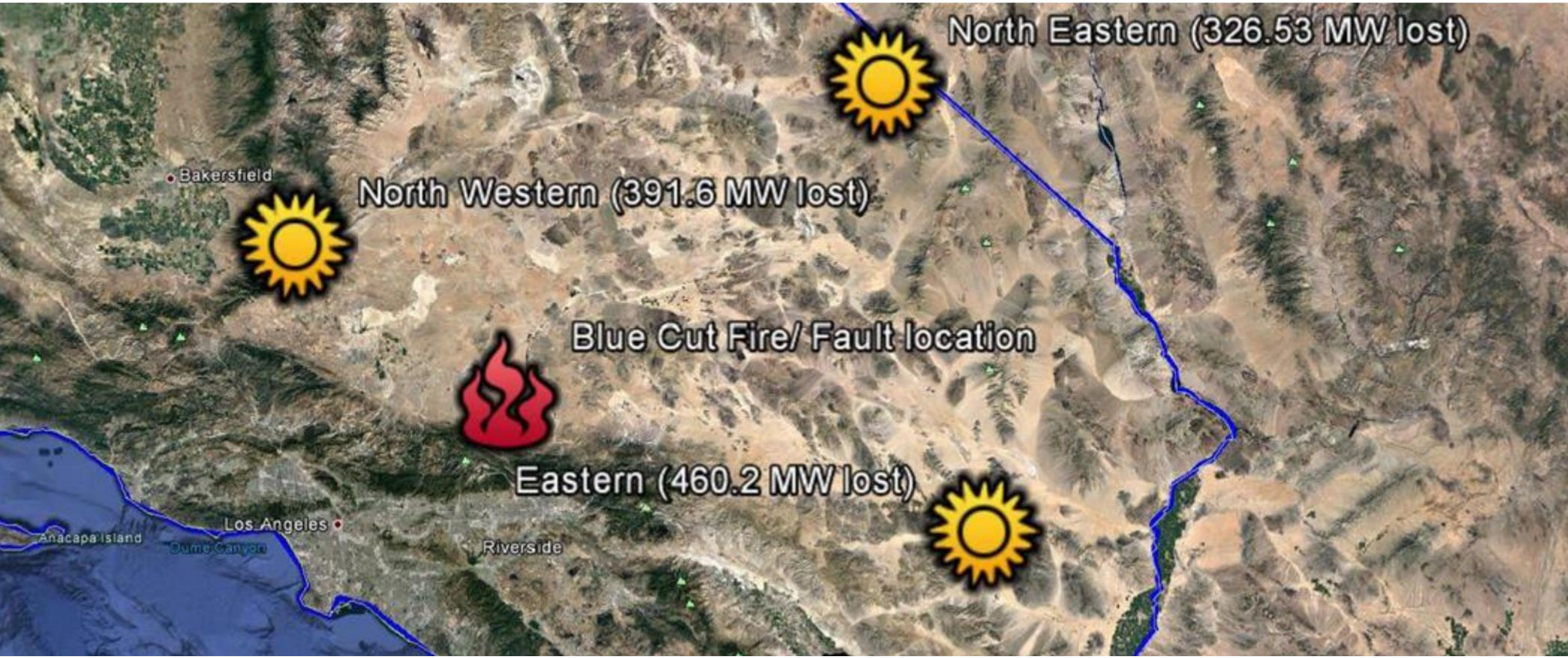
大电网
绿色电力能源*

郑罡



*仅代表个人观点。Content are all from public sites and solely the author's and do not reflect the opinions and beliefs of affiliates.

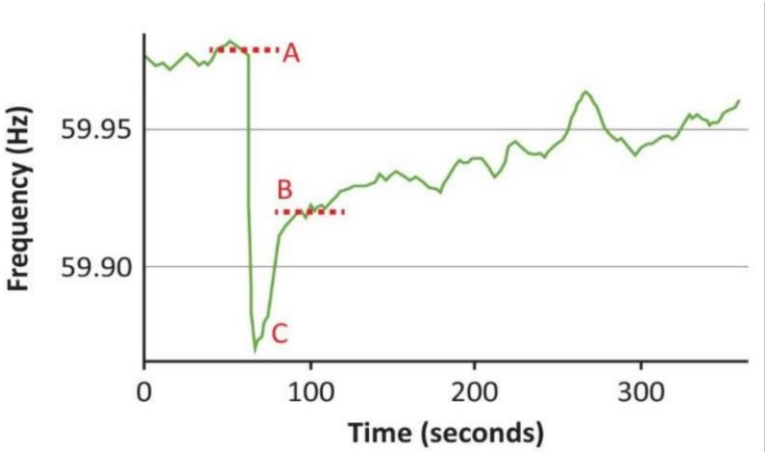
Blue Cut Fire induced 1,200 MW Solar Plant Trip

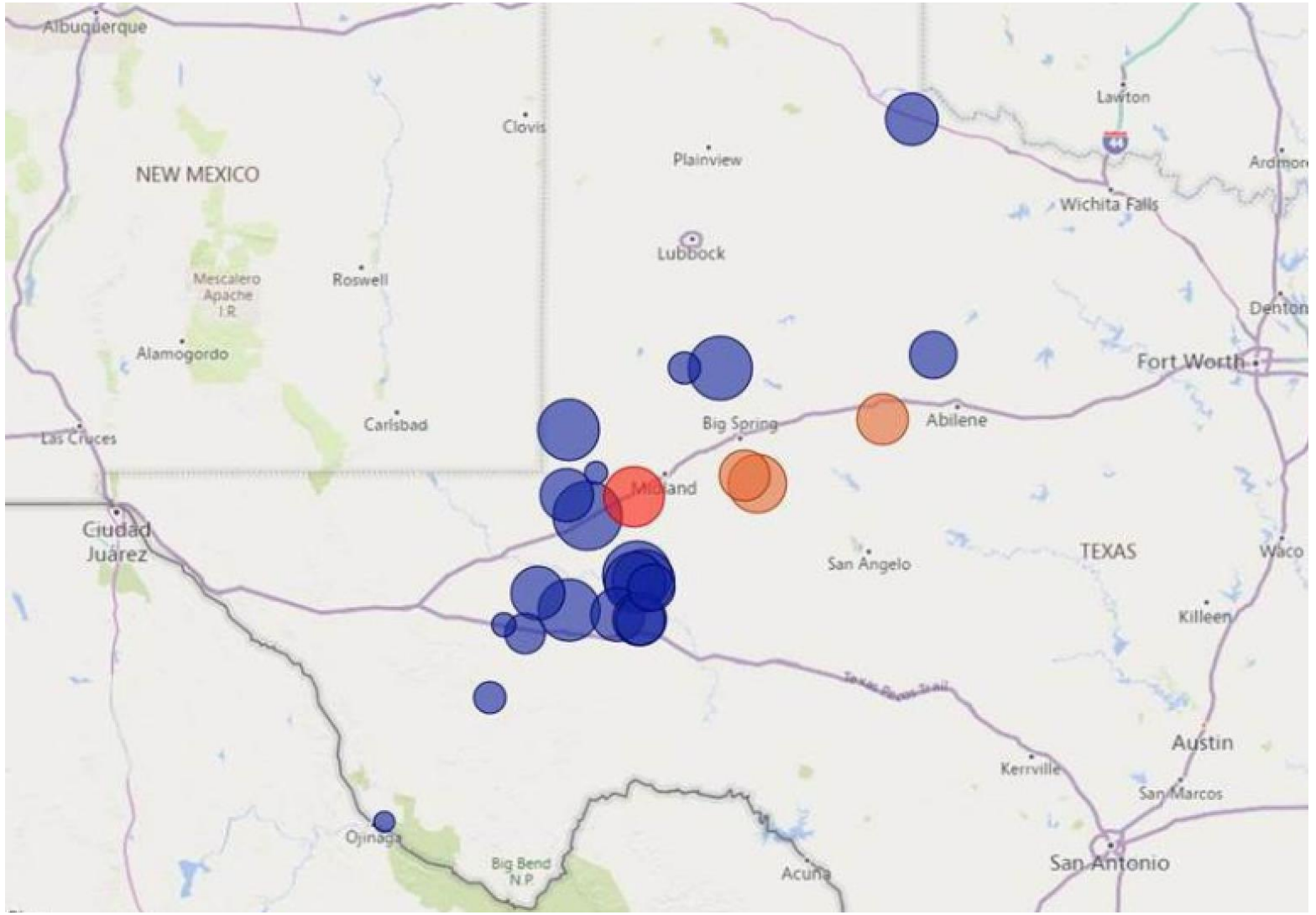


Fault induced 1,112 MW Solar Plant Trip

A single-line-to-ground (Phase A) fault occurred on a generator step-up (GSU) transformer at a combined-cycle power plant near Odessa, Texas. The fault caused voltages in the area to drop to 0.72 pu at the 345 kV connecting station for the generation facility, 0.84 pu around Fort Stockton at a 138 kV station, and as low as 0.54 pu at a 69 kV bus near Alpine, Texas.

In addition to the generation loss at the combined cycle plant, a number of solar PV and wind plants connected to the BPS also exhibited active power reductions caused by the fault event.





AGENDA

可持续的清洁能源

- 全球气候变暖？
- 全球能源消耗趋势
- 全球电力生产趋势

大电网的运行和控制

- 电的产生和运输
- 常用电力设备
- 北美电网组成
- 大电网稳定性问题
- 大停电事件

BC电网

- BC电网简介
- Site C
- Visitor Centres
- Outage Map
- Rebates

清洁能源 - WHY?

难以忽视的真相

An Inconvenient Truth

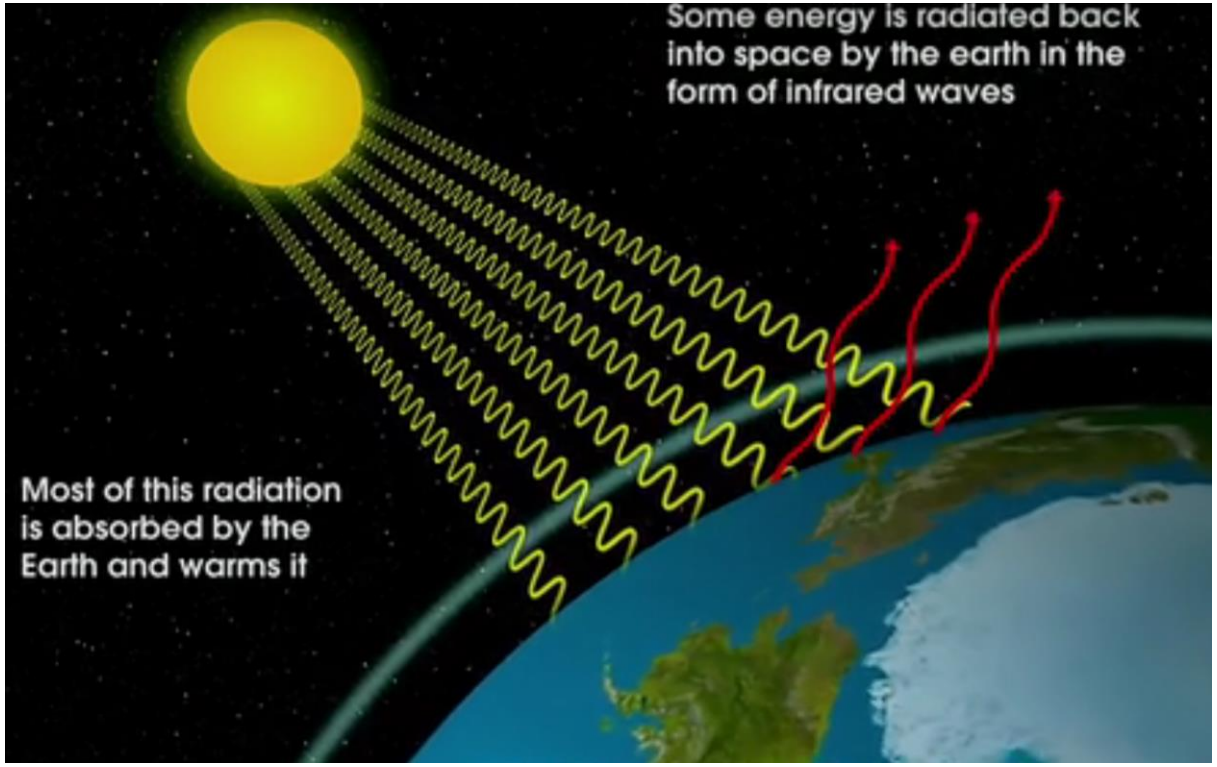
小艾伯特·阿诺德·“阿尔”·戈尔（Albert Arnold "Al" Gore, Jr.），是一名美国政治家，曾于1993年至2001年间在總統比尔·克林顿執政时期担任副總統。2000年美國總統大選後成为国际知名的环境活动家，戈尔之後成为一名世界著名的环境活动家，他经常以全球暖化问题作为他在公开场合演讲的主题。2006年，他推出了自己参与制作和演出的纪录片《难以忽视的真相》（An Inconvenient Truth），主要讲述了工业化对全球气候变暖和人类生存的影响。此片在不少国家引起了广大的回响，并获得第79届奥斯卡金像奖的最佳纪录片与最佳电影歌曲奖。在他的组织下，全球于2007年7月7日举行了Live Earth全球抗暖化明星接力演唱會，深获全球好评。

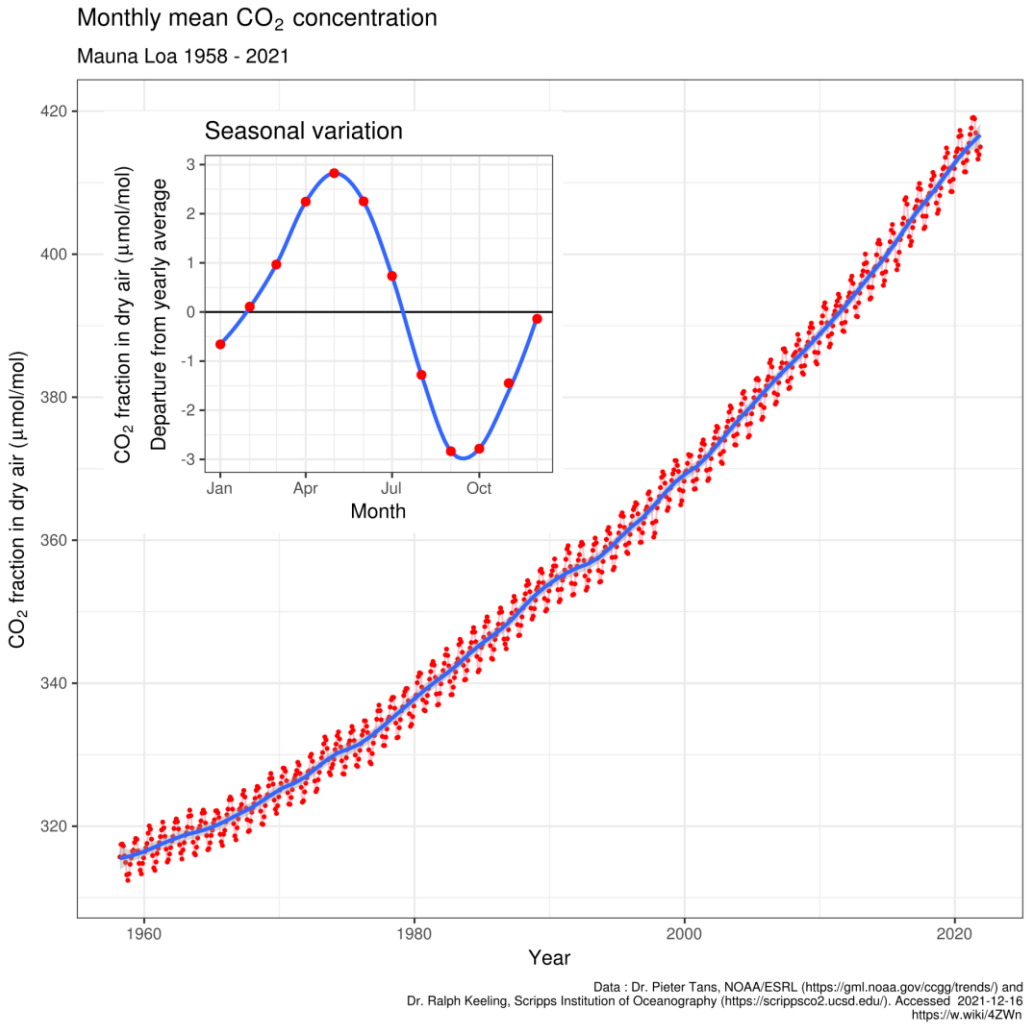
2007年10月，他和联合国组织政府间气候变化专门委员会一起获得了诺贝尔和平奖，理由是他“唤醒了对由气候变化所带来的危险的意识”。戈爾在其個人網站表示會將獎金全數捐予由他創辦的環保教育組織-氣候保護聯盟



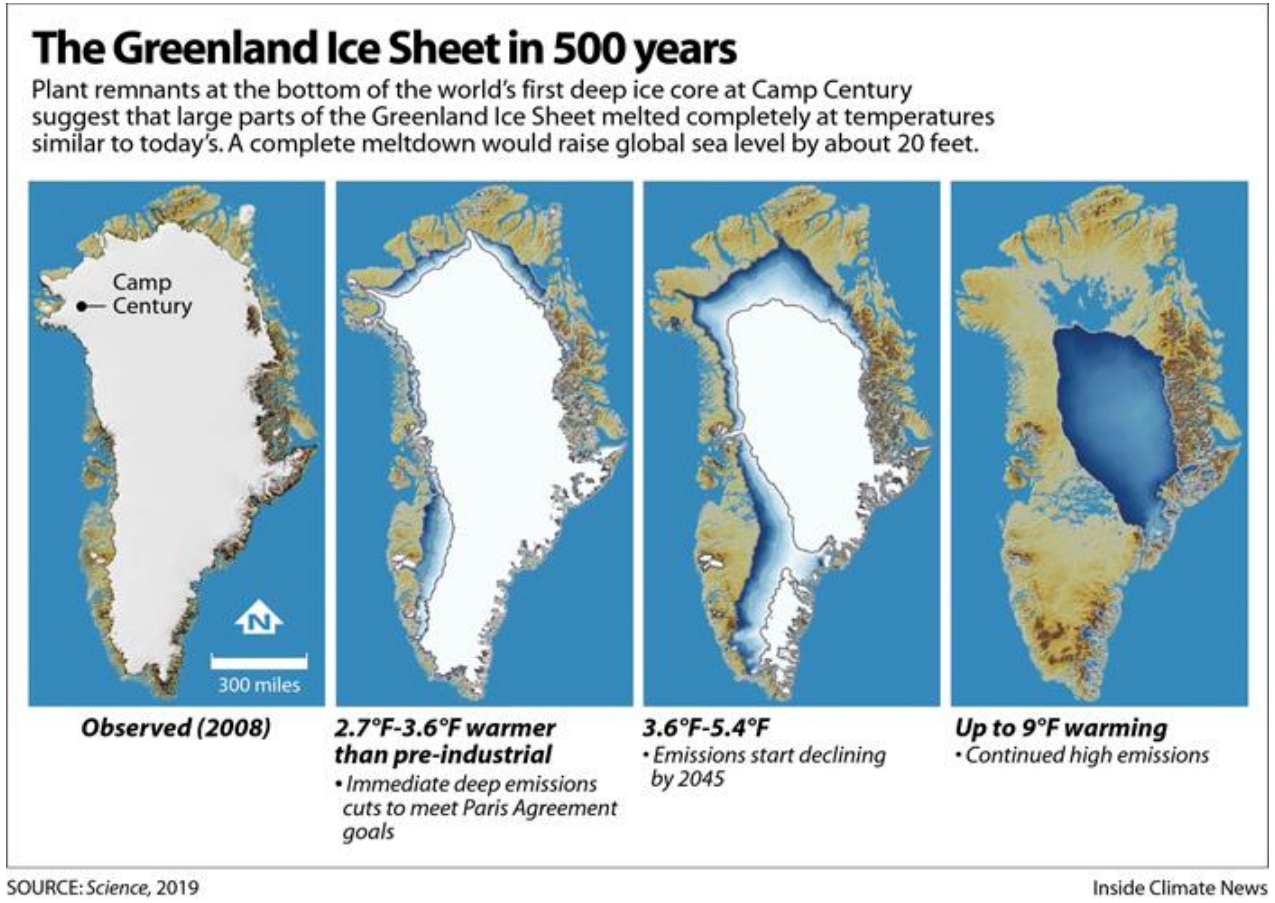
难以忽视的真相

CO2温室气体和排放量

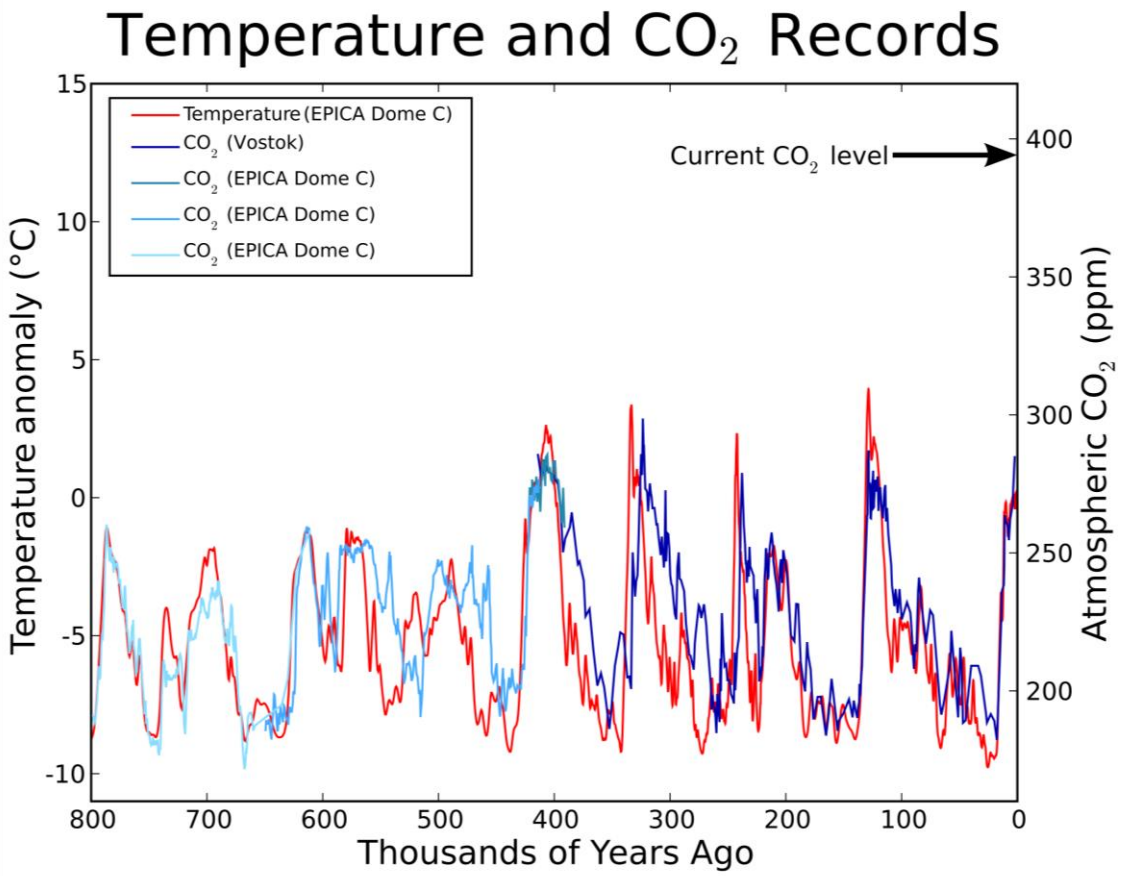


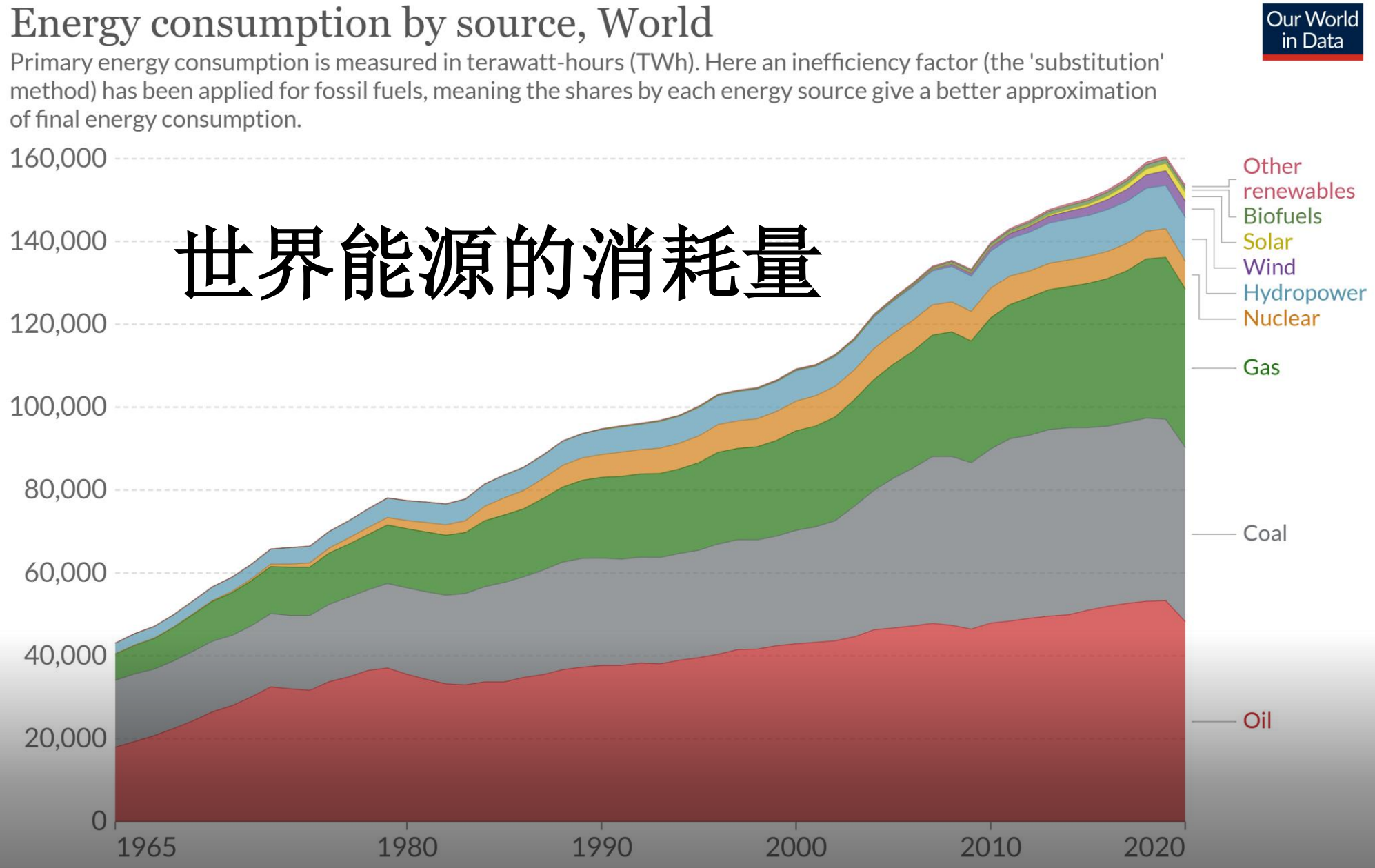


冰川融化和海平面升高



CO2和气温，相关？

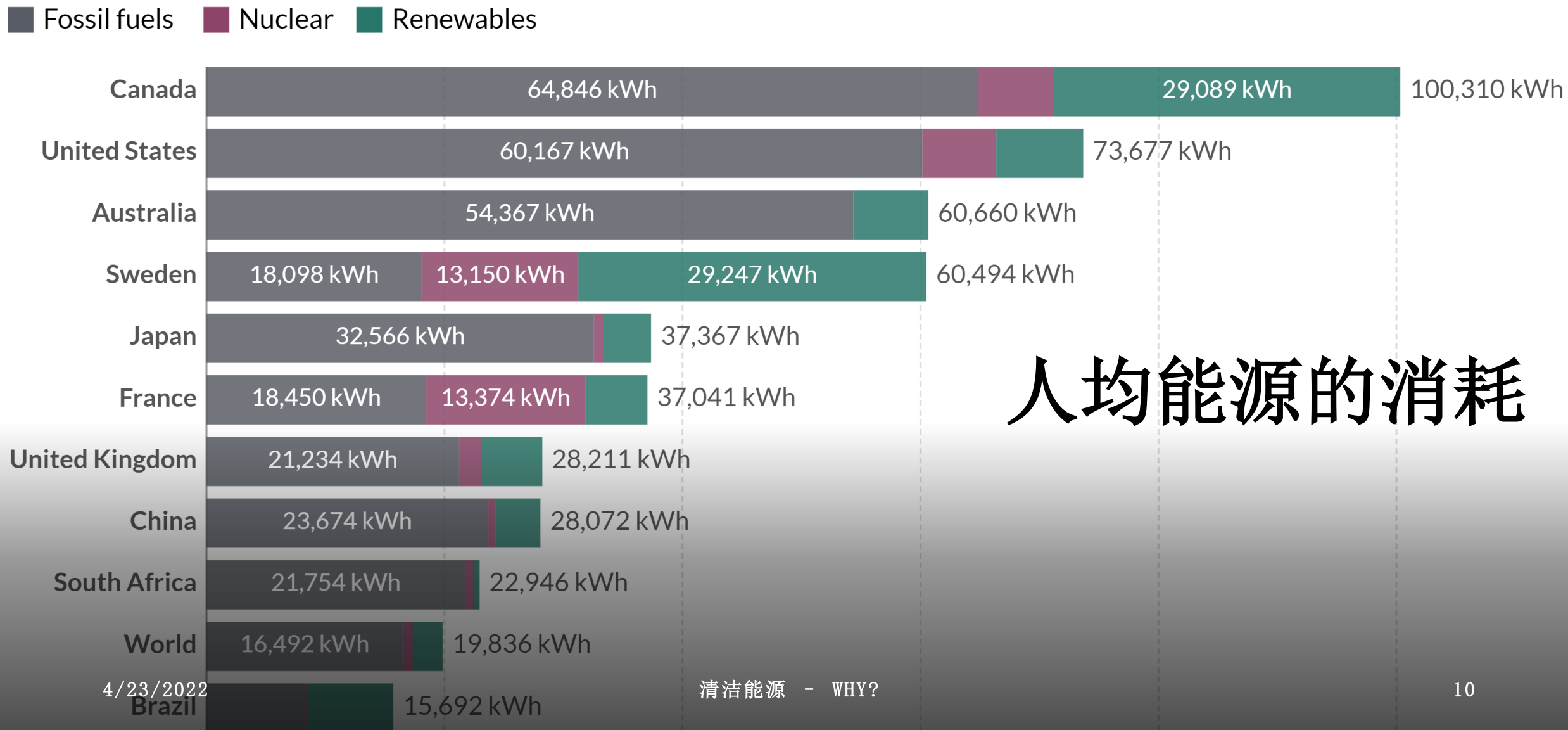



Energy consumption by source, World
Primary energy consumption is measured in terawatt-hours (TWh). Here an inefficiency factor (the 'substitution' method) has been applied for fossil fuels, meaning the shares by each energy source give a better approximation of final energy consumption.
Our World in Data
世界能源的消耗量
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1965
1980
1990
2000
2010
2020
Other renewables
Biofuels
Solar
Wind
Hydropower
Nuclear
Gas
Coal
Oil
Source: BP Statistical Review of World Energy
Note: 'Other renewables' includes geothermal, biomass and waste energy.
OurWorldInData.org/energy • CC BY

Per capita energy from fossil fuels, nuclear and renewables, 2020

Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.

Our World in Data

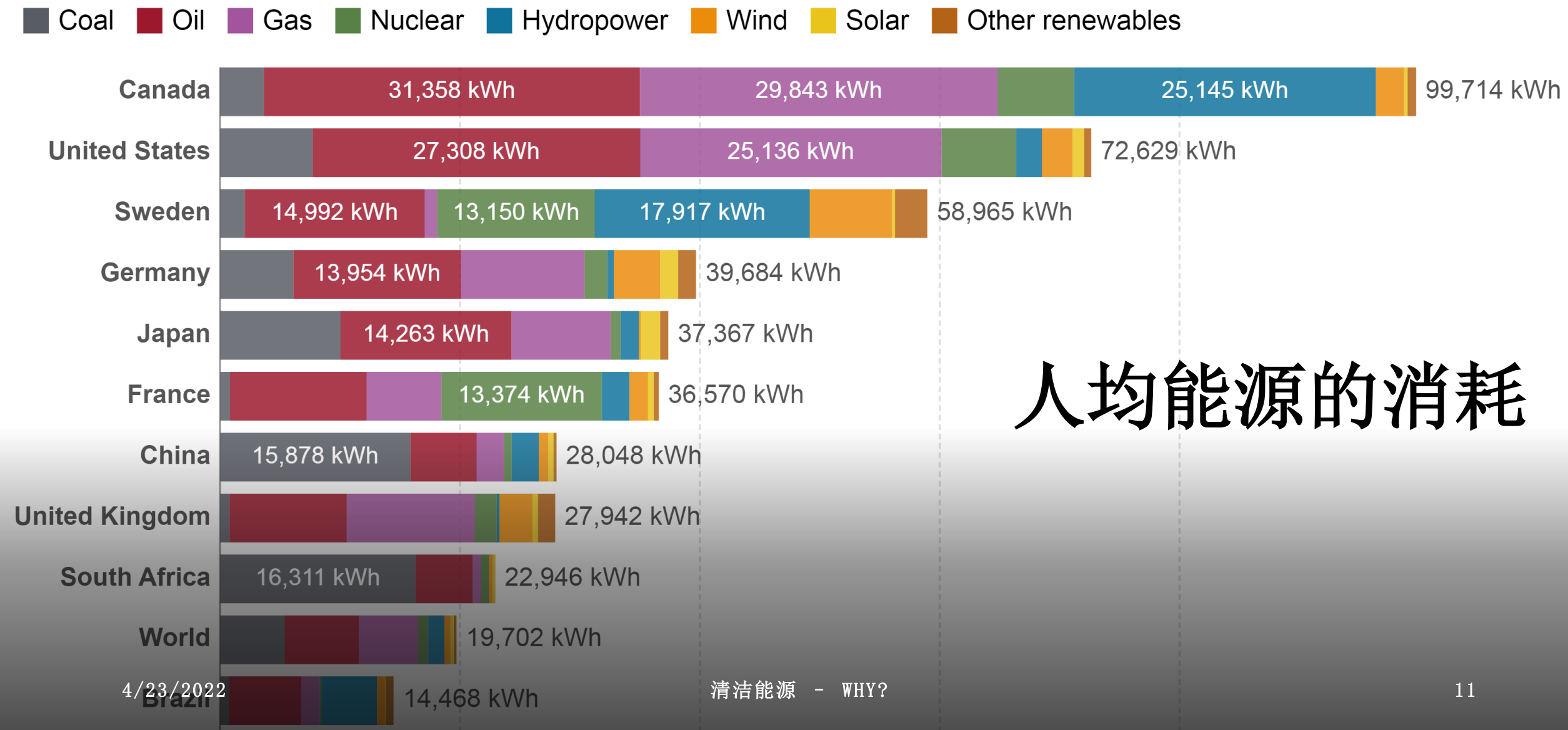


人均能源的消耗

Per capita primary energy consumption by source, 2020

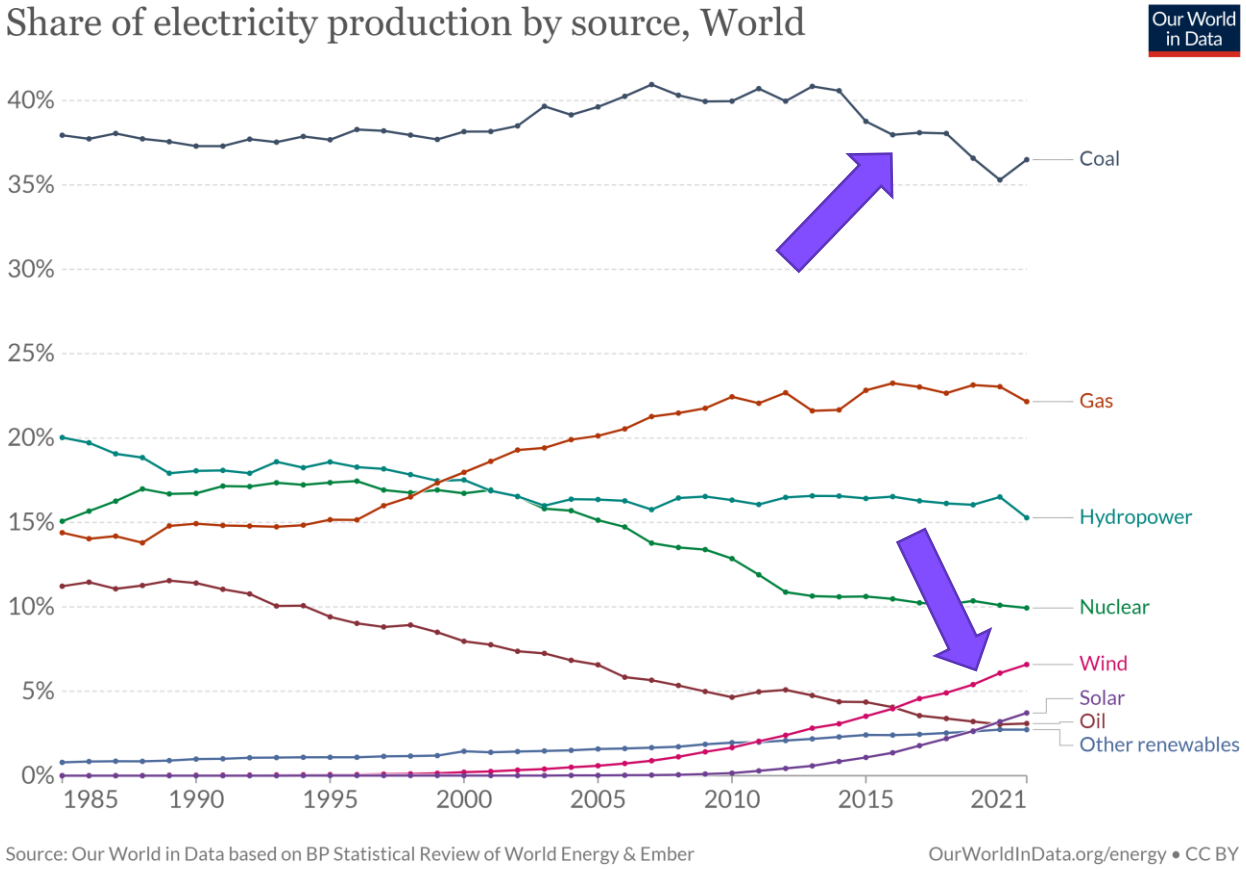
Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.

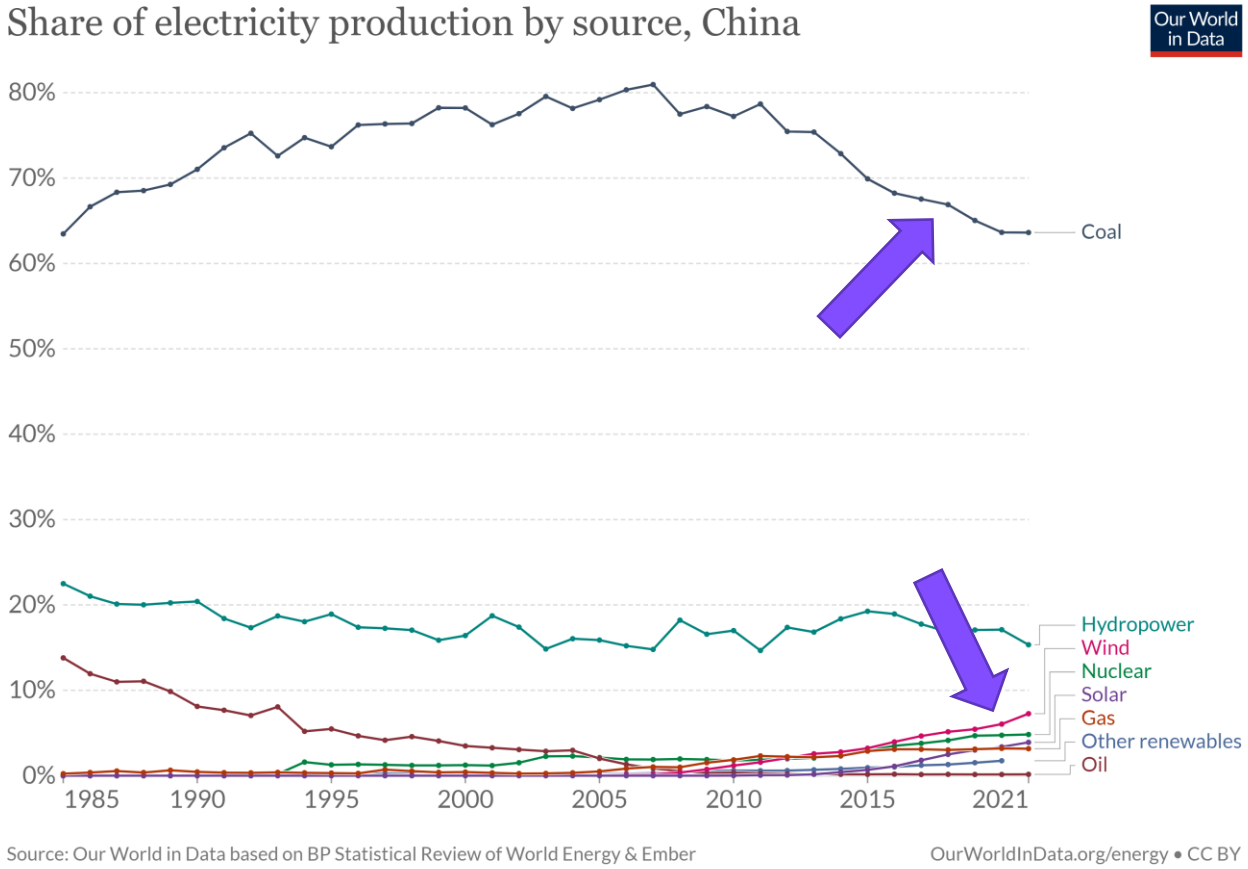
Our World in Data



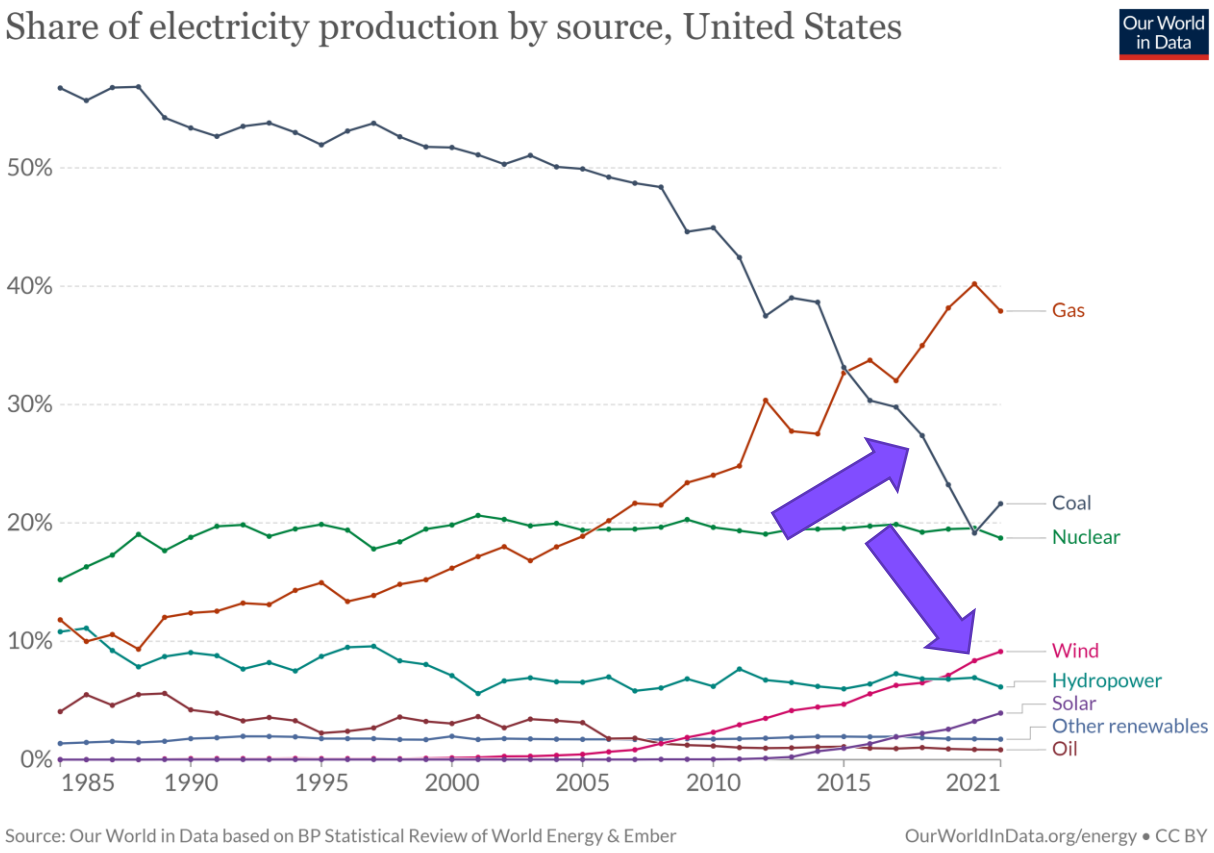
人均能源的消耗

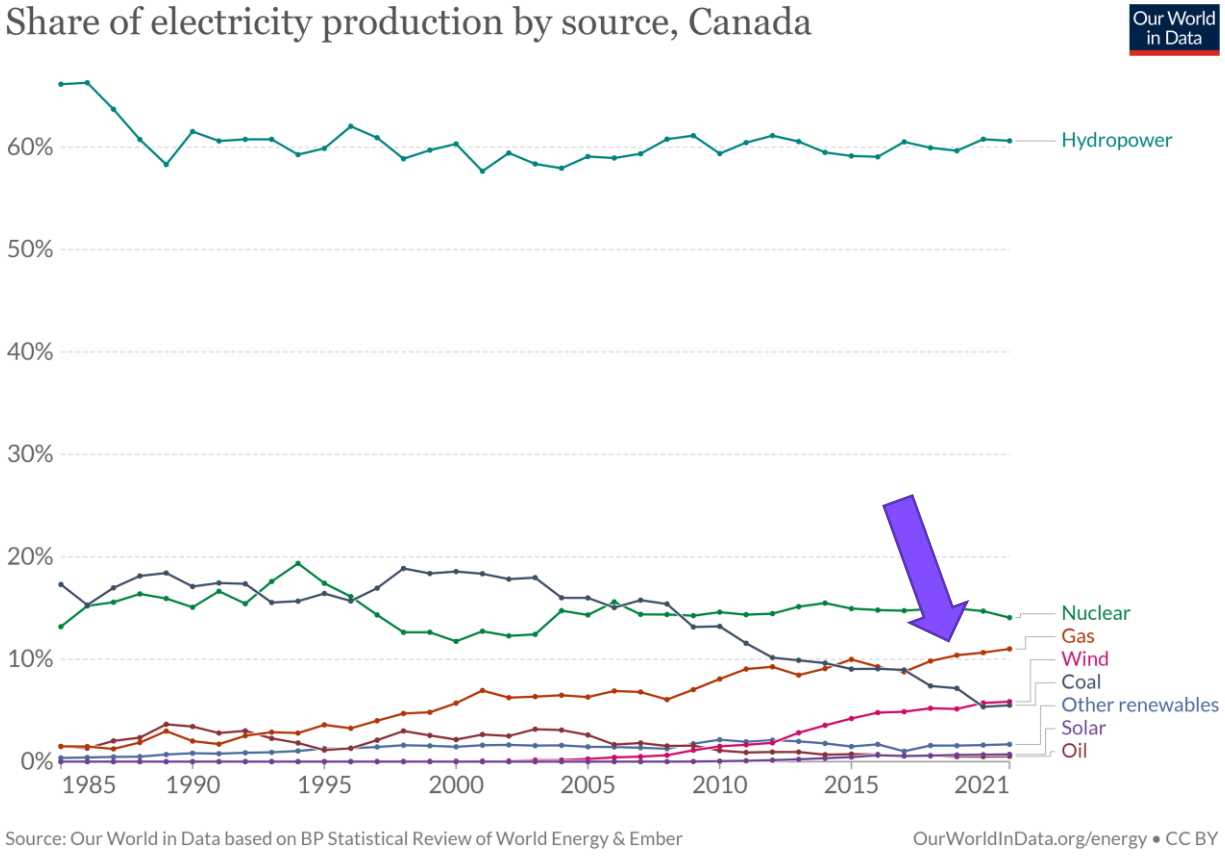
电力的来源（世界和中国）


Share of electricity production by source, World
Our World in Data
40%
35%
30%
25%
20%
15%
10%
5%
0%
1985
1990
1995
2000
2005
2010
2015
2021
Coal
Gas
Hydropower
Nuclear
Wind
Solar
Oil
Other renewables
Source: Our World in Data based on BP Statistical Review of World Energy & Ember
OurWorldInData.org/energy • CC BY


Share of electricity production by source, China
Our World in Data
80%
70%
60%
50%
40%
30%
20%
10%
0%
1985
1990
1995
2000
2005
2010
2015
2021
Coal
Hydropower
Wind
Nuclear
Solar
Gas
Other renewables
Oil
Source: Our World in Data based on BP Statistical Review of World Energy & Ember
OurWorldInData.org/energy • CC BY

电力的来源（美国和加拿大）

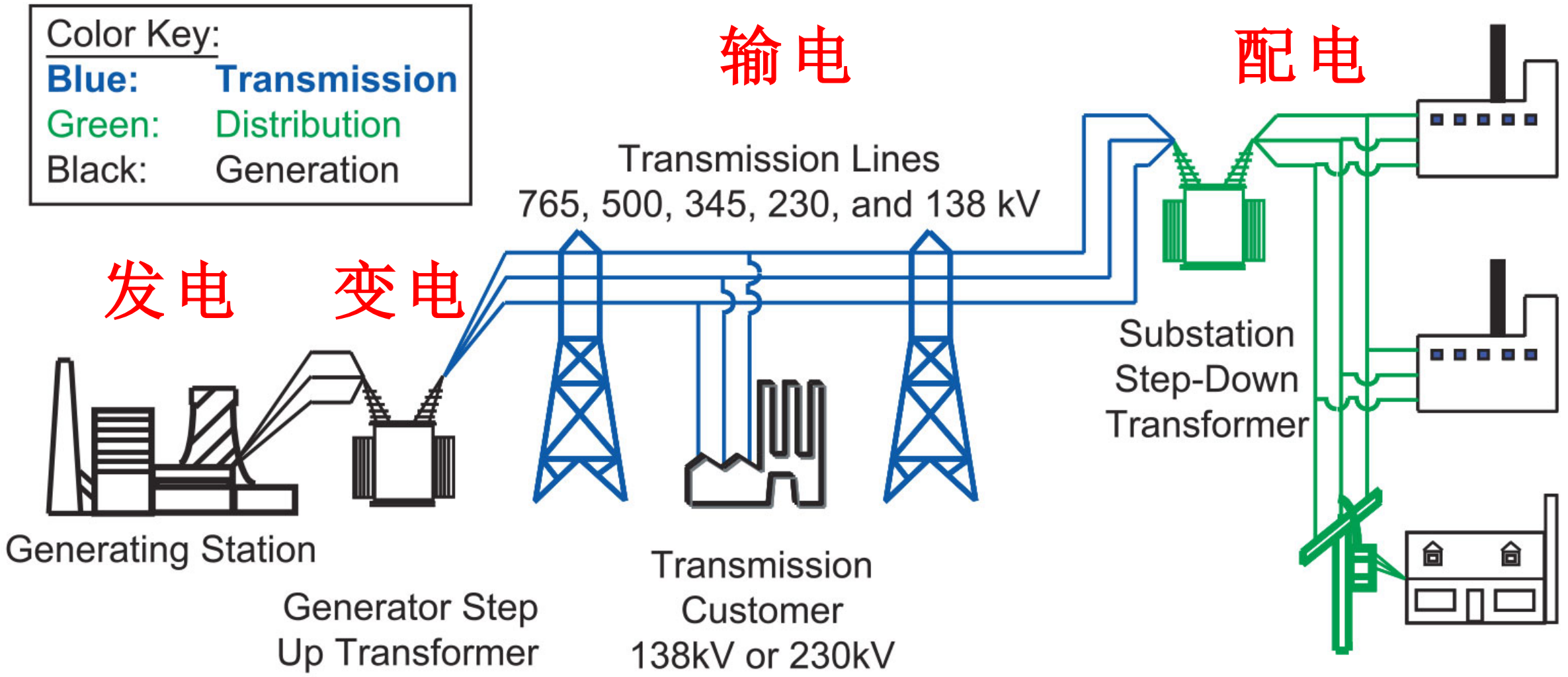




大电网的运行和控制

电的产生和运输

用电

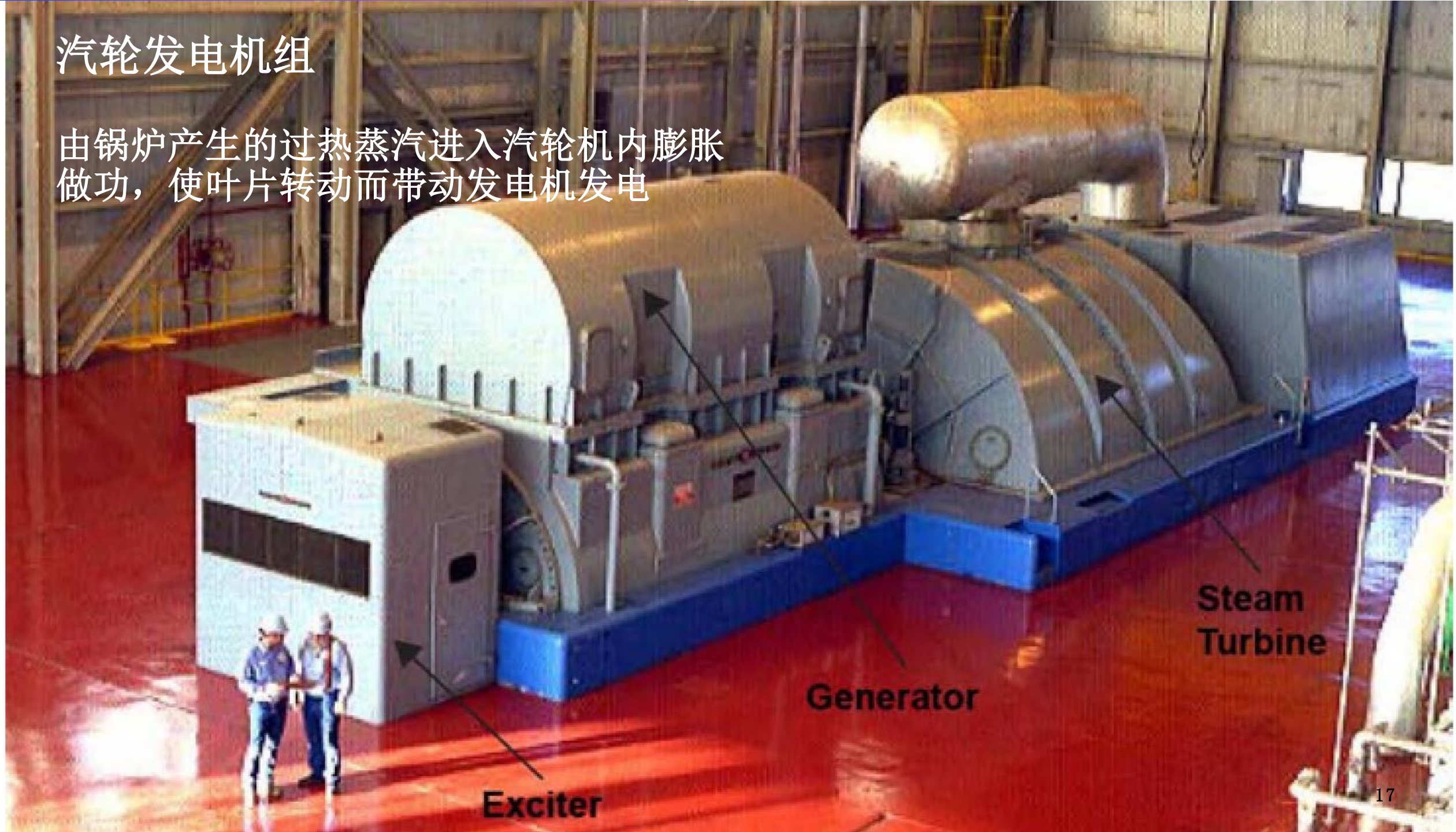

Color Key:
Blue: Transmission
Green: Distribution
Black: Generation
输电
配电
Transmission Lines
765, 500, 345, 230, and 138 kV
发电
变电
Substation
Step-Down
Transformer
Generating Station
Generator Step
Up Transformer
Transmission
Customer
138kV or 230kV



https://www.youtube.com/watch?v=n2VCRwVs8yE

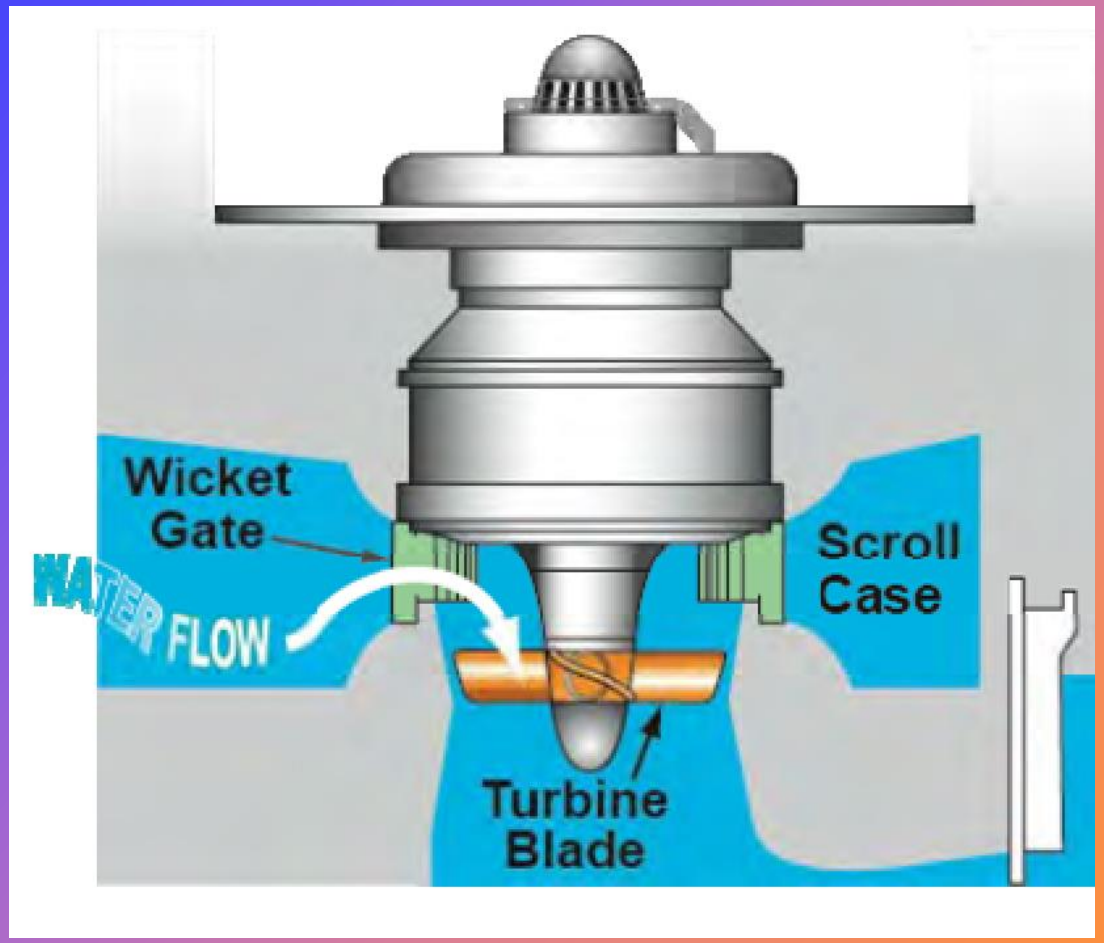
汽轮发电机组

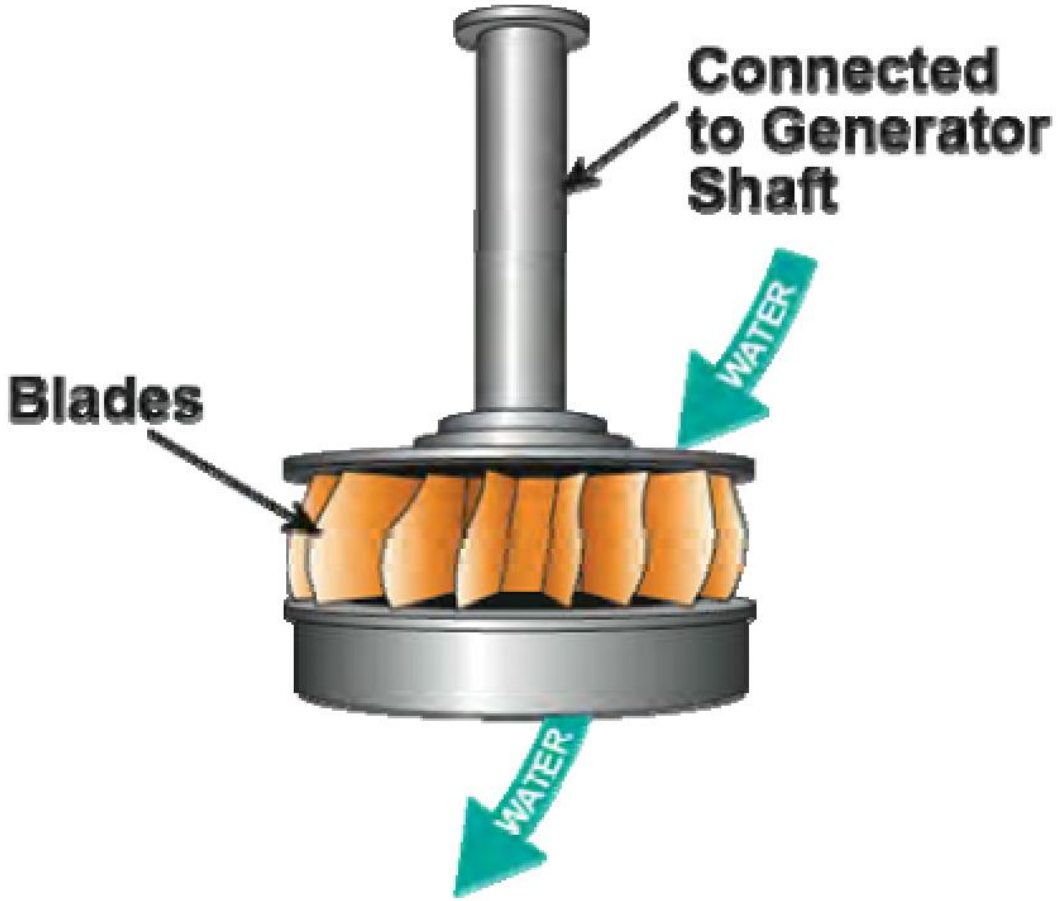
由锅炉产生的过热蒸汽进入汽轮机内膨胀做功，使叶片转动而带动发电机发电



水轮发电机组

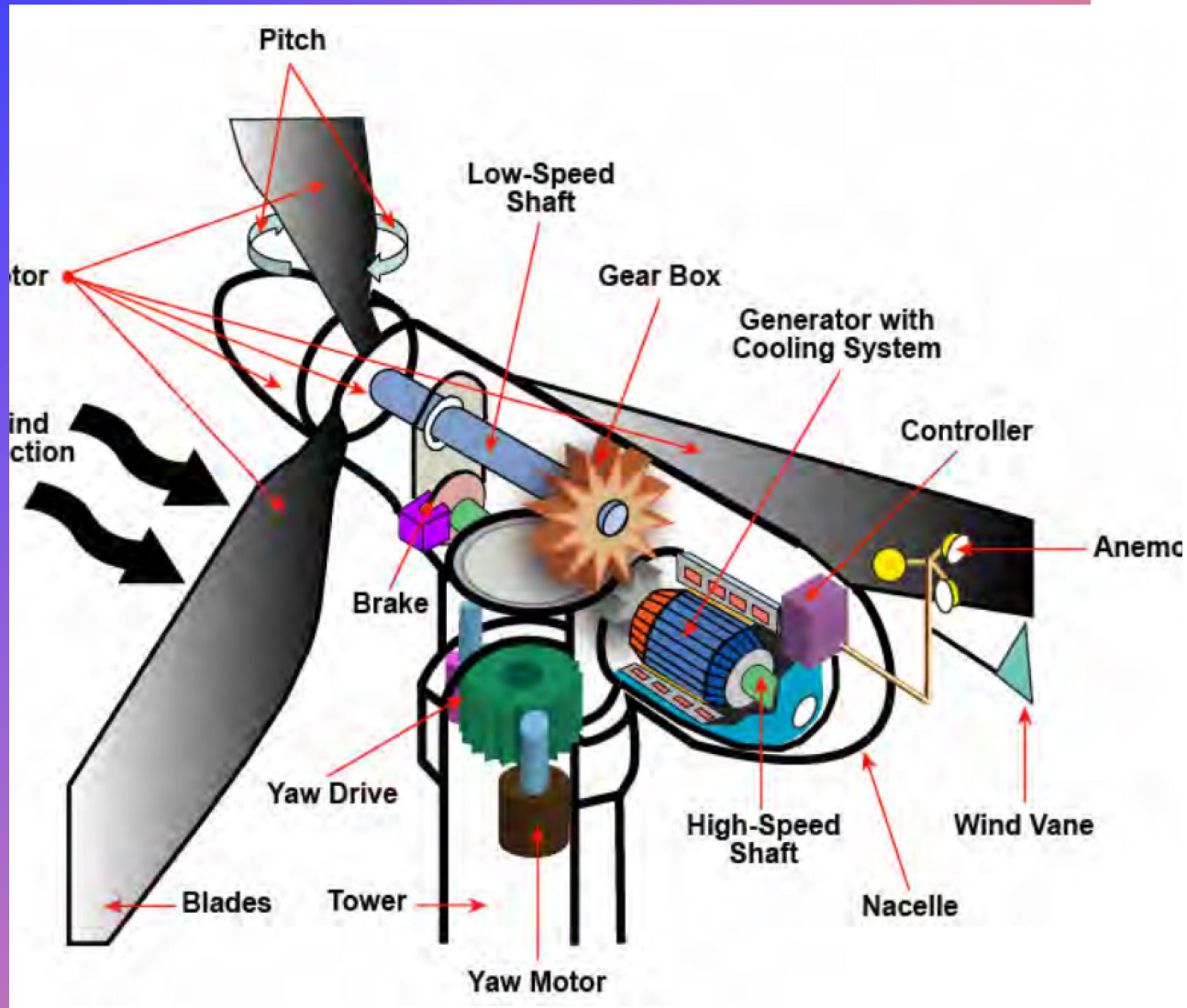
水轮发电机是指以水轮机为原动机将水能转化为电能的发电机。水流经过水轮机时，将水能转换成机械能，水轮机的转轴又带动发电机的转子，将机械能转换成电能而输出。





风力发电机组

风力发电机组包括风轮、发电机；风轮中含叶片、轮毂、加固件等组成；它有叶片受风力旋转发电、发电机机头转动等功能。风力发电电源由风力发电机组、支撑发电机组的塔架、蓄电池充电控制器、逆变器、卸荷器、并网控制器、蓄电池组等组成。

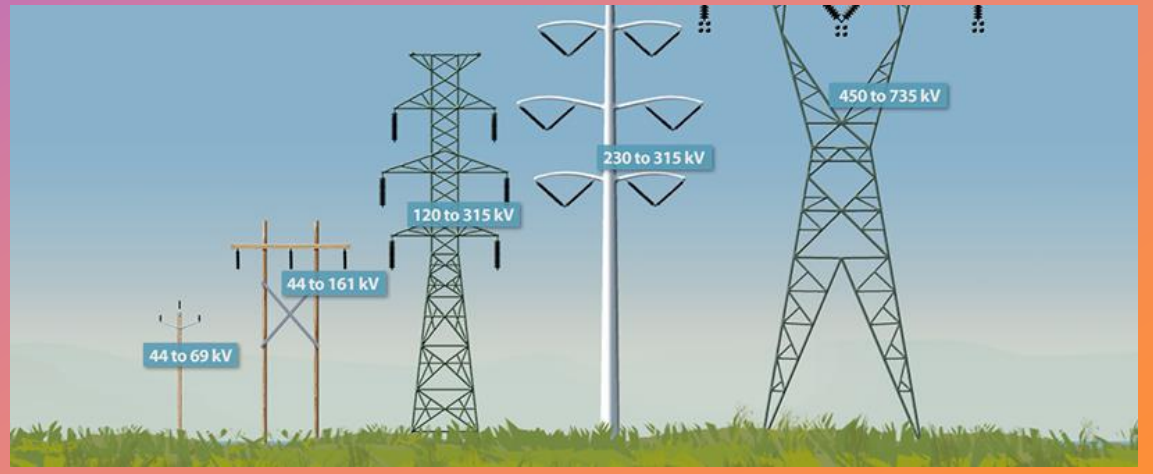


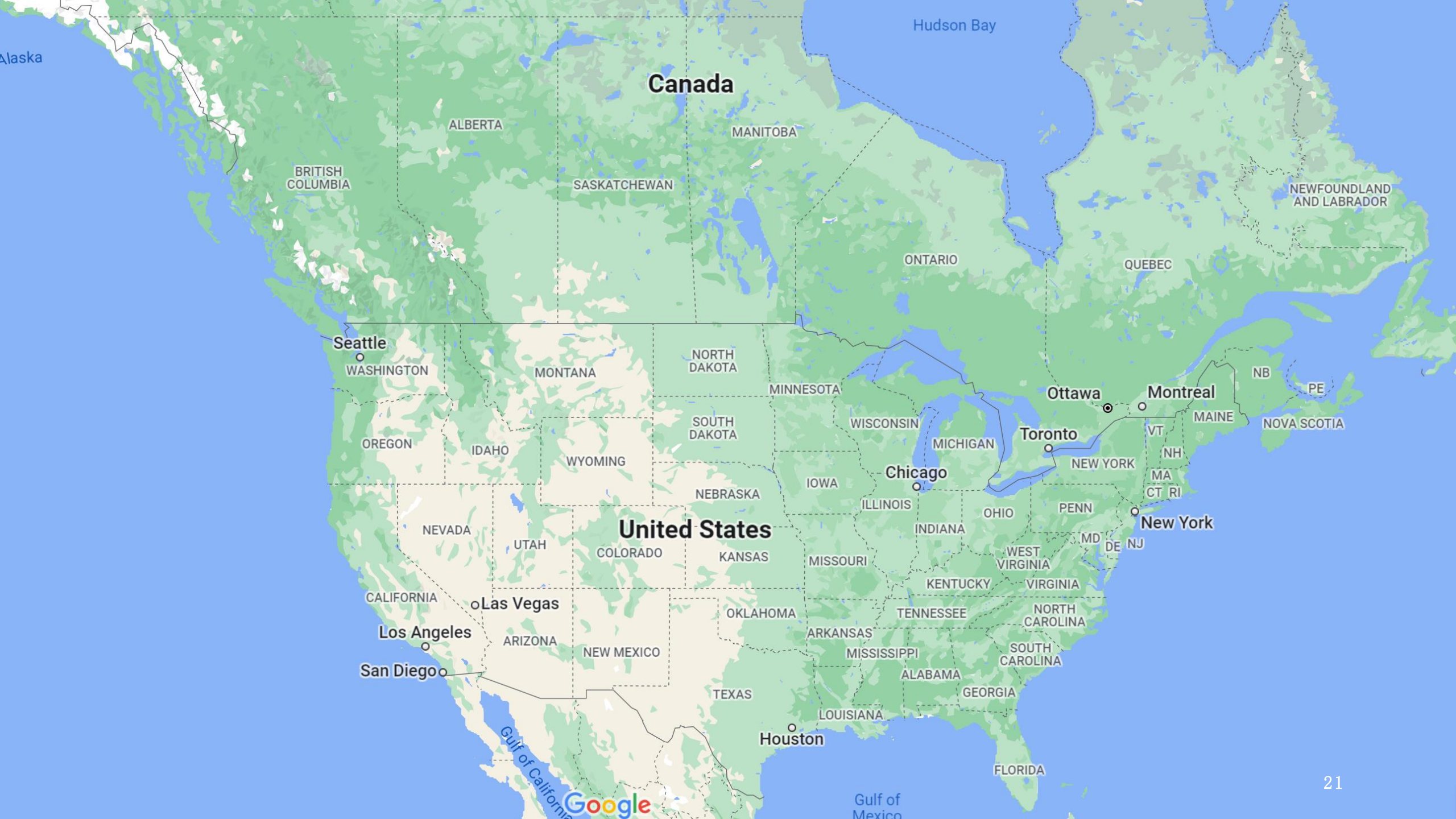


常见电力设备

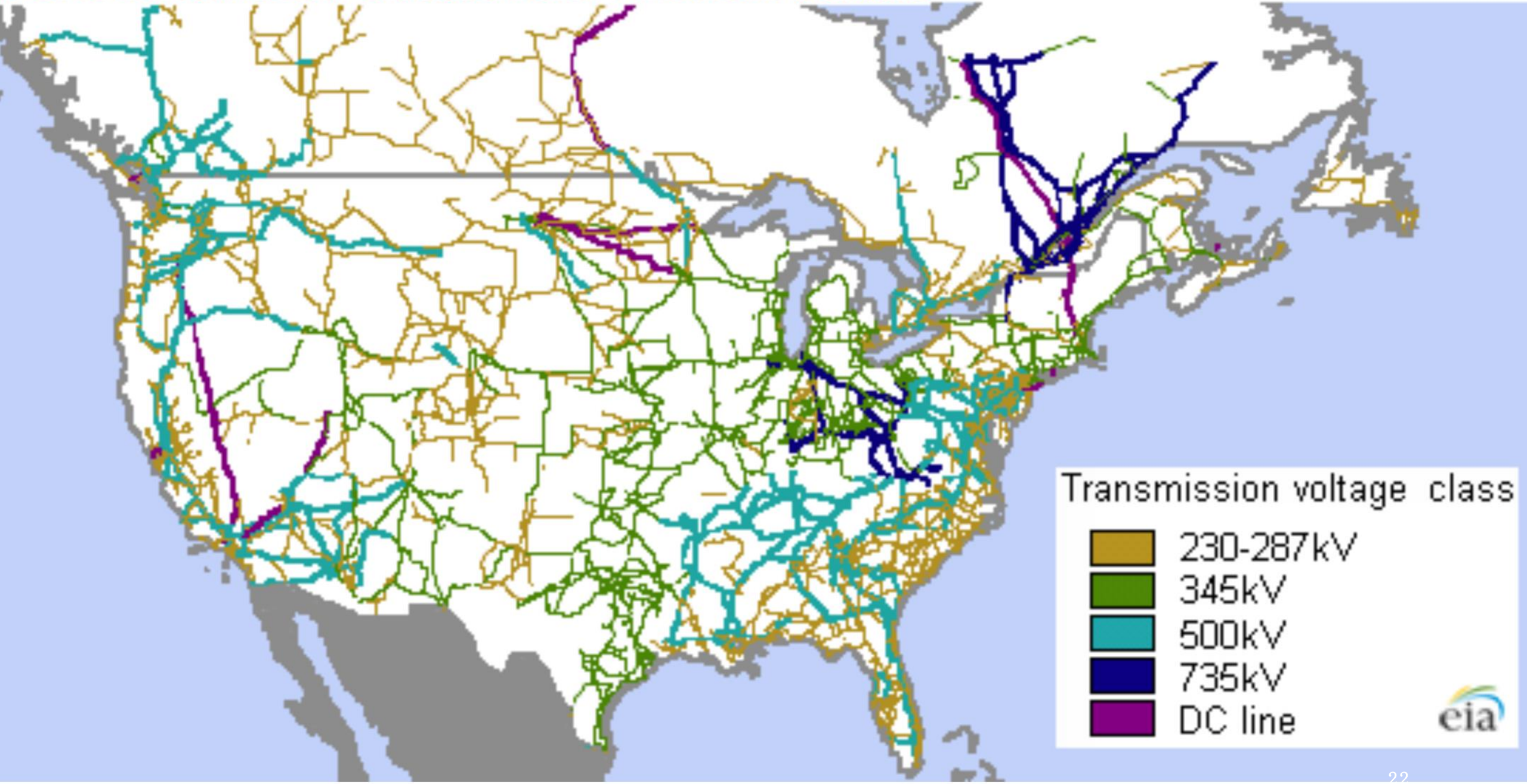




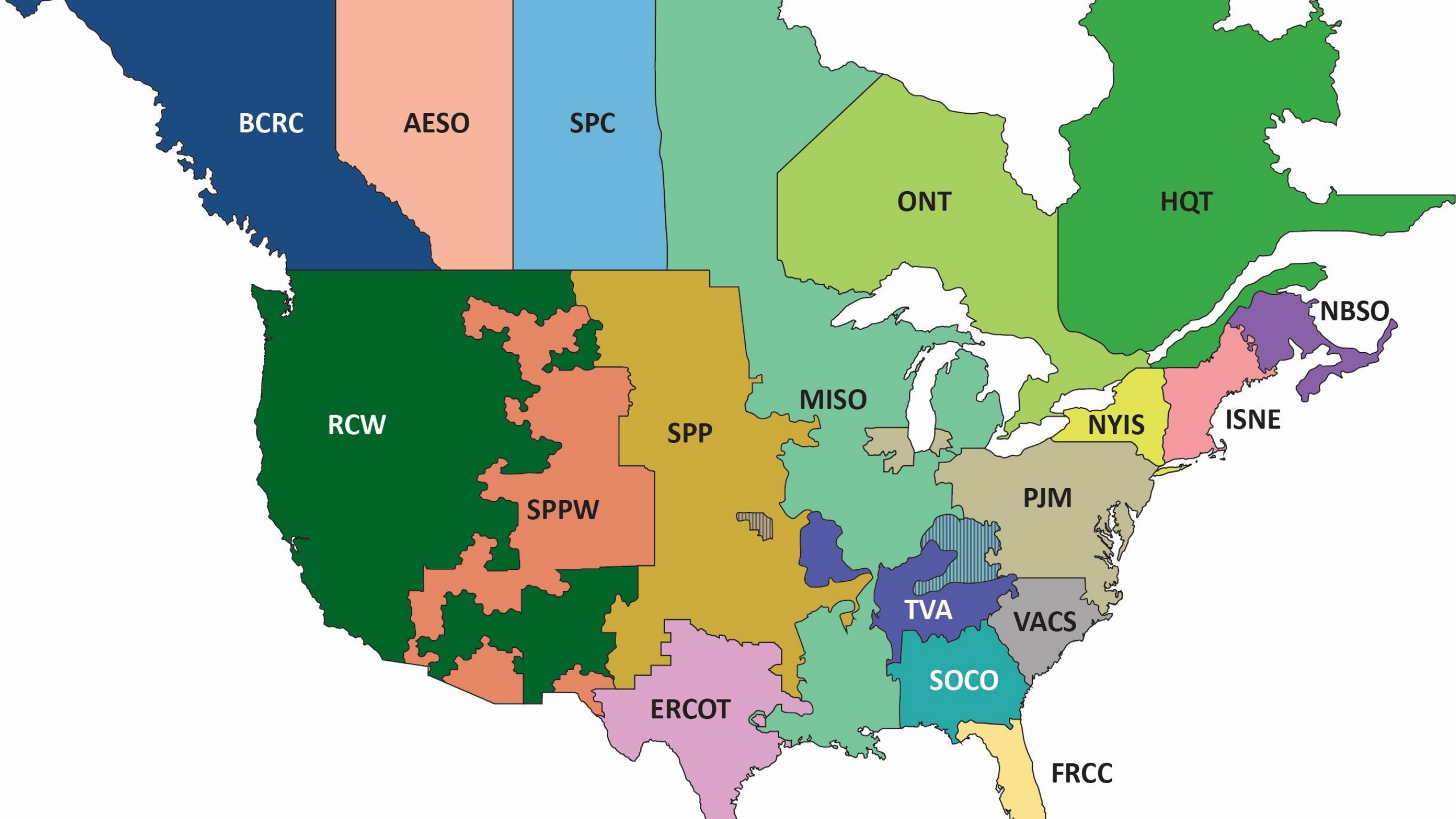


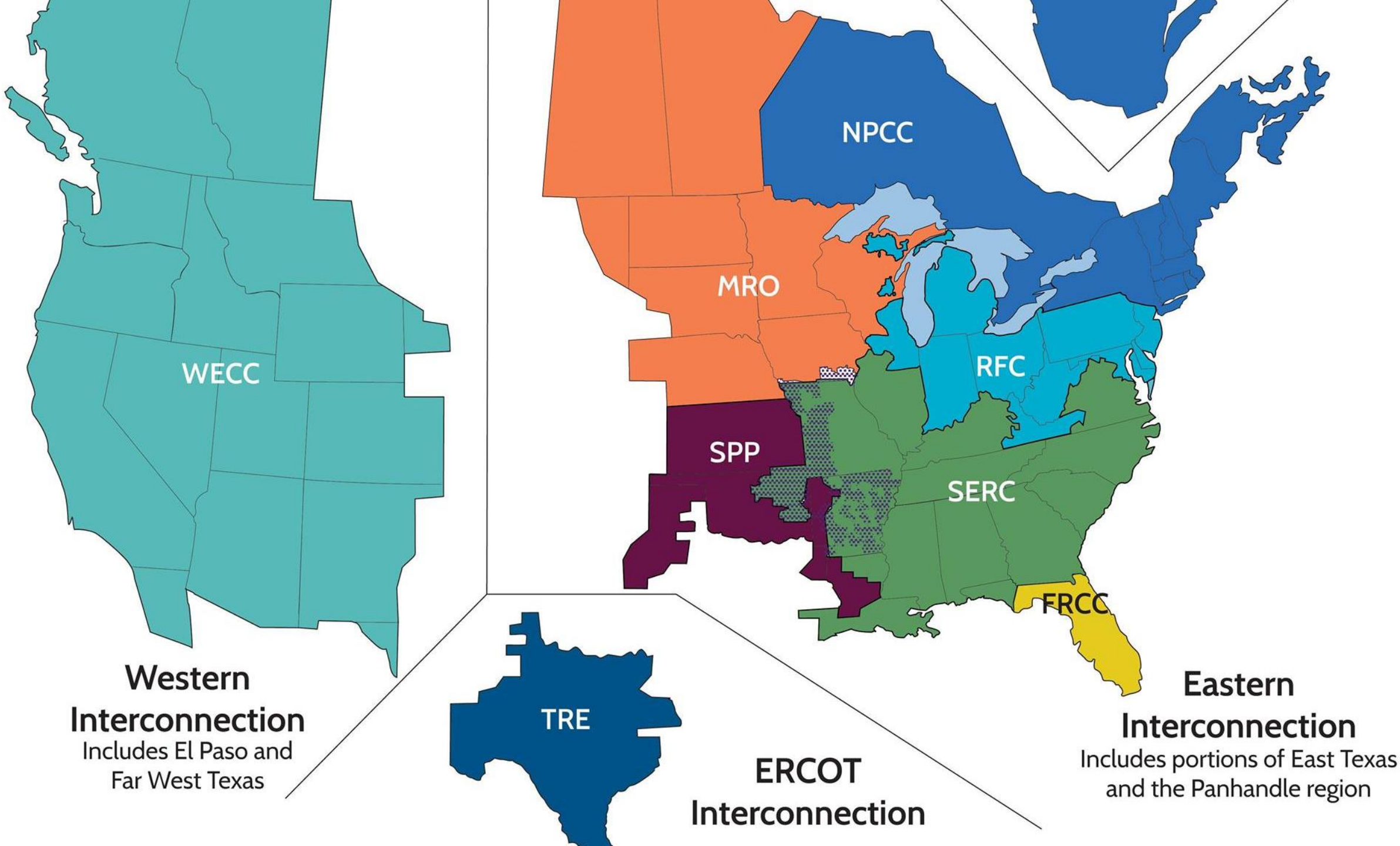

Hudson Bay
Alaska
Canada
ALBERTA
MANITOBA
BRITISH COLUMBIA
SASKATCHEWAN
NEWFOUNDLAND AND LABRADOR
ONTARIO
QUEBEC
Seattle
WASHINGTON
NORTH DAKOTA
MONTANA
MINNESOTA
Ottawa
Montreal
NB
PE
SOUTH DAKOTA
WISCONSIN
MAINE
NOVA SCOTIA
Toronto
OREGON
IDAHO
MICHIGAN
VT
WYOMING
NEW YORK
NH
Chicago
IOWA
MA
NEBRASKA
CT
RI
ILLINOIS
OHIO
PENN
New York
United States
NEVADA
UTAH
INDIANA
MD
DE
NJ
COLORADO
KANSAS
MISSOURI
WEST VIRGINIA
KENTUCKY
VIRGINIA
CALIFORNIA
Las Vegas
OKLAHOMA
TENNESSEE
NORTH CAROLINA
Los Angeles
ARKANSAS
ARIZONA
NEW MEXICO
MISSISSIPPI
SOUTH CAROLINA
San Diego
ALABAMA
TEXAS
GEORGIA
LOUISIANA
Houston
FLORIDA
Gulf of Mexico
Google

lectric transmission crosses North American borders

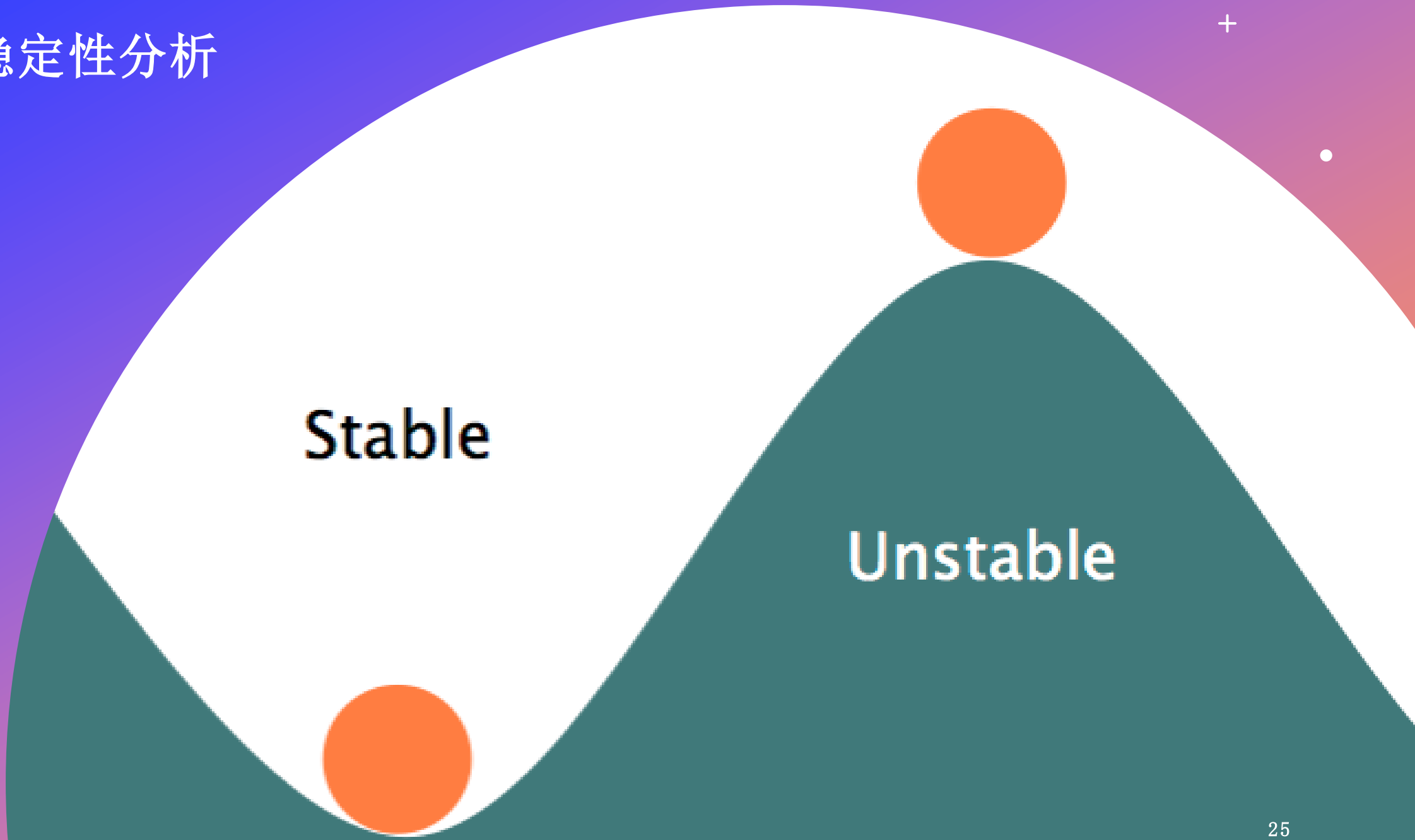


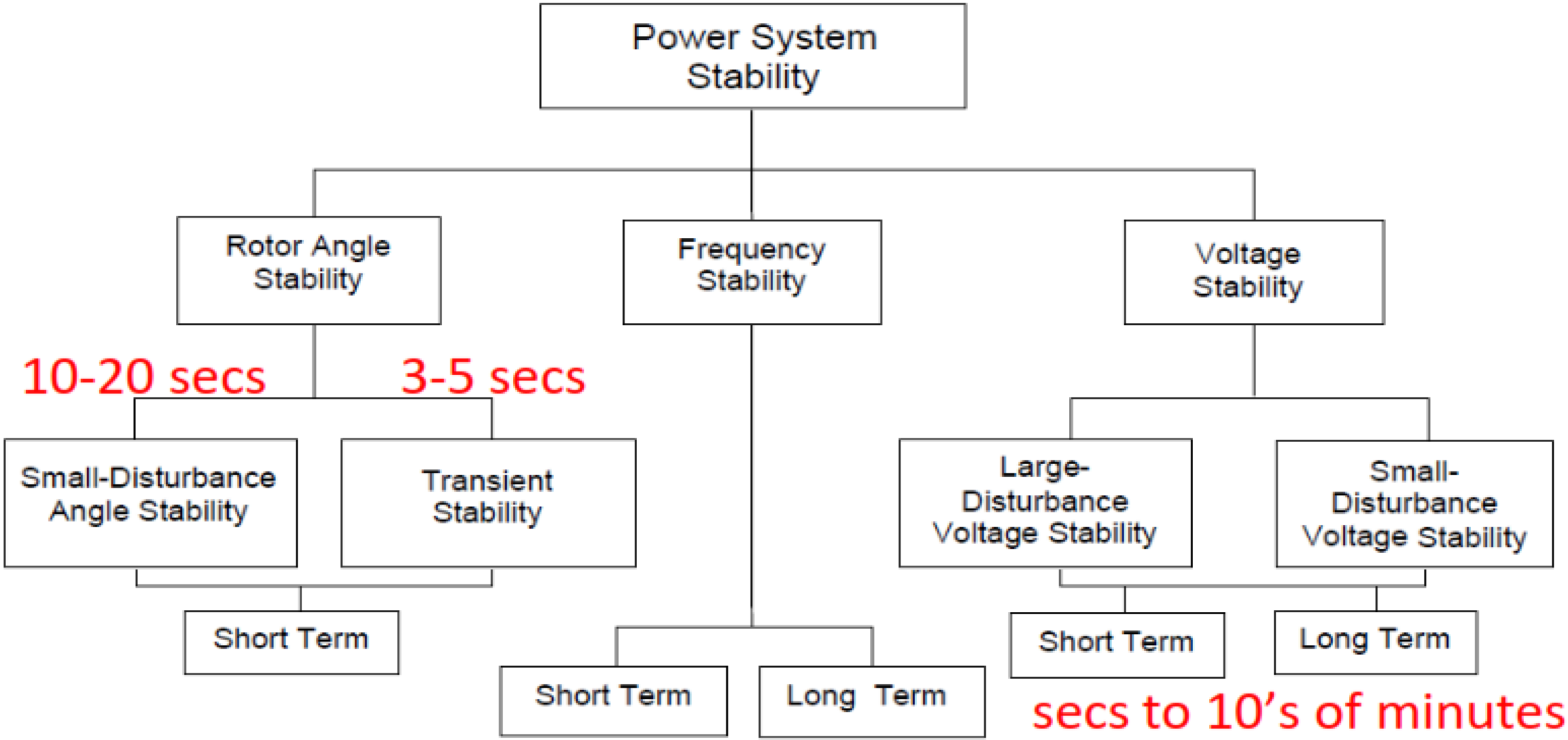
ources: U.S. Energy Information Administration, based on Energy Velocity.


BCRC
AESO
SPC
ONT
HQT
NBSO
RCW
SPP
MISO
NYIS
ISNE
SPPW
PJM
TVA
VACS
SOCO
ERCOT
FRCC


NPCC
MRO
WECC
RFC
SPP
SERC
FRCC
TRE
Western Interconnection
Includes El Paso and Far West Texas
ERCOT Interconnection
Eastern Interconnection
Includes portions of East Texas and the Panhandle region

系统稳定性分析

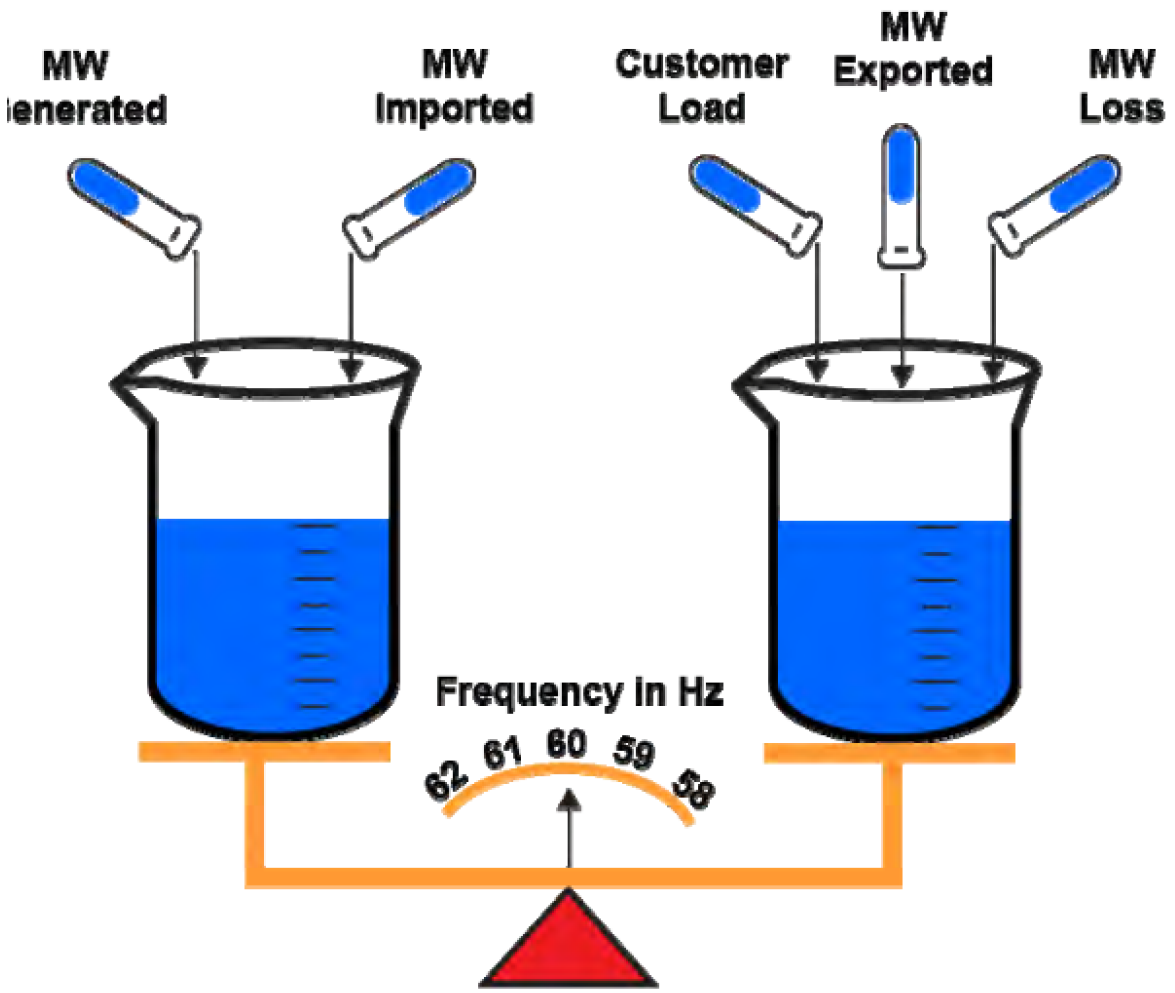



Power System Stability
Rotor Angle Stability
Frequency Stability
Voltage Stability
10-20 secs
3-5 secs
Small-Disturbance Angle Stability
Transient Stability
Short Term
Short Term
Long Term
Large-Disturbance Voltage Stability
Small-Disturbance Voltage Stability
Short Term
Long Term
secs to 10's of minutes
Fraction of secs to several minutes

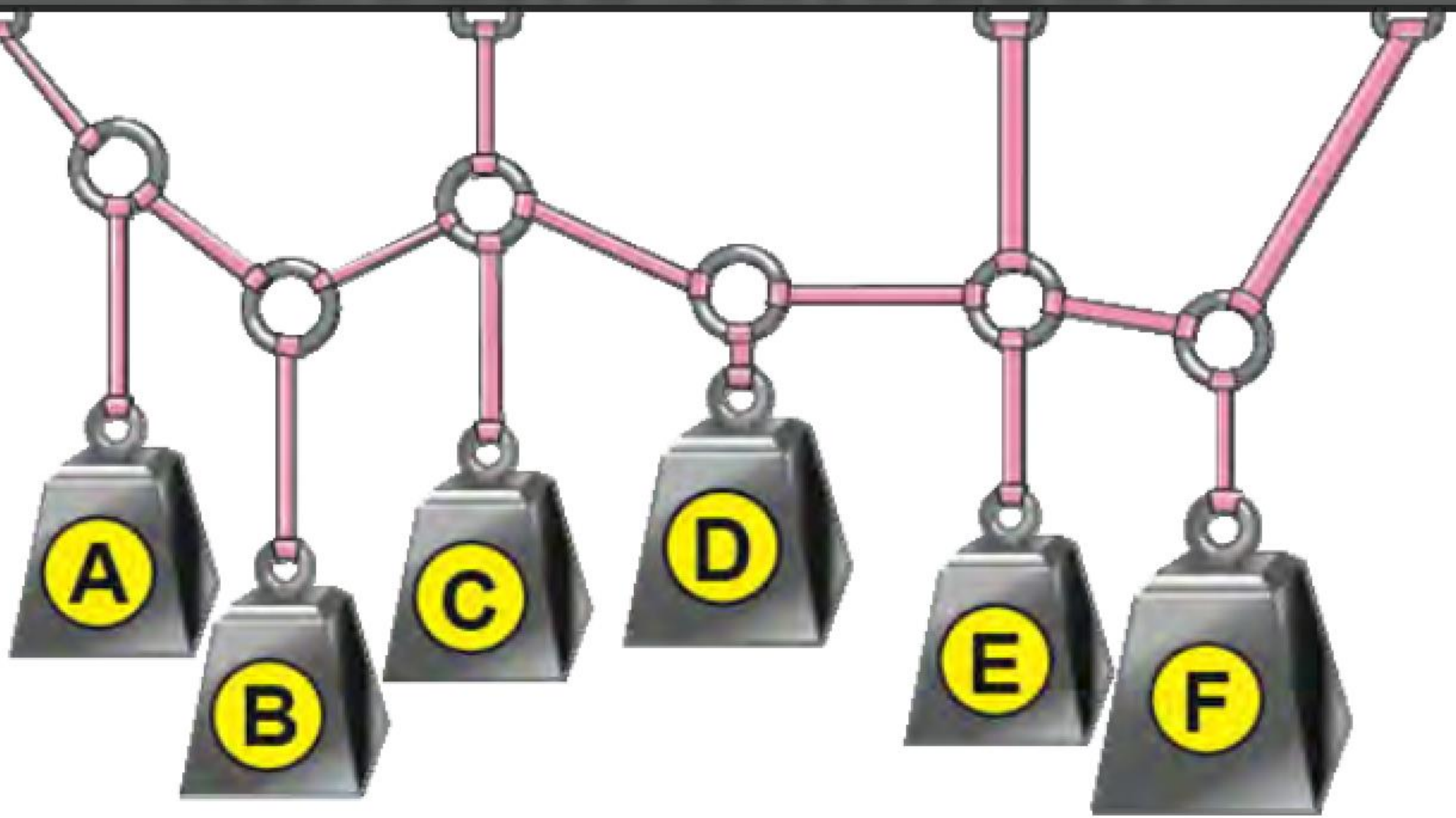


电网频率的控制

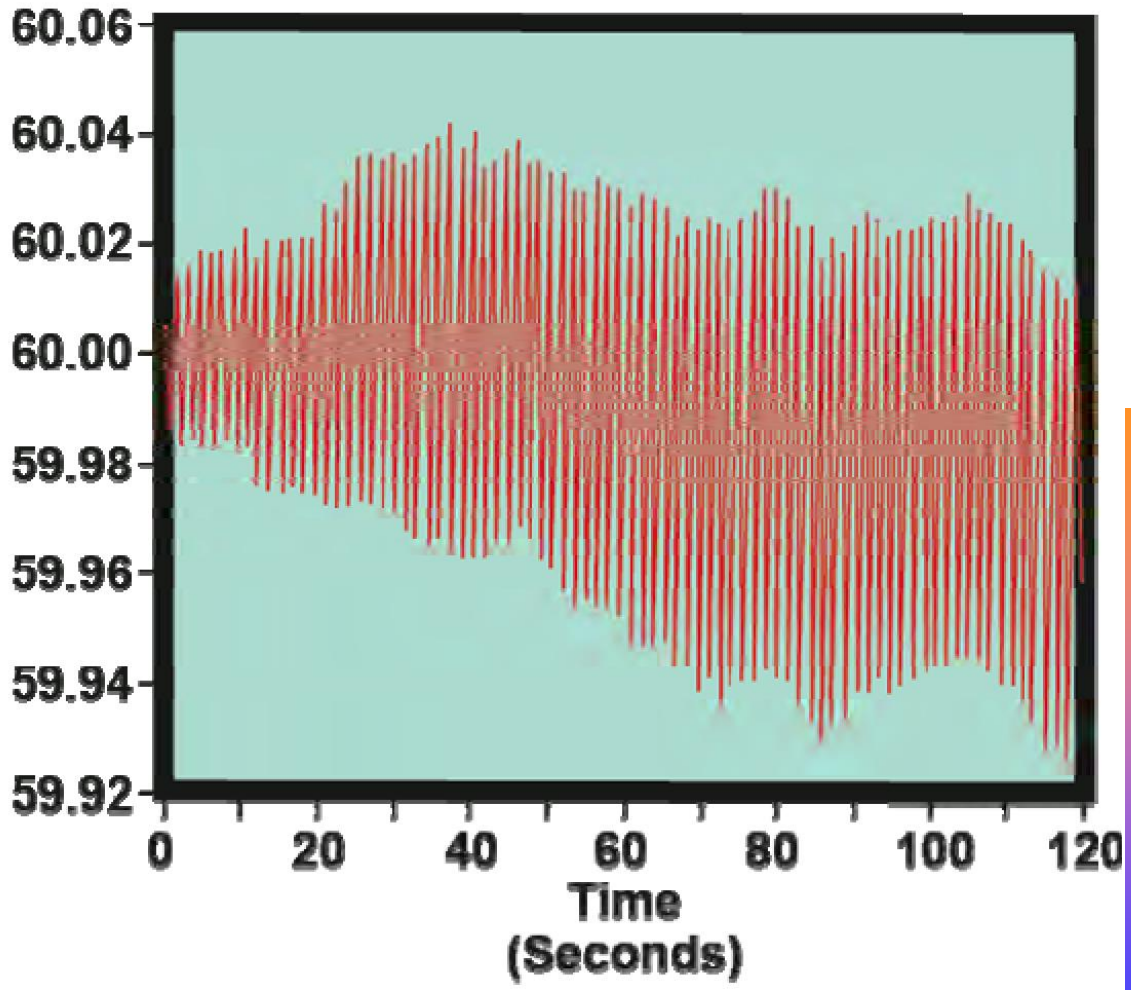
供给 = 需求

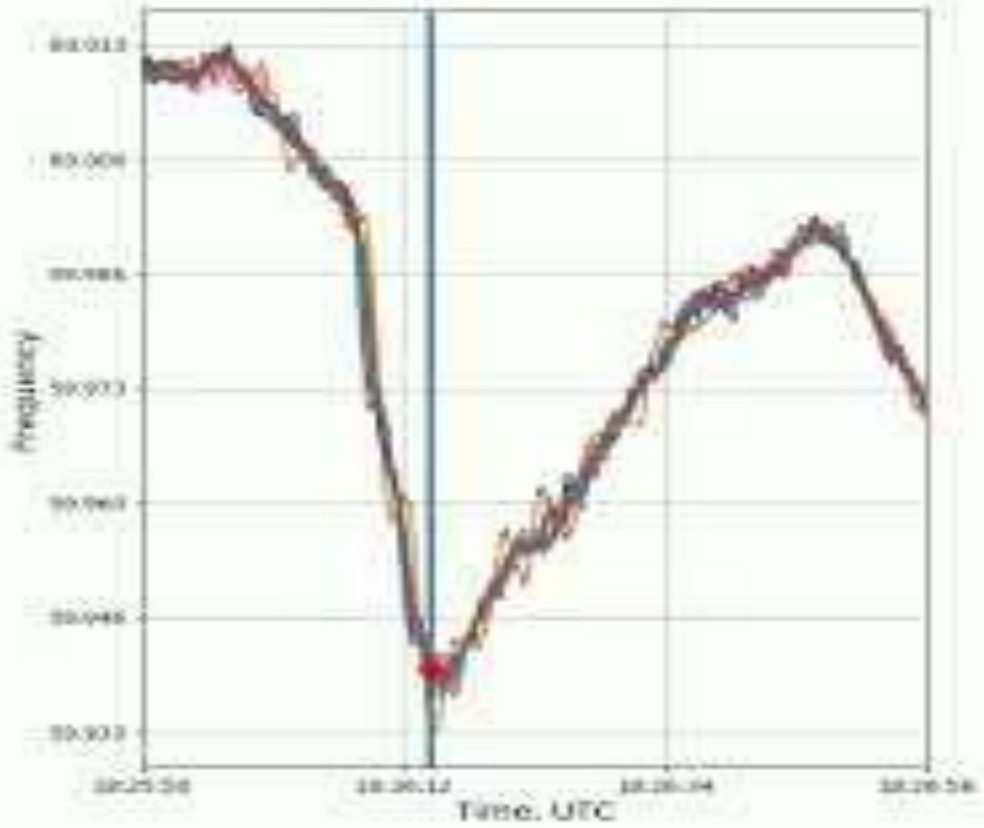


The Infinite Bus
(Voltage & Frequency Constant)



波动的电网频率


60.06
60.04
60.02
60.00
59.98
59.96
59.94
59.92
0
20
40
60
80
100
120
Time
(Seconds)





THE UNIVERSITY OF TENNESSEE KNOXVILLE

OAK RIDGE National Laboratory

大停电

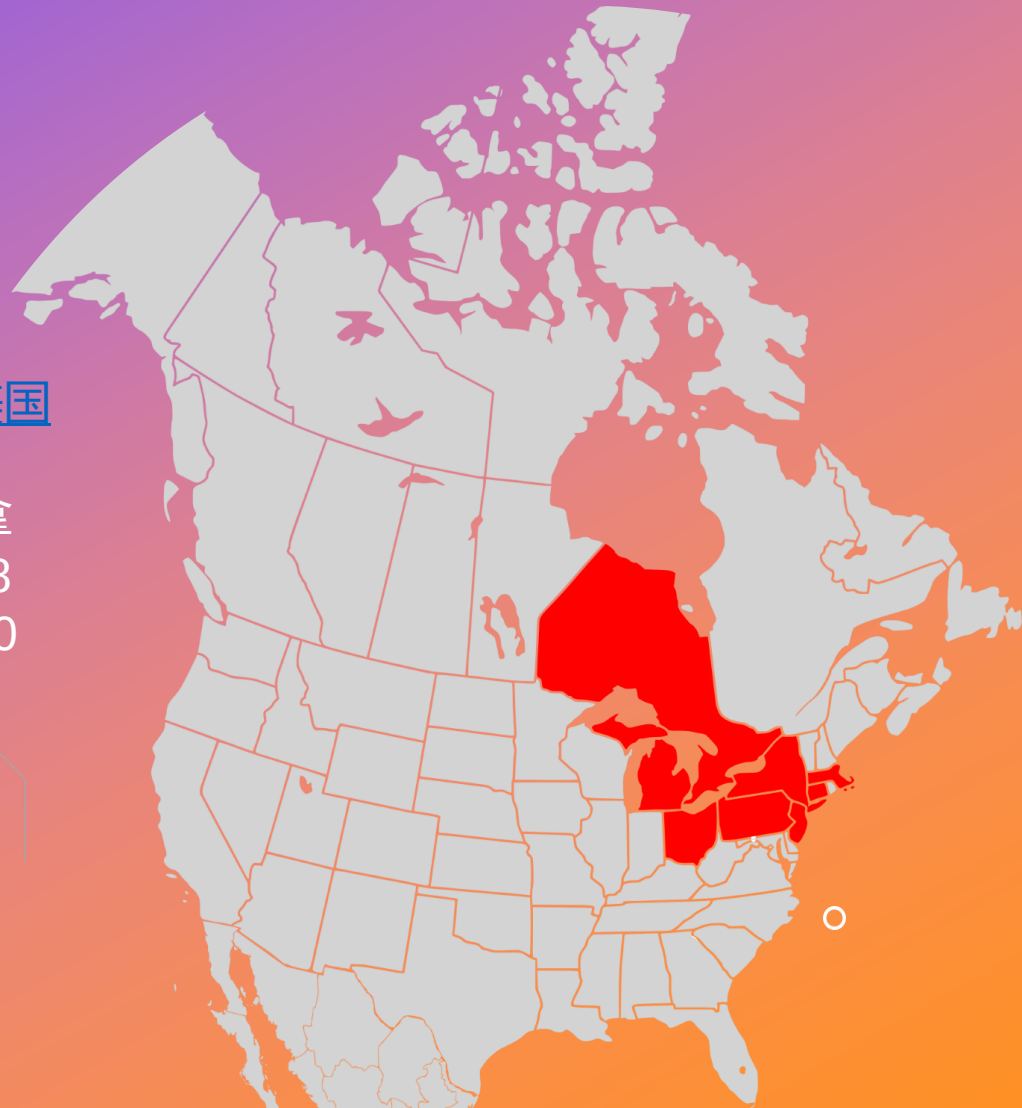


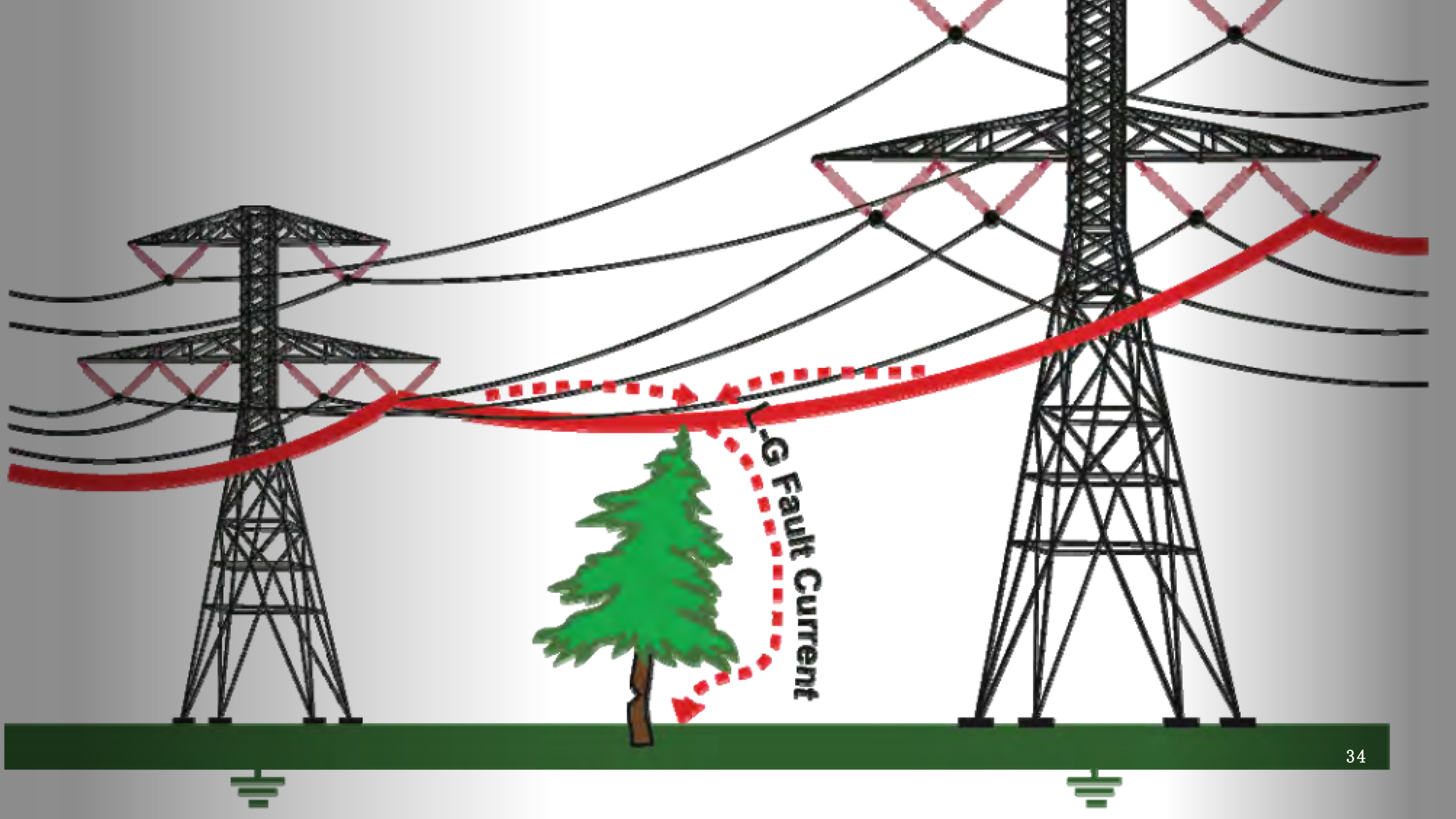
2003年美加大停电

超過265個電廠，508機組跳脫，停電量高達61,800MW

Northeast blackout of 2003）是指2003年8月14日起在美国东北部部分地区以及加拿大东部地区出现的大范围停电。这是北美历史上最大范围的停电，受影响的人估计在加拿大有1000万（三分之一的人口）在美国有4000万。美国8个州以及加拿大的安大略省的电力中断。该大停电持续10天。

2003年美加大停电 - 维基百科，自由的百科全书 (wikipedia.org)




I-G Fault Current

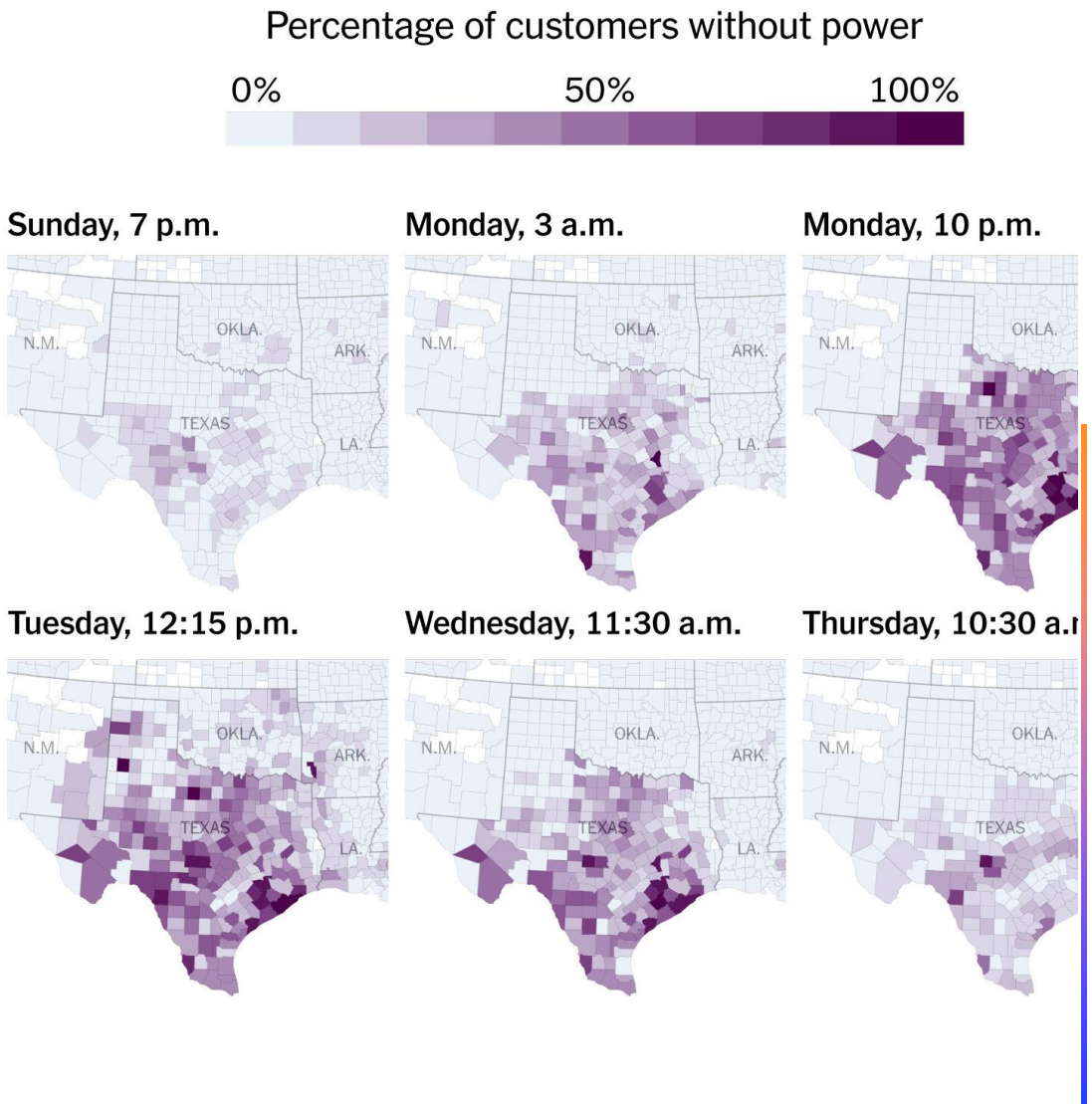
2021年德克薩斯州大停電

450萬戶家庭和企業停電，供水設施、食物供應鏈和網絡通訊設施也受到影響

2021年冬天，來自極地漩渦的寒流自加拿大進入美國，美國中部多地氣溫創下歷史同期新低。

天然气发电站断电（天然气管道冻结）
核电站断电（水管冻结）
风能减产（风机冻结）

[2021年德克薩斯州大停電 - 维基百科，自由的百科全书 (wikipedia.org)]

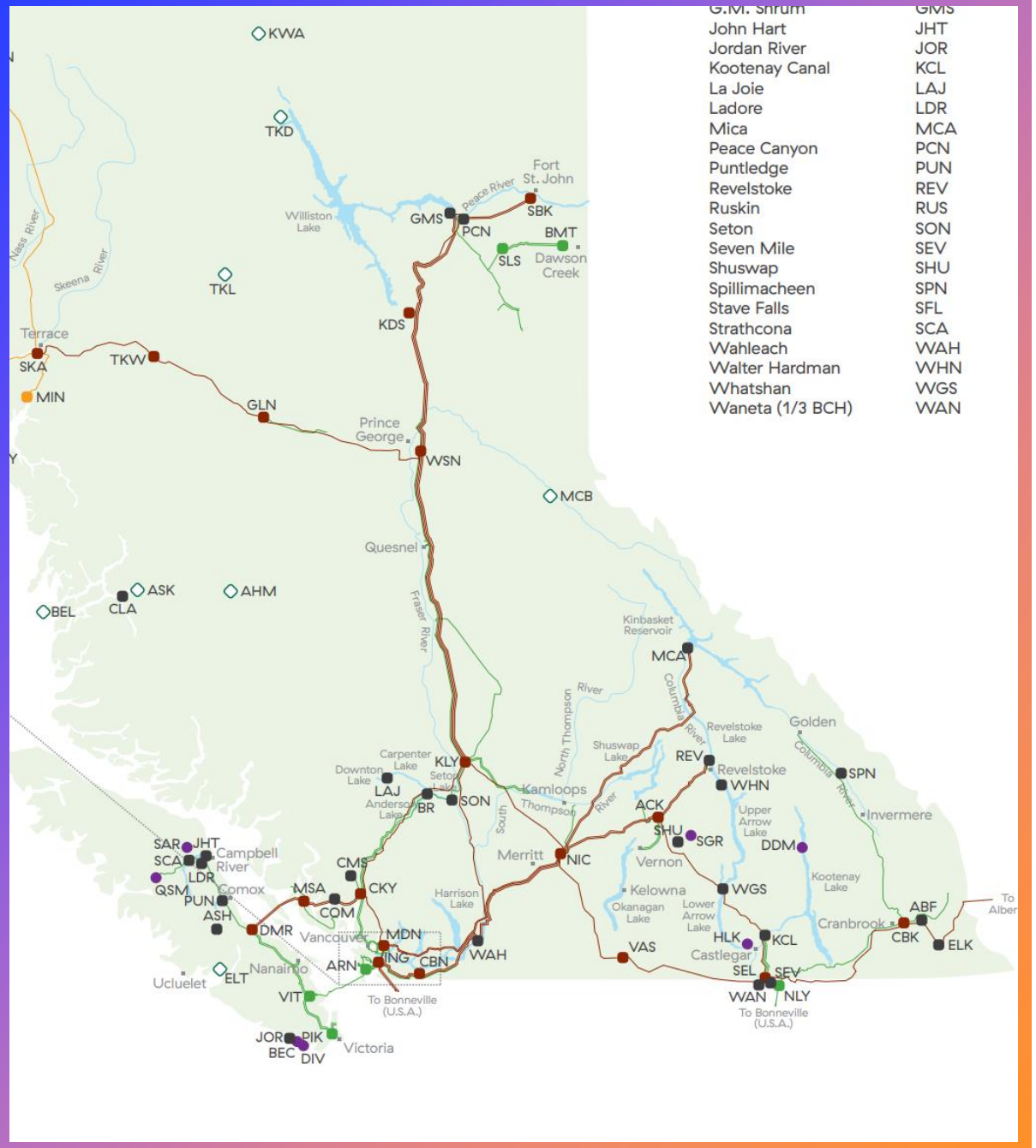


全球大停电事件

HTTPS://EN.WIKIPEDIA.ORG/WIKI/LIST_OF_MAJOR_POWER_OUTAGES

Article	People affected (millions)	Location	Date
2012 India blackouts	620	India	July 30–31, 2012
2001 India blackout	230	India	January 2, 2001
2021 Pakistan blackout	200 (90% population)	Pakistan	January 9, 2021
2014 Bangladesh blackout	150	Bangladesh	November 1, 2014
2015 Pakistan blackout	140	Pakistan	January 26, 2015
2019 Java blackout	120	Indonesia	August 4–5, 2019
2005 Java–Bali blackout	100	Indonesia	August 18, 2005
1999 Southern Brazil blackout	97	Brazil	March 11–June 22, 1999
2015 Turkey blackout	70	Turkey	March 31, 2015
2009 Brazil and Paraguay blackout	60	Brazil, Paraguay	November 10–20, 2009
2003 Italy blackout	56	Italy, Switzerland	September 28, 2003
Northeast blackout of 2003	55	Canada, United States	August 14–28, 2003

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BC Hydro quick facts*

We are here to safely provide our customers with reliable, affordable, clean electricity

A commercial **crown corporation** owned by the province of British Columbia

Provides over **4,000,000** customers with reliable electricity

Fifth lowest** residential rates in North America

98.0% clean electricity generated in B.C. in 2020/21

Serves **95%** of the province's population

The average household uses approximately **11,000 kWh** per year

Our Demand Side Management portfolio achieved **801 GWH of new incremental electricity savings in 2020/21*****

30 Hydro Plants

BC Hydro has a network of approximately **80,000 kms** of transmission & distribution lines

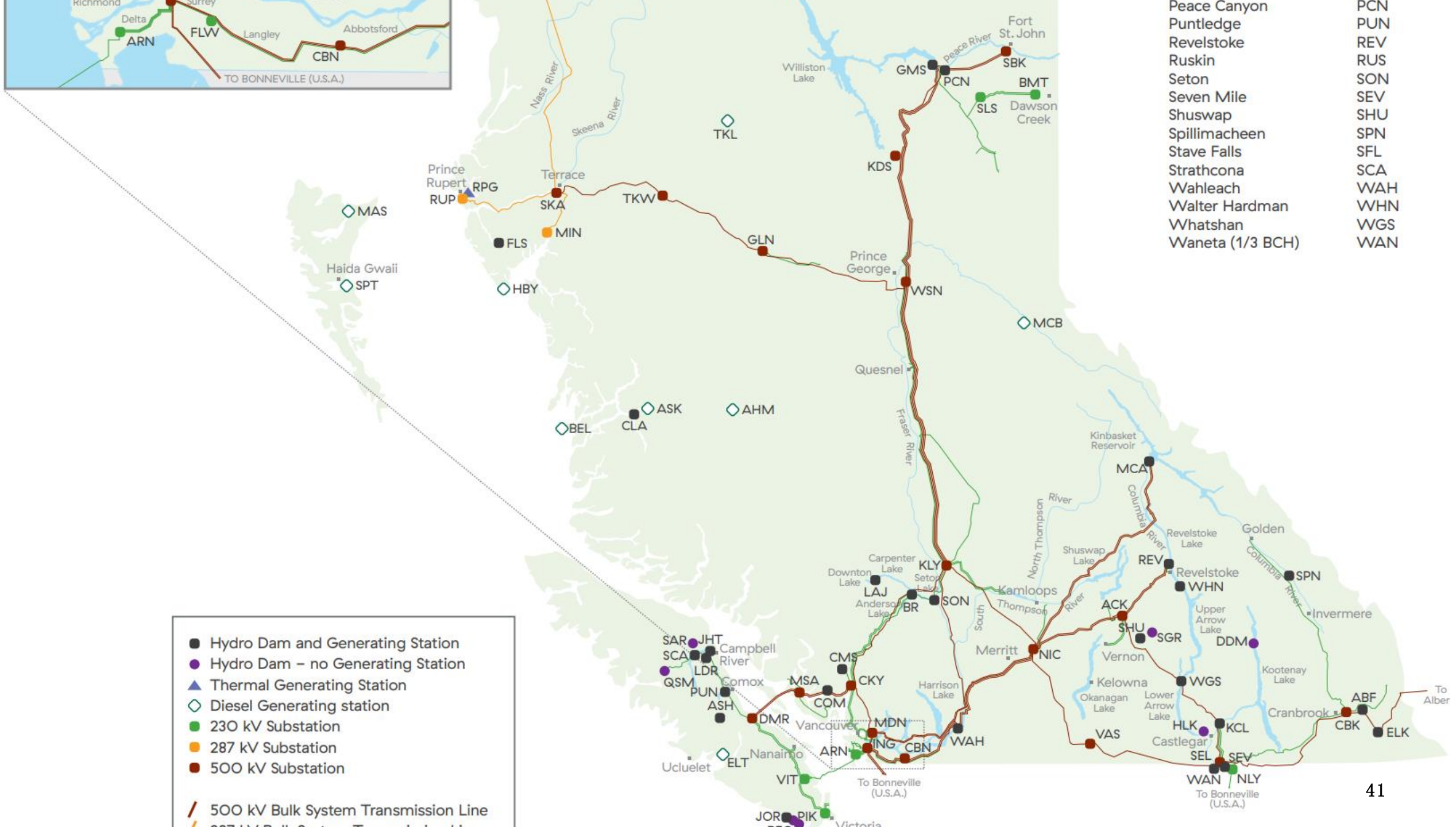
Over 300 substations



Rates in effect April 1, 2021.

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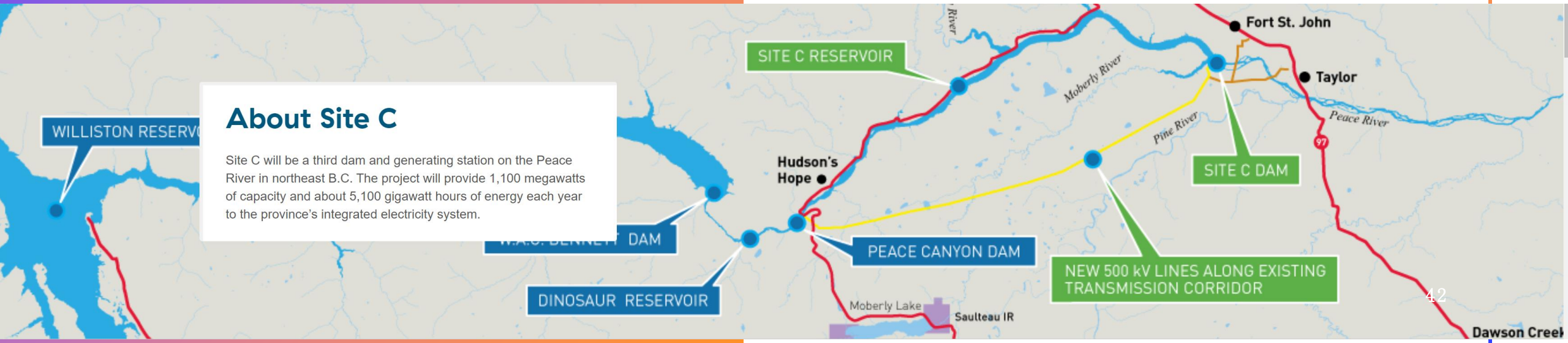
Site C


Richmond
Surrey
Delta
ARN
FLW
Langley
Abbotsford
CBN
TO BONNEVILLE (U.S.A.)
Peace Canyon PCN
Puntledge PUN
Revelstoke REV
Ruskin RUS
Seton SON
Seven Mile SEV
Shuswap SHU
Spillimacheen SPN
Stave Falls SFL
Strathcona SCA
Wahleach WAH
Walter Hardman WHN
Whatshan WGS
Waneta (1/3 BCH) WAN
Fort St. John
SBK
Peace River
GMS
PCN
BMT
SLS
Dawson Creek
Williston Lake
Nass River
Skeena River
TKL
KDS
Prince Rupert
RPG
RUP
Terrace
SKA
TKW
MAS
MIN
FLS
GLN
Prince George
WSN
Haida Gwaii
SPT
HBY
MCB
Quesnel
BEL
CLA
ASK
AHM
Fraser River
Kinbasket Reservoir
MCA
Columbia River
North Thompson River
Revelstoke Lake
Golden
Shuswap Lake
REV
Revelstoke
WHN
SPN
Carpenter Lake
Downton Lake
KLY
Seton Lake
LAJ
Anderson Lake
BR
SON
Kamloops
South Thompson River
ACK
Upper Arrow Lake
Invermere
SHU
SGR
DDM
Merritt
NIC
Vernon
SAR
JHT
SCA
LDR
QSM
PUN
ASH
Campbell River
Comox
CMS
MSA
CKY
COM
DMR
Harrison Lake
Kootenay Lake
Kelowna
Okanagan Lake
Lower Arrow Lake
WGS
ABF
Cranbrook
CBK
ELK
To Alber
HLK
KCL
Castlegar
VAS
SEL
SEV
Vancouver
MDN
ING
CBN
WAH
ARN
Nanaimo
Ucluelet
ELT
VIT
To Bonneville (U.S.A.)
WAN
NLY
To Bonneville (U.S.A.)
JOR
PIK
Victoria
Hydro Dam and Generating Station
Hydro Dam – no Generating Station
Thermal Generating Station
Diesel Generating station
230 kV Substation
287 kV Substation
500 kV Substation
500 kV Bulk System Transmission Line

Site C will provide 1,100 megawatts (MW) of capacity, and produce about 5,100 gigawatt hours (GWh) of electricity each year – enough energy to power the equivalent of about 450,000 homes per year in B.C.

https://www.youtube.com/watch?v=7Ju60HLwE14&t=4s

Construction of the project started in summer 2015. The first generators will be on line in 2024 and the project will be completed in 2025.



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BC Hydro Visitor Centres



POWERHOUSE AT STAVE FALLS

https://www.bchydro.com/community/recreation_areas/visitor-centres.html



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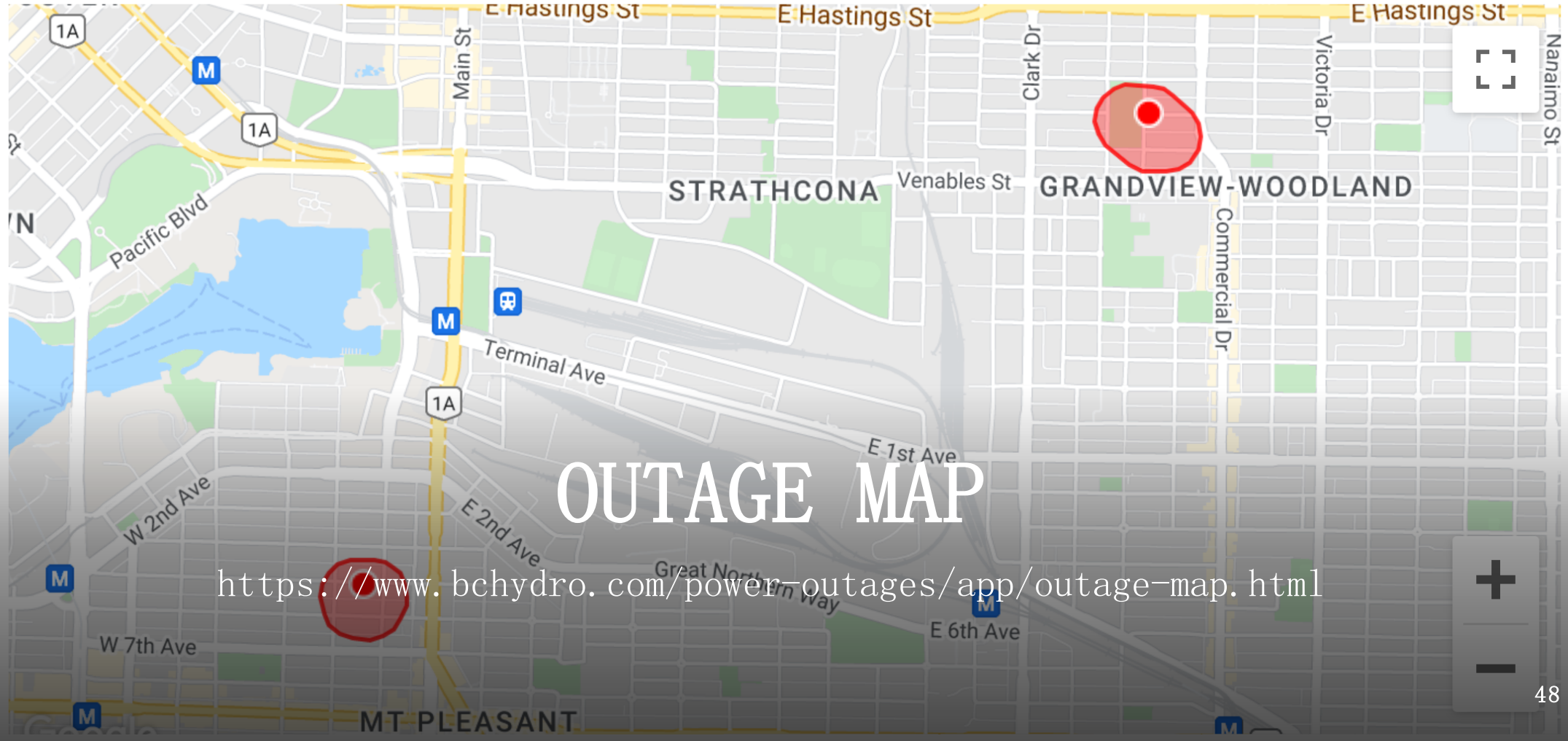
Outage Map

Report an outage

Lost power? Check the outage map to see if we're aware of the outage. If your outage isn't shown, call 1 800 BCHYDRO (1 800 224 9376) or *HYDRO (*49376) on your mobile or report it online.

See our outage status definition list to learn what the status of your outage means.

All times listed are Pacific Time



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Rebate



Rebates for home renovations

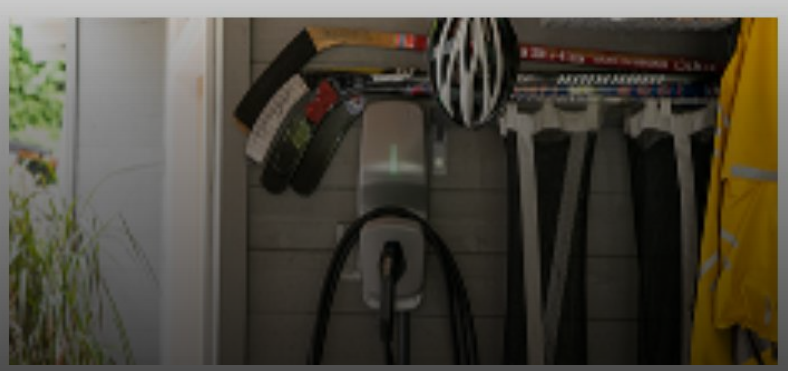
- Windows & doors
- Insulation
- Space heating
- Water heating

https://www.bchydro.com/powersmart/residential/rebates-programs.html



Rebates for energy-efficient products

Light bulbs, fridges, washers and dryers, thermostats and more – check for rebates on products that help you save energy.



Rebates for fuel switching

- Heat pump rebate top-up for fuel switching
- Electric vehicle charger rebates

绿色电力能源









THANK YOU*

郑罡

*仅代表个人观点