductors!

Global supplies of:
- **silicon <sand)**
- **aluminum <bauxite)**
- **plastics <CO_2 capture, sea & air)**
- **energy <Sun)**

are sufficient for this!

We have the technologies and resources to do it, we just need the *will* !

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