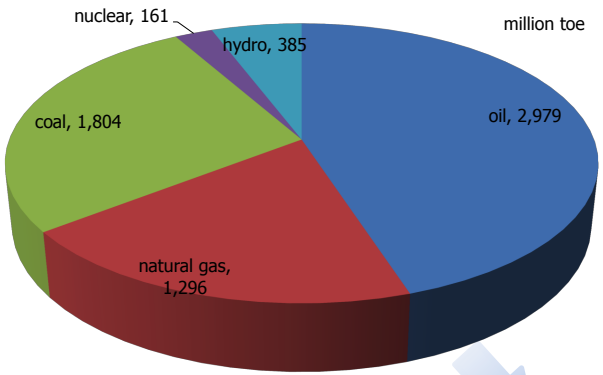
Social impacts of the incorporation of solar-solar hybrid systems in KSA

Promising Energy

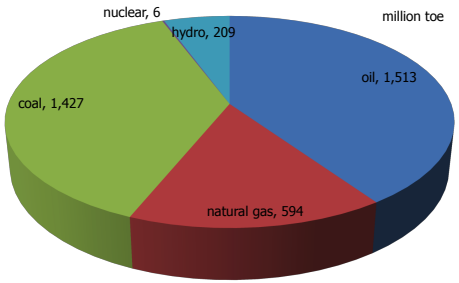
28th September, 2012

Global Solar+ Initiative, UT

Gento Mogi

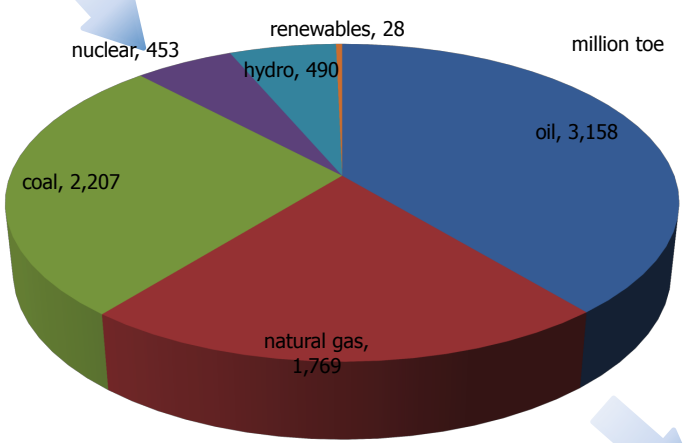


1980

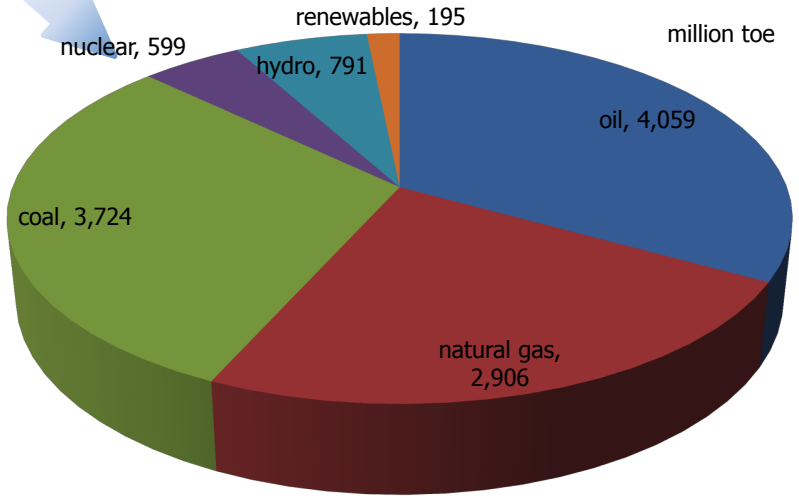


1965

What is the problem?



1995



2011

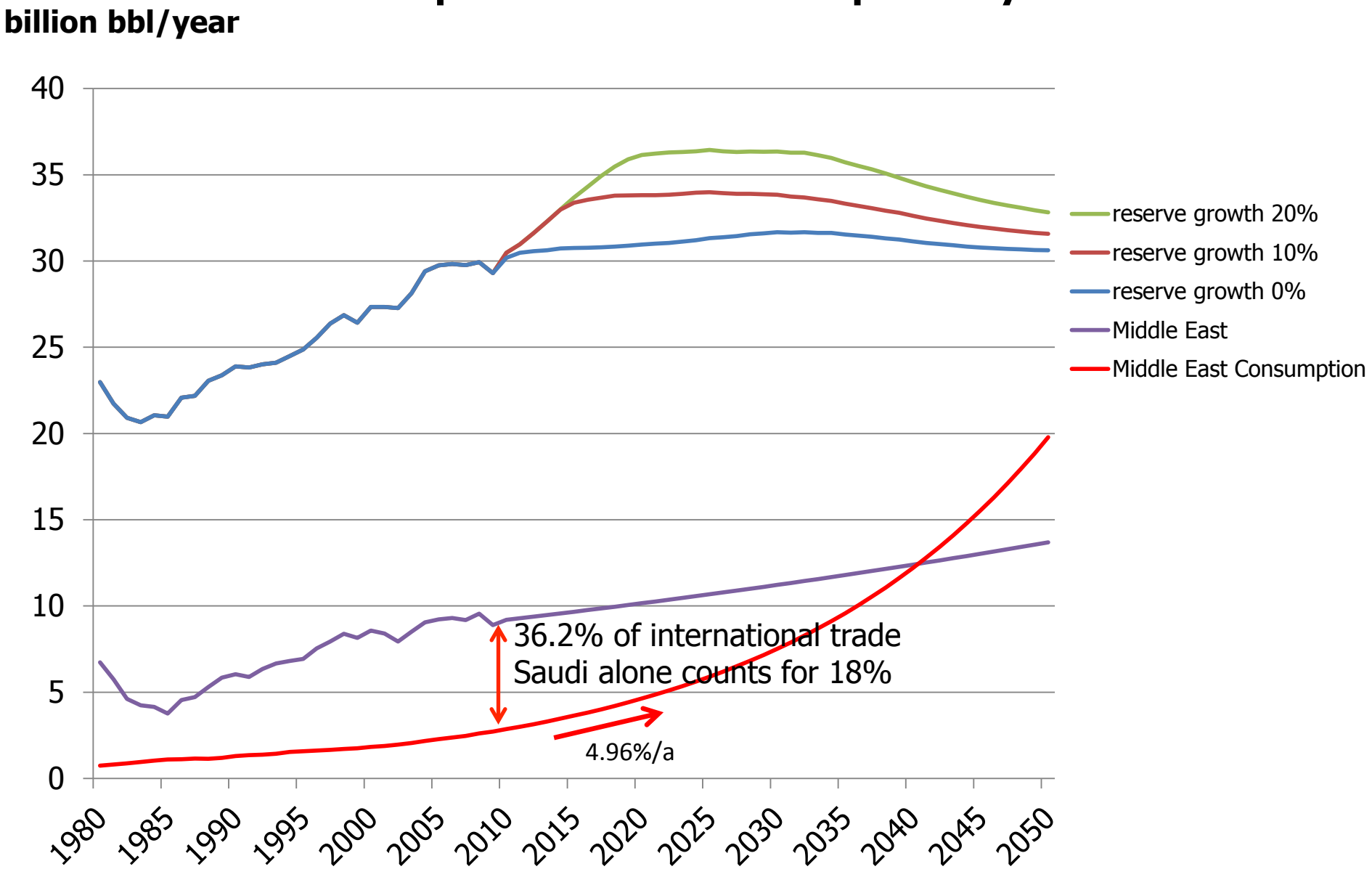
We depend on:

4.06Gt/year of oil

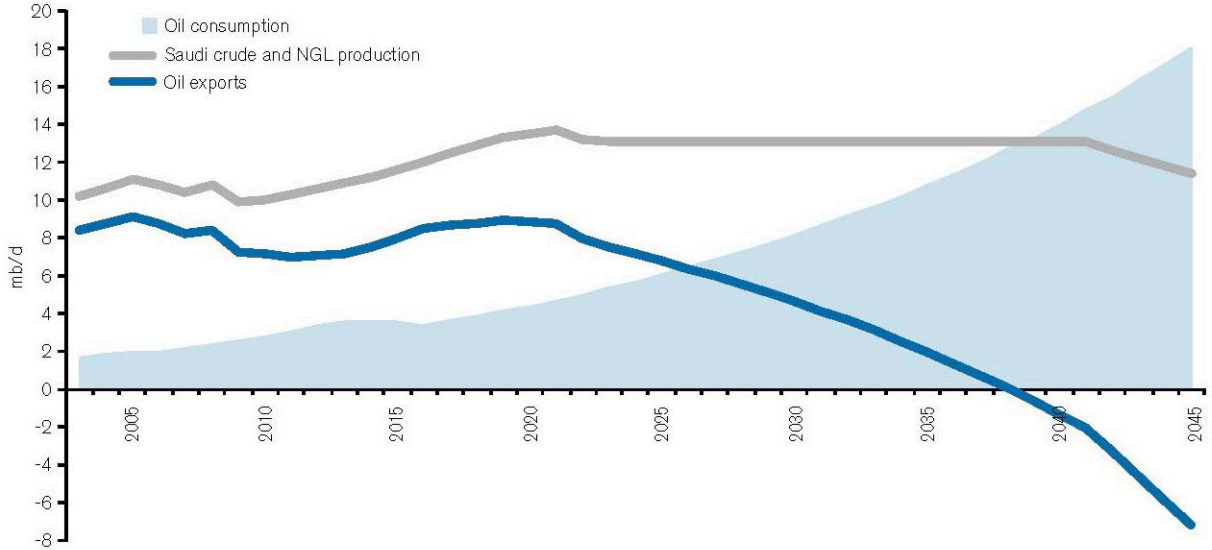
out of 12.31Gtoe/year

primary energy consumption

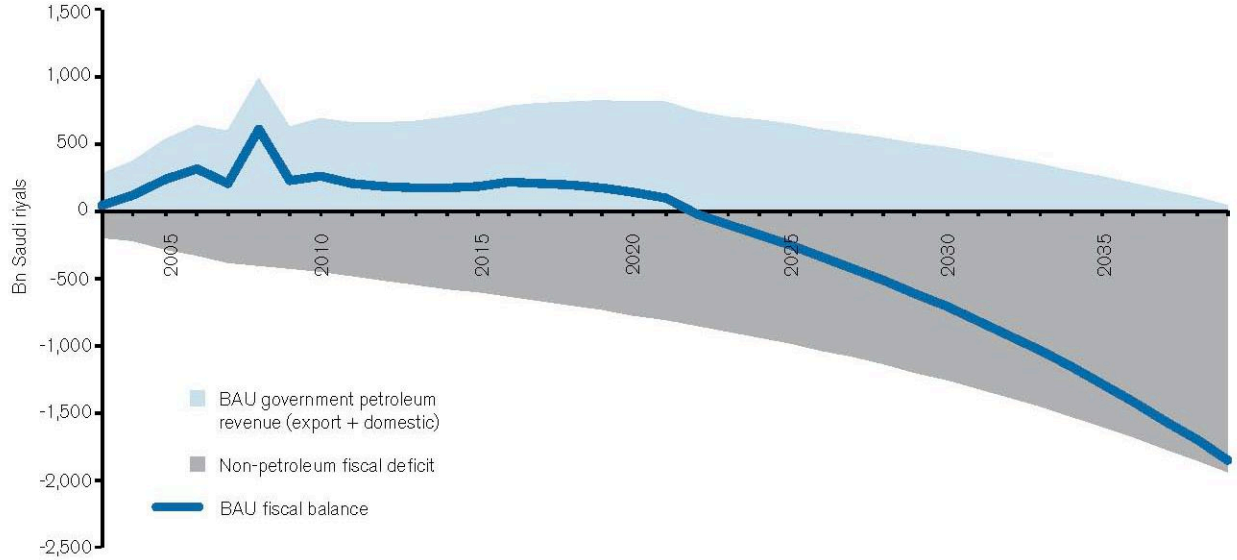
Oil production capacity



Saudi Arabia's oil balance on a business-as-usual trajectory

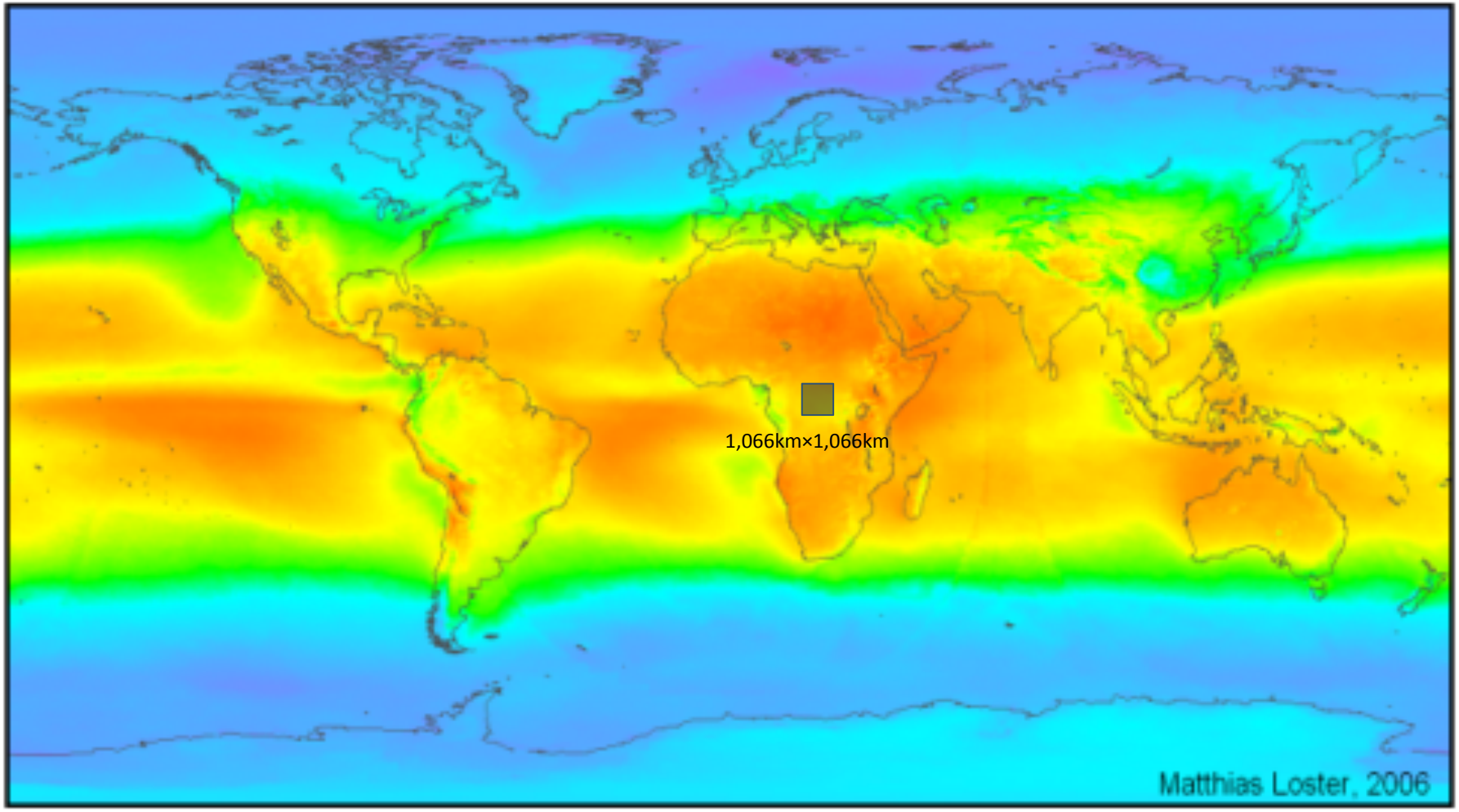


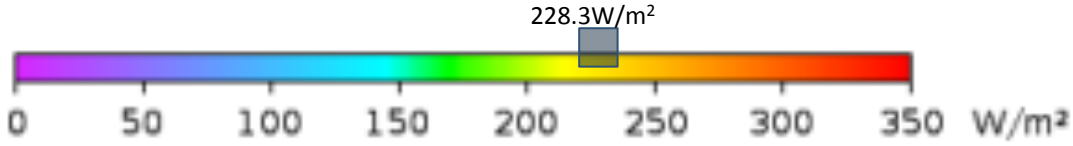
Saudi Arabia's fiscal deficit on a business-as-usual trajectory



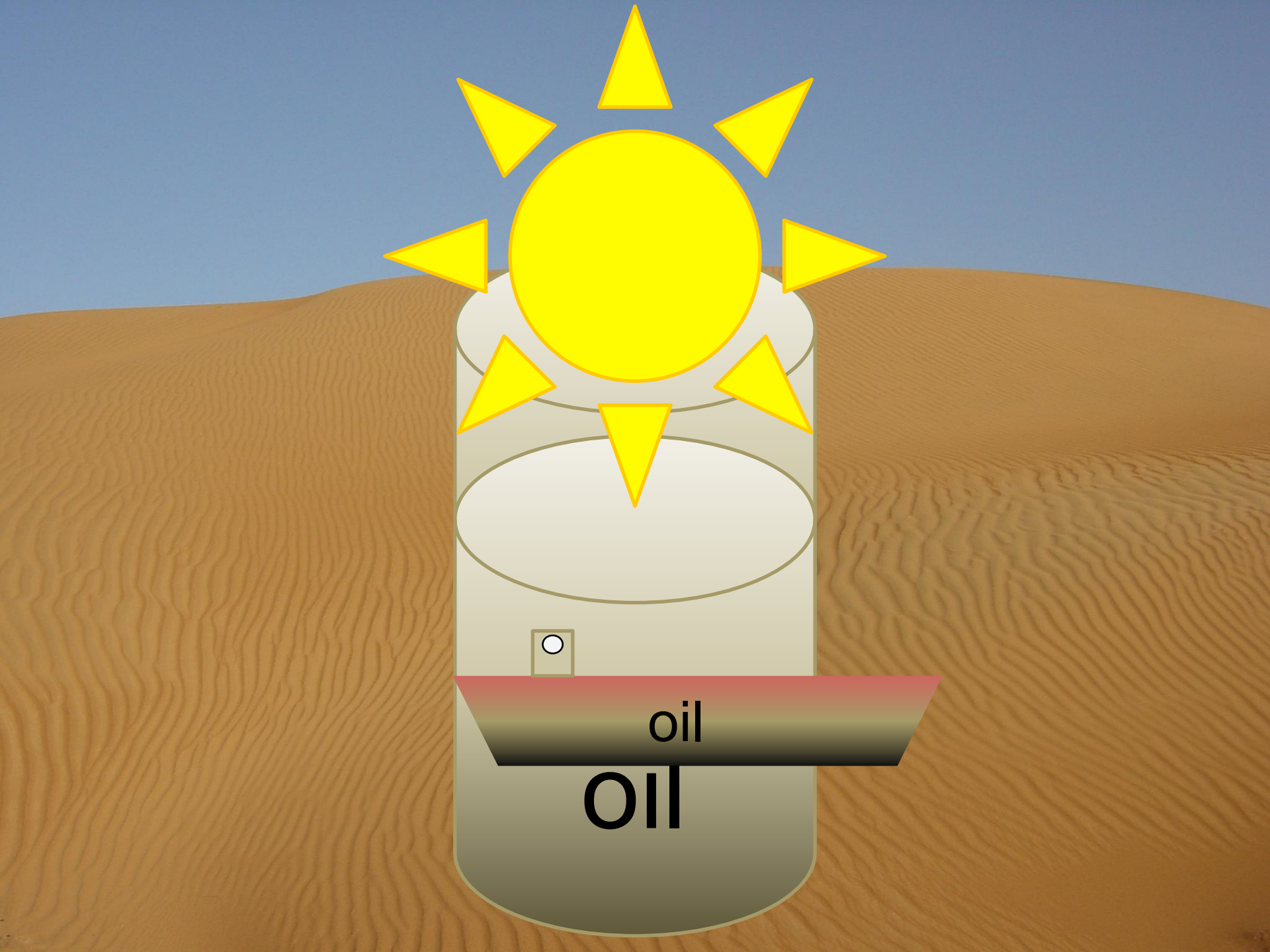
Glada Lahn, Paul Stevens, "Burning Oil to Keep Cool: The Hidden Energy Crisis in Saudi Arabia," Chatham House (The Royal Institute of International Affairs) report, UK, 2011.

Annual average insolation

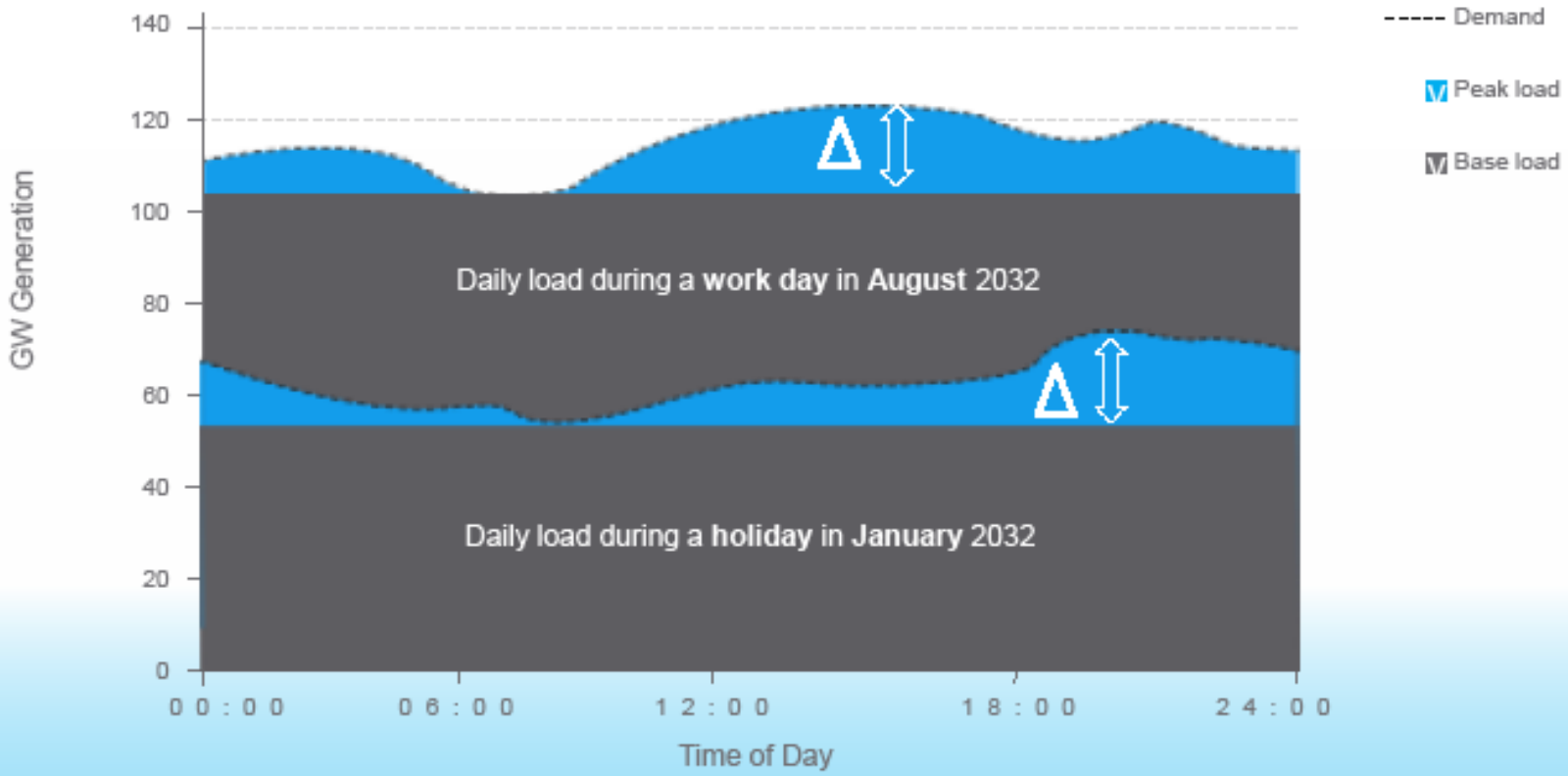




Module area to ground ratio: 50%
Total efficiency: 21% (cell 28%)
Area to generate 18Gtoe power


oil
oil

Forecasted Daily Electricity Demand Pattern 2032



Solar-Solar hybrid system

PV power generation

Crystalline silicon

Thin film

Chemical compound

Multi-junction chemical compound

future cost

CSP

Energy storage

Heliostat

Molten salt heat storage

Parabolic mirror

Trough mirror

Concentrating System

Solar receiver

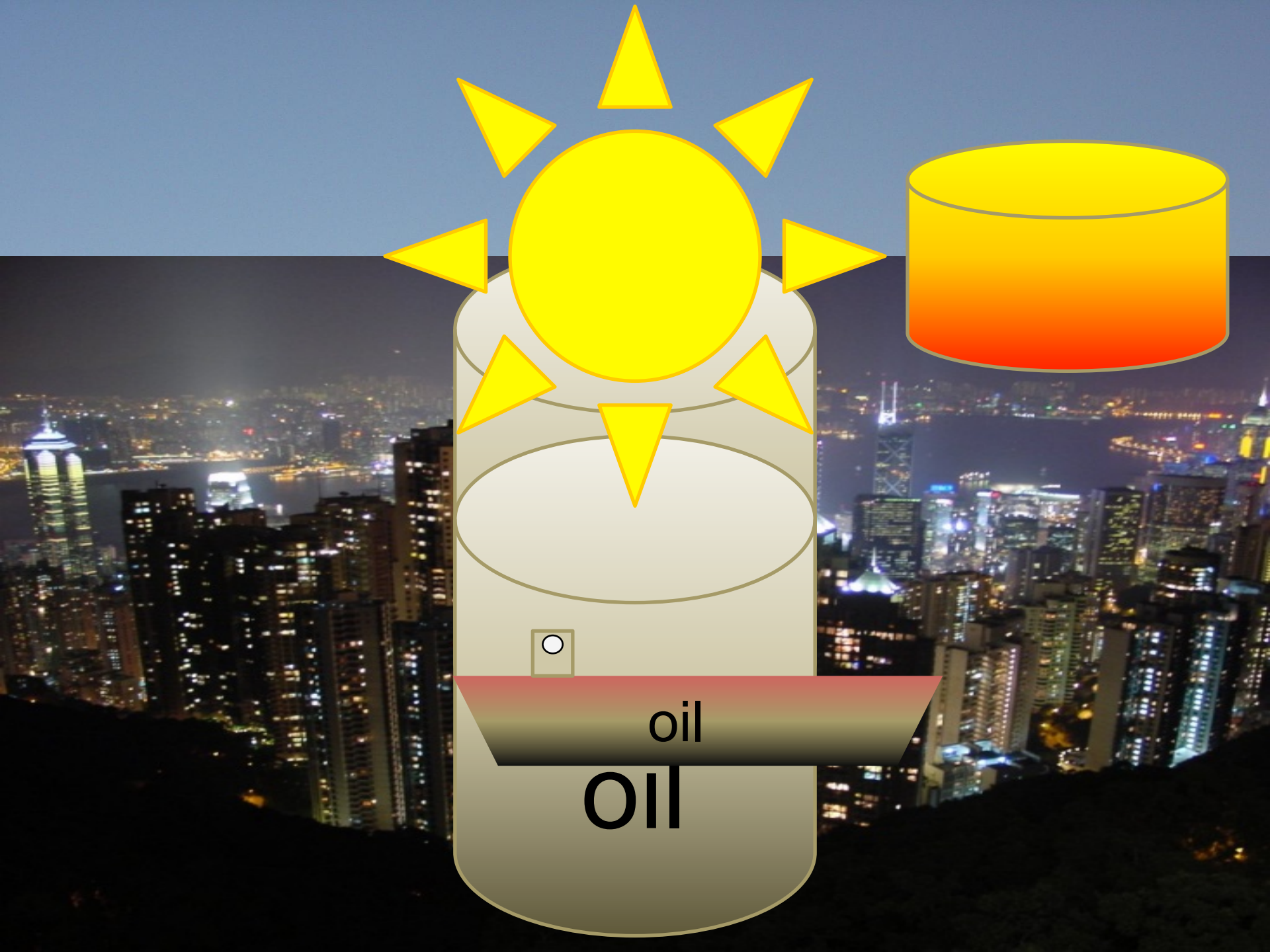
Molten salt Heat storage

Concentrating System

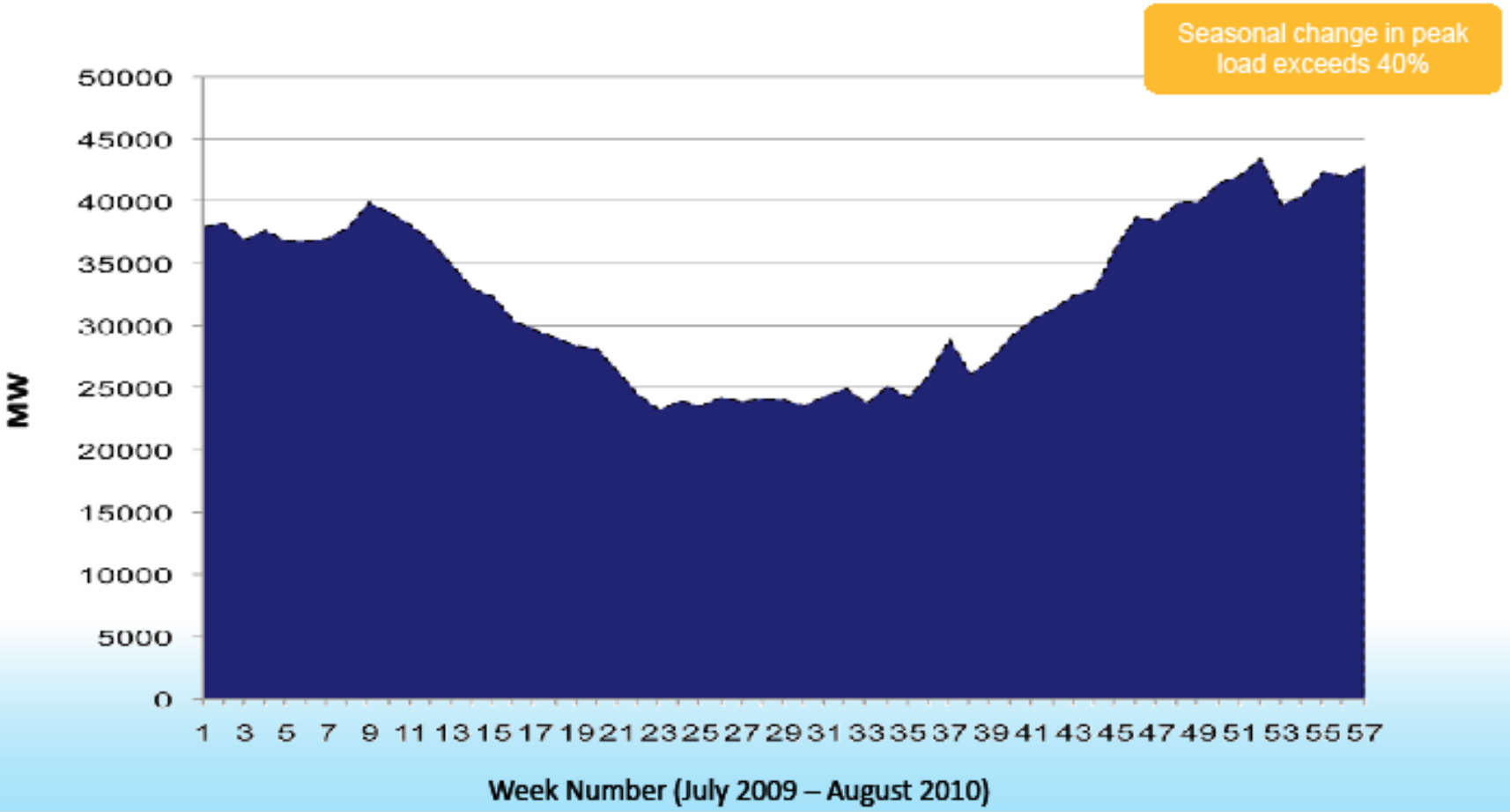
Multi-junction chemical compound type PV module

power

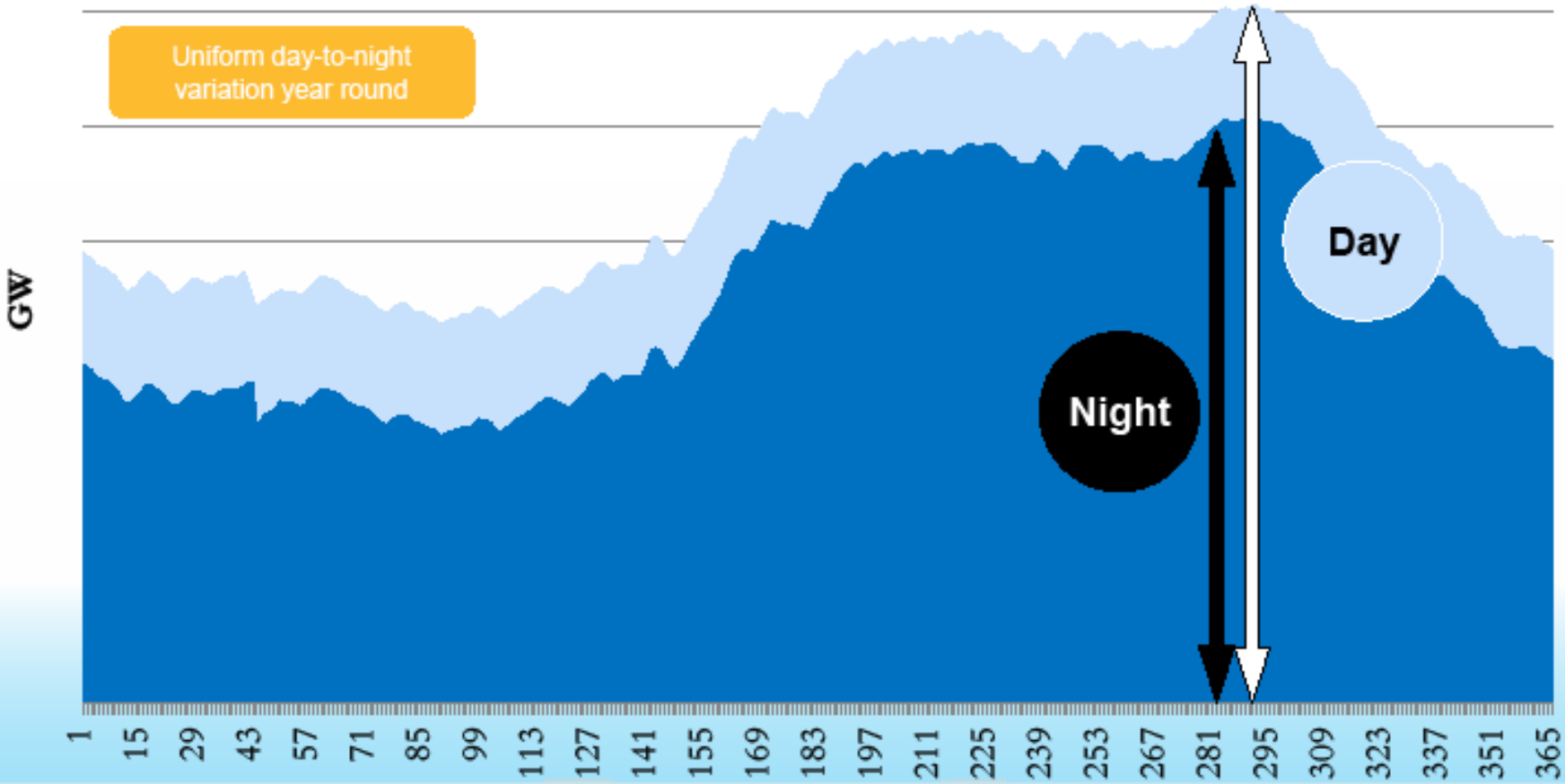
Gas turbine


oil
Oil

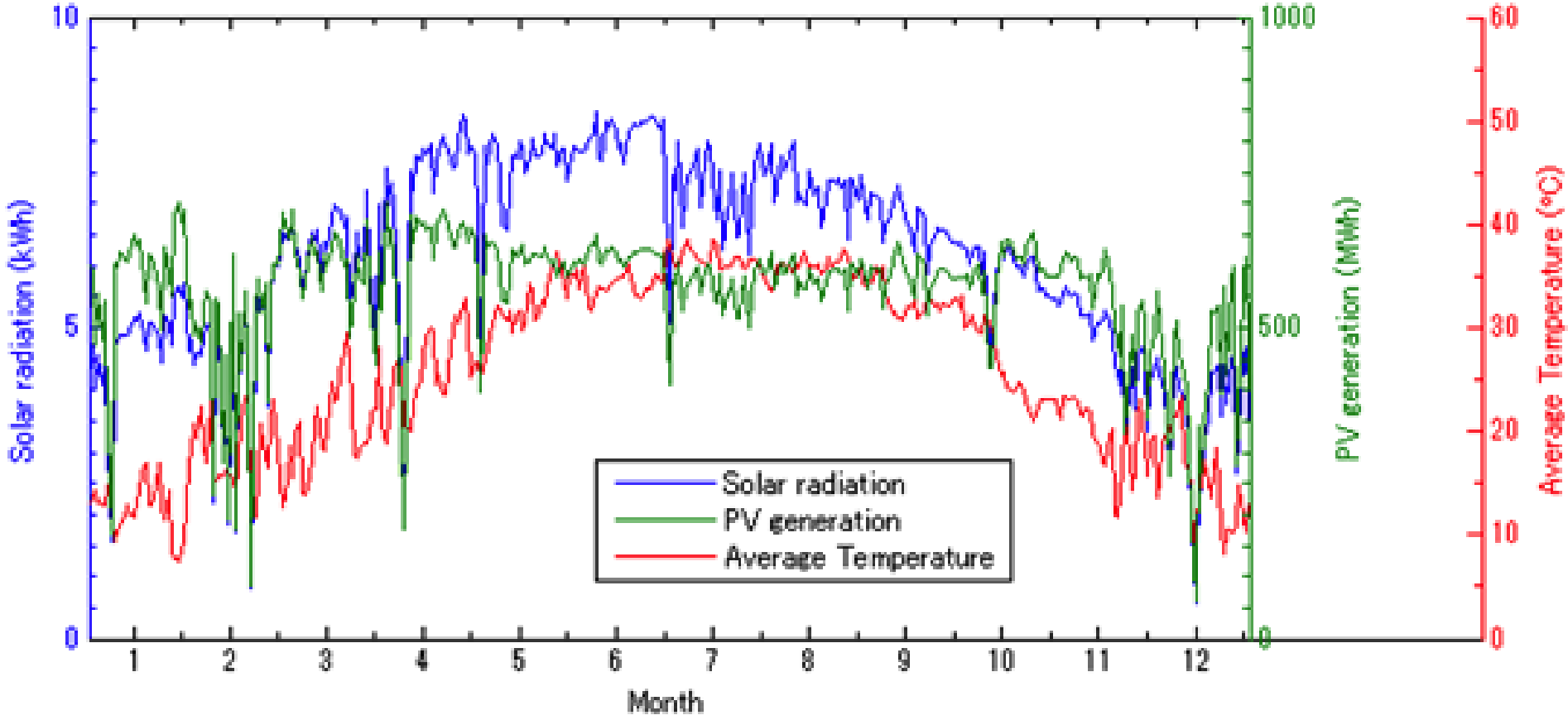
Annual Electricity Demand Pattern in KSA



Day-Night Load Variation for Saudi Arabia

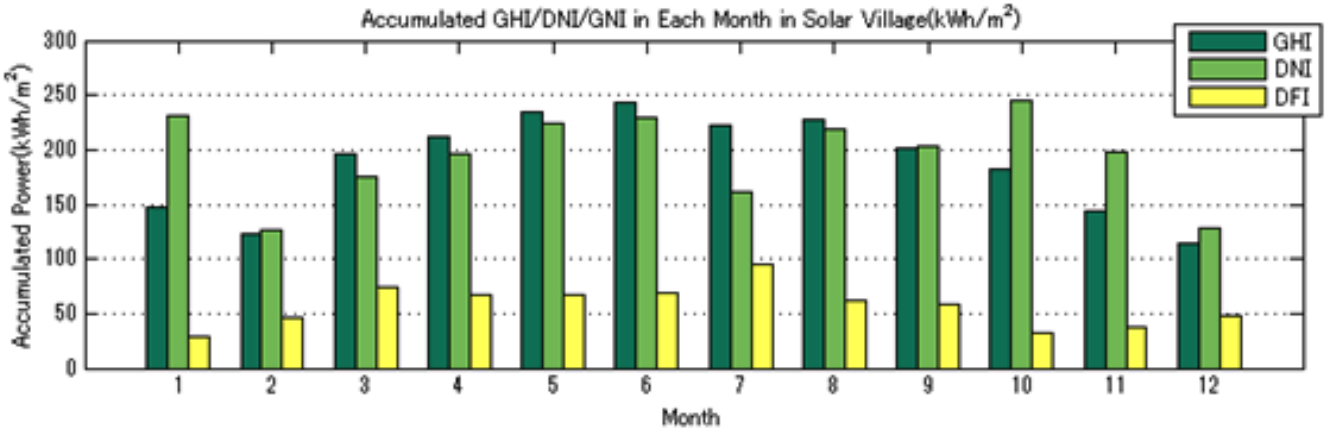


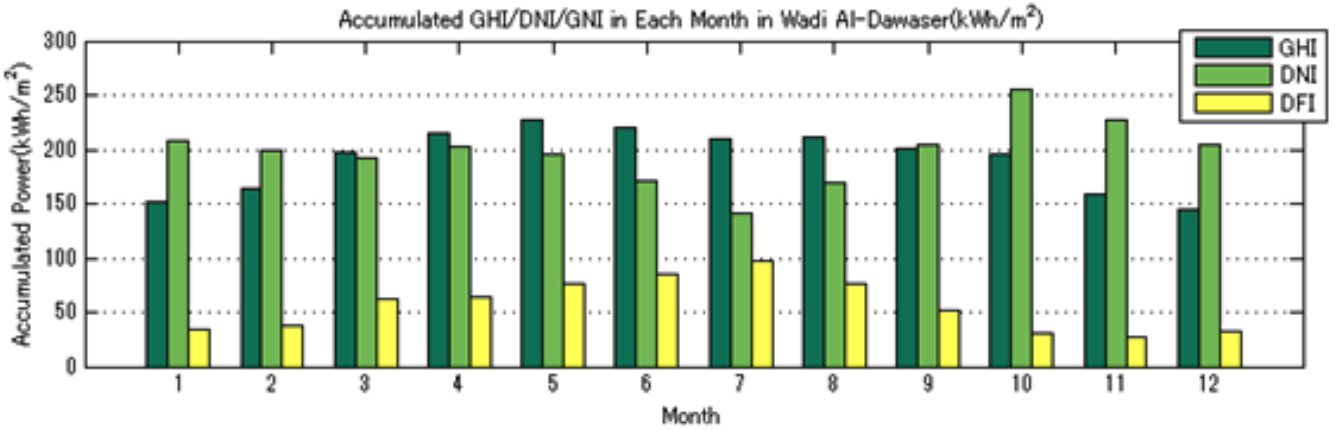
Characteristics of PV power generation

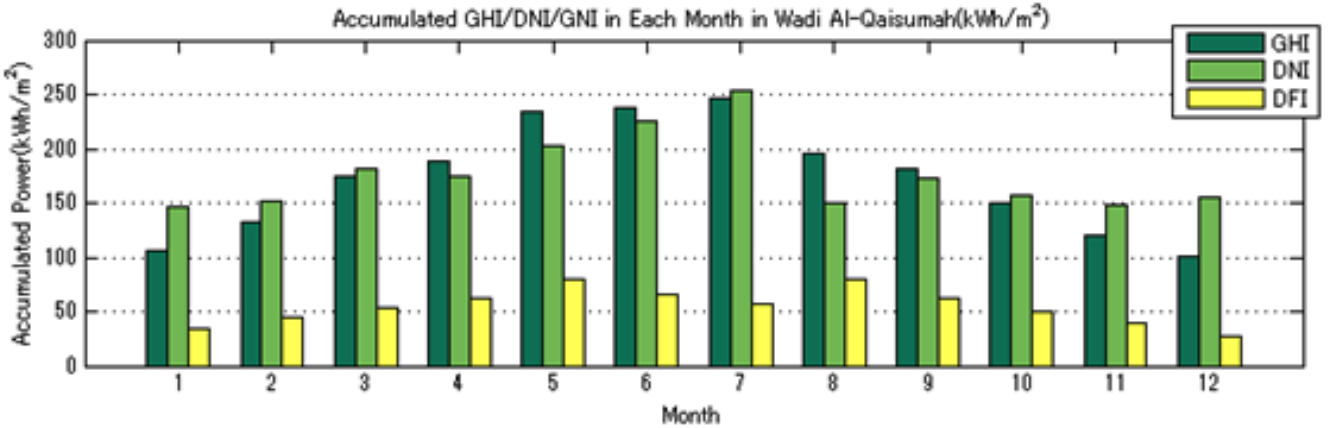


Daily accumulated radiation, PV generation and daily average temperature
(Solar Village, Saudi Arabia)

"NASA Remote Sensing Validation Data: Saudi Arabia,"

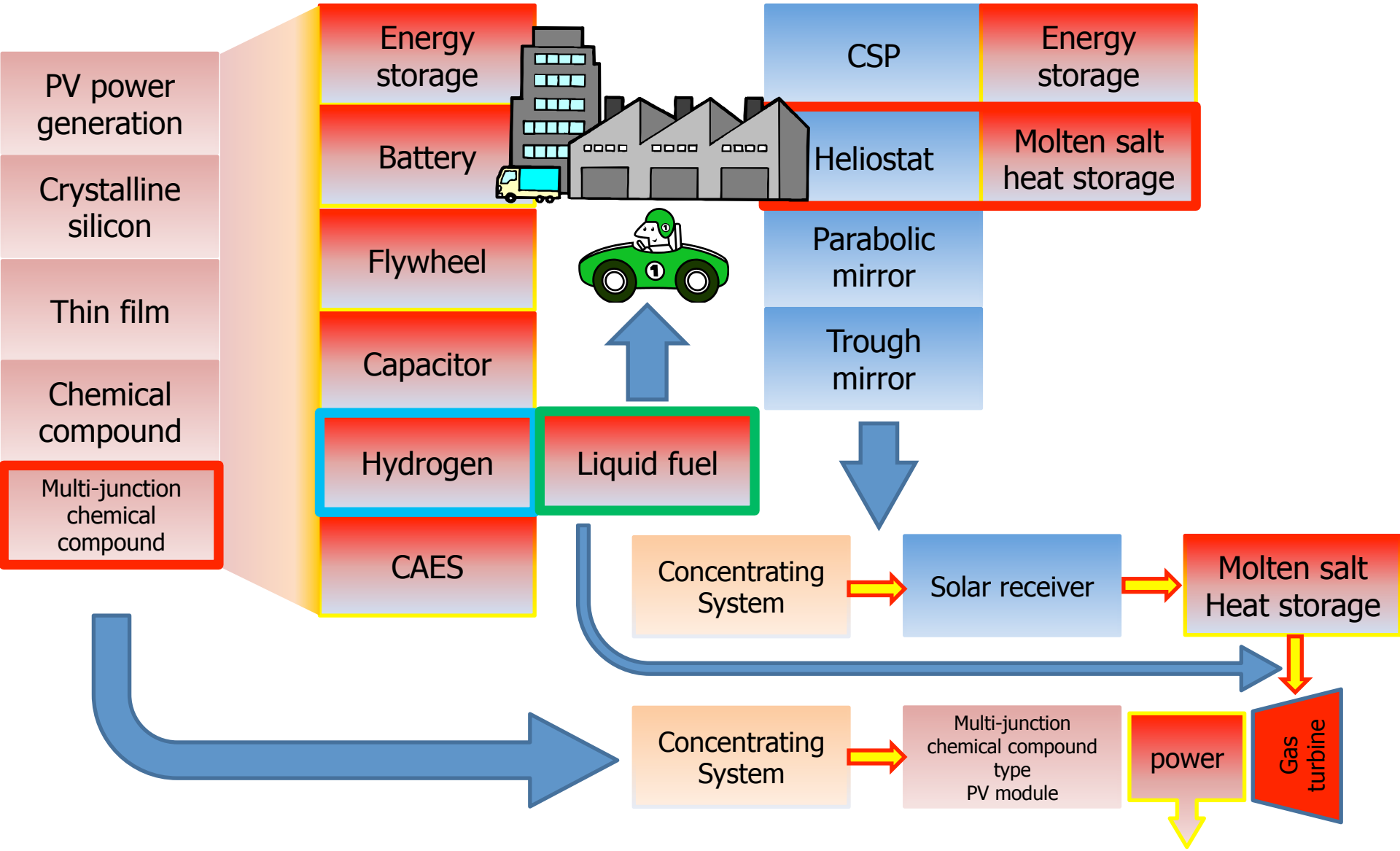




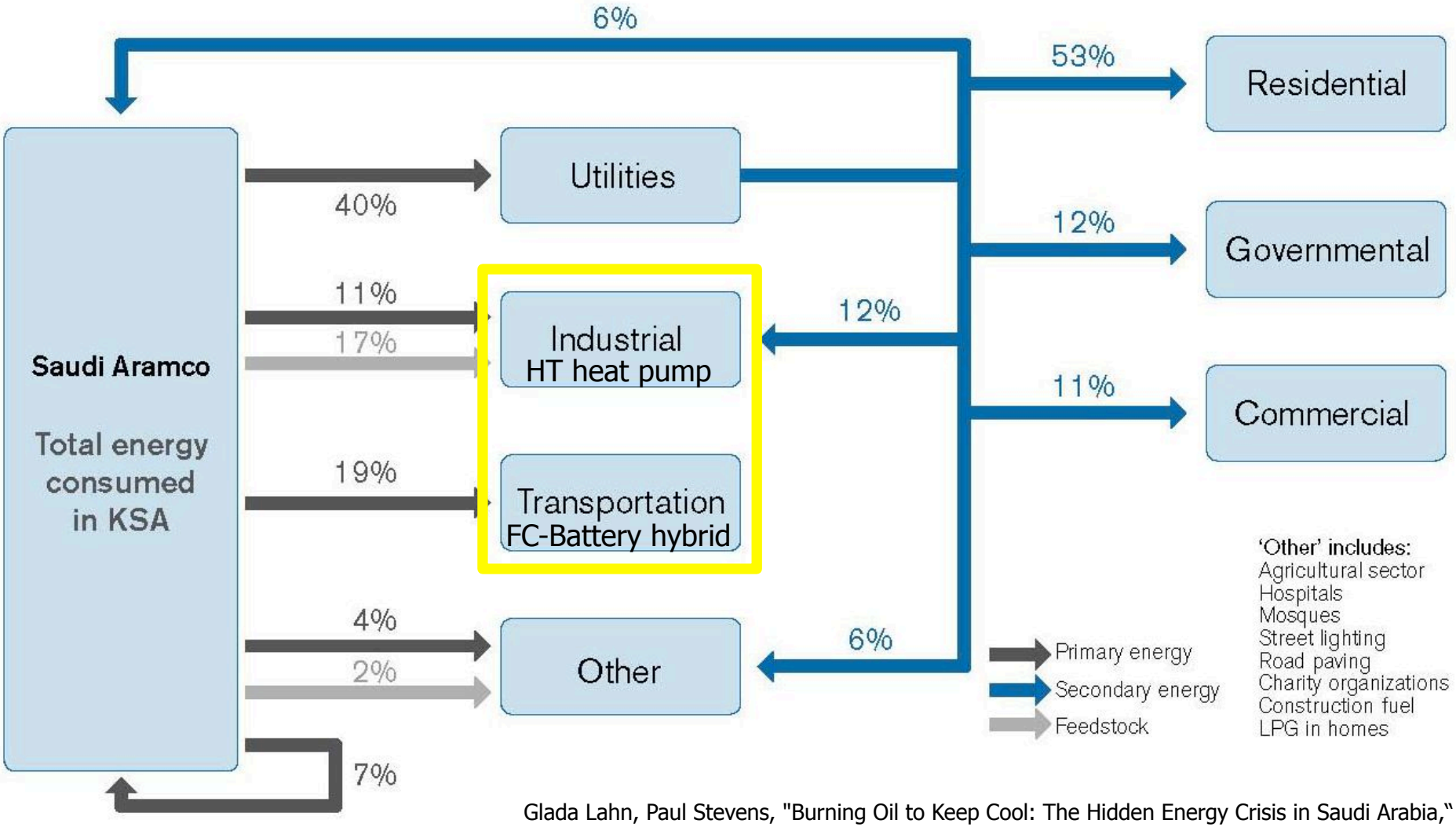


global horizontal irradiance (GHI), direct normal irradiance (DNI), diffuse horizontal irradiance (DHI)

Self-contained Solar-Solar hybrid system

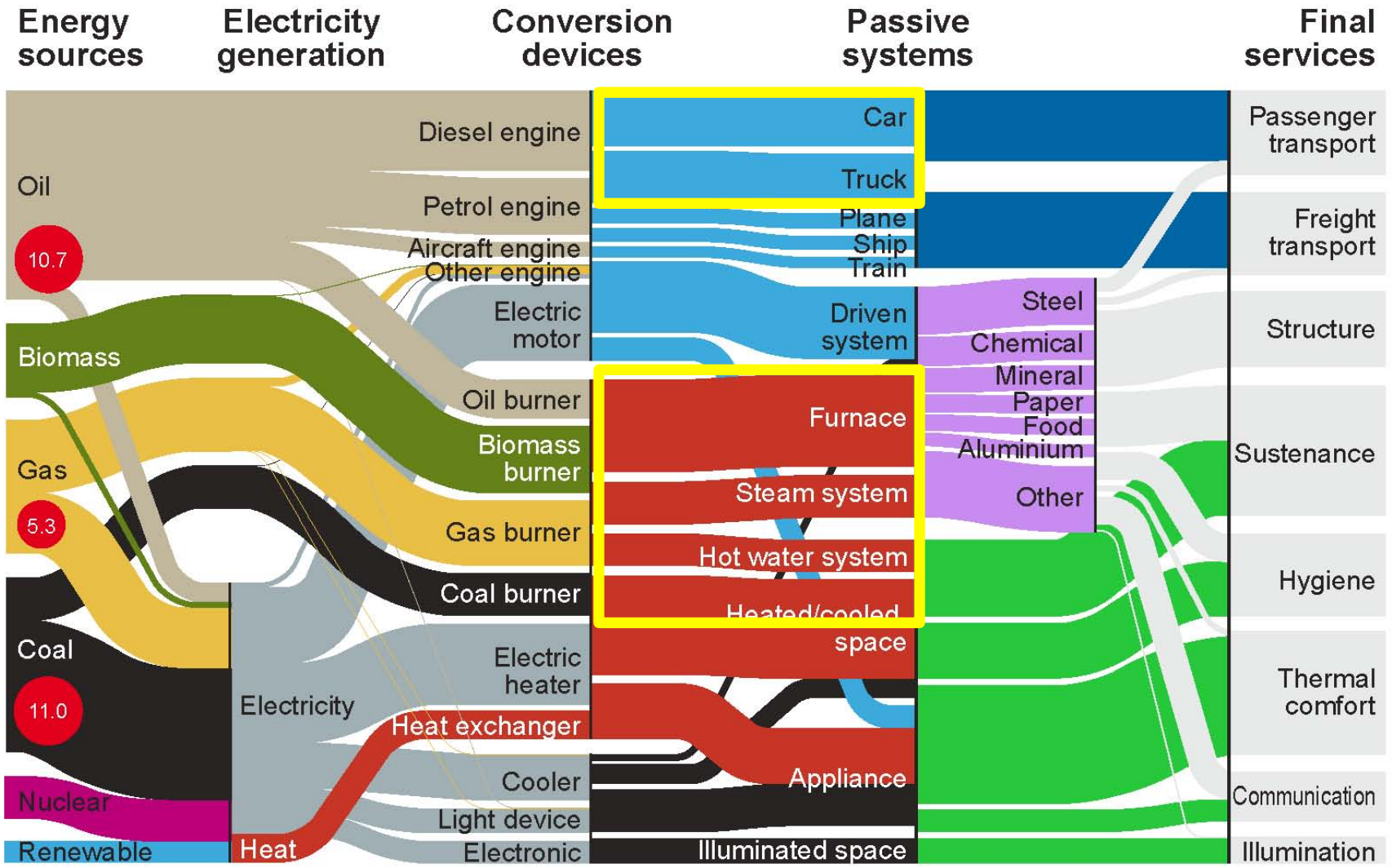


Distribution of domestic oil and gas consumption by sector



Glada Lahn, Paul Stevens, "Burning Oil to Keep Cool: The Hidden Energy Crisis in Saudi Arabia," Chatham House (The Royal Institute of International Affairs) report, UK, 2011.

Global Energy Flow



Global energy demand in 2005, total = 475 EJ

Global carbon emissions in 2005, total = 27 Gt CO_2

JM Cullen and JM Allwood
Energy Policy 38 (2010) 75–81

UNIVERSITY OF CAMBRIDGE

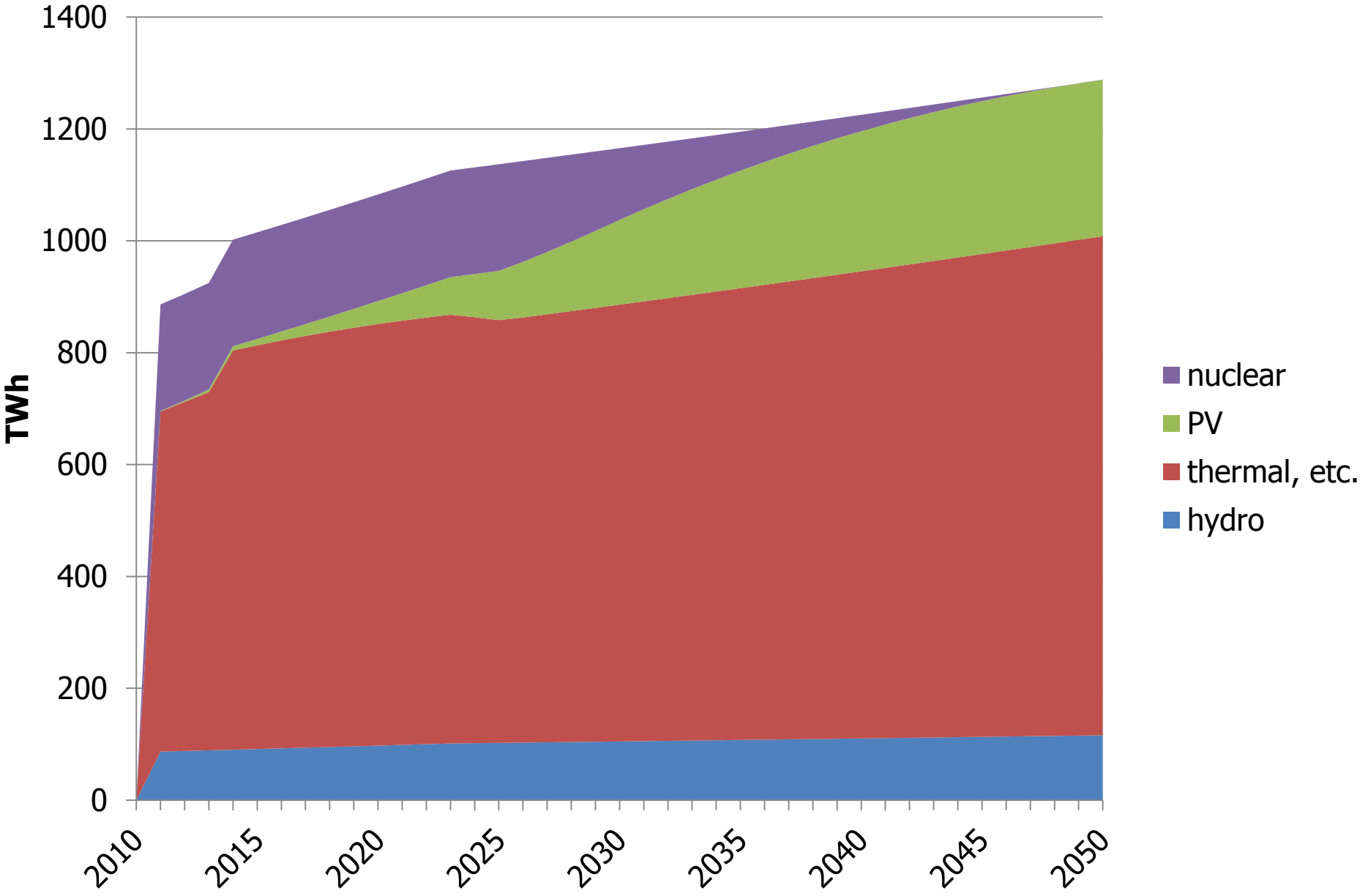
Economical impact of PV introduction - case of Japan -

I/O table analysis and applied general equilibrium analysis

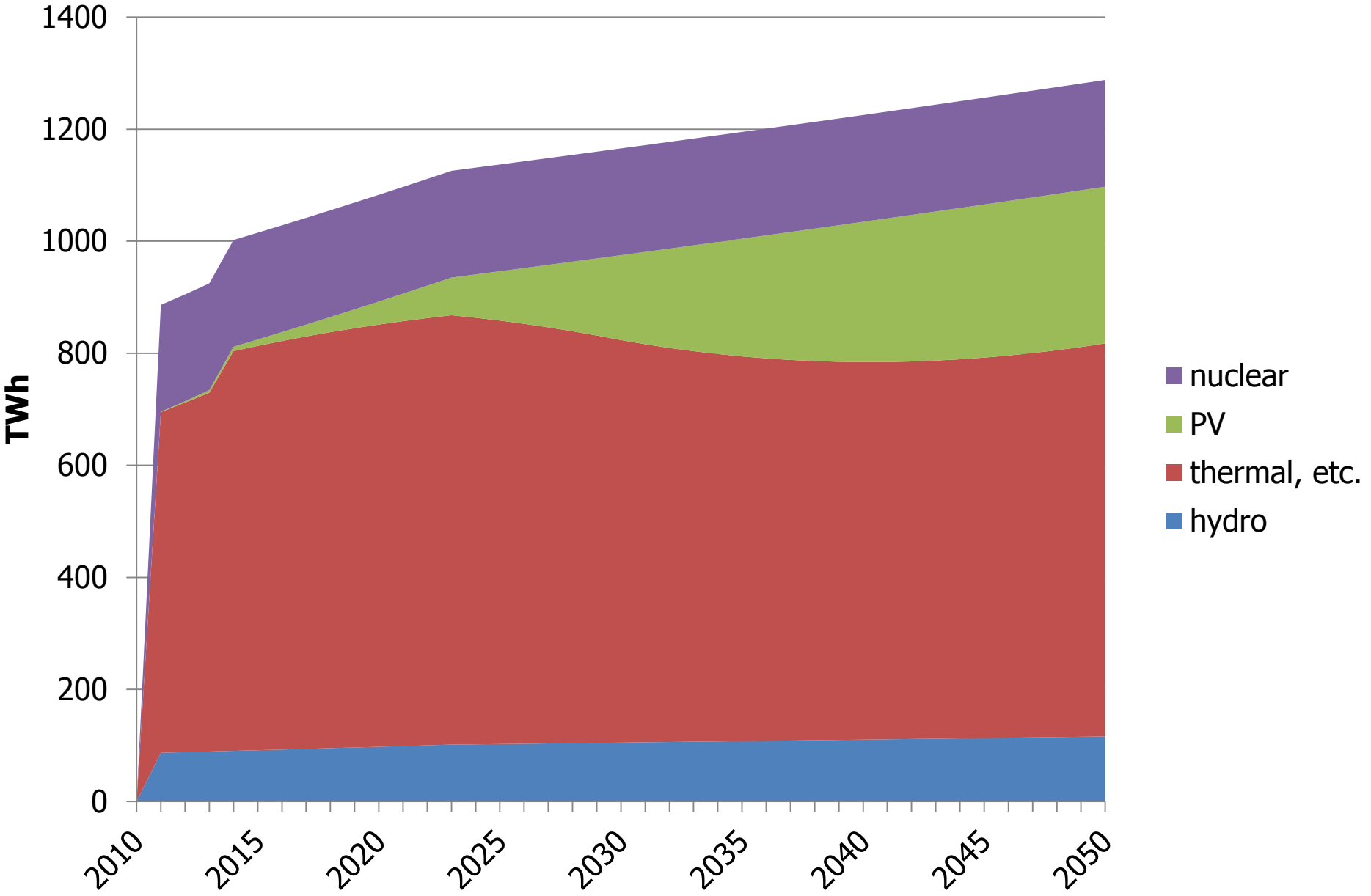
Assumptions for I/O table analysis

- Total efficiency of PV power generation 12%
- FIT level set to secure 6% of return by PV power generation
- Modules and ancillary cost reduce according to learning curves at 0.80 and 0.92, respectively
- Construction cost constant
- Module deterioration rate 1% and system life 20 years
- Production facilities build according to demand
- Production facilities amortized in 20 years
- PV generated power reach 296TWh in 35 years, thereafter the facilities will be constantly supplied to maintain the level
- Conservation cancels the increased electricity price and other demand will not be affected

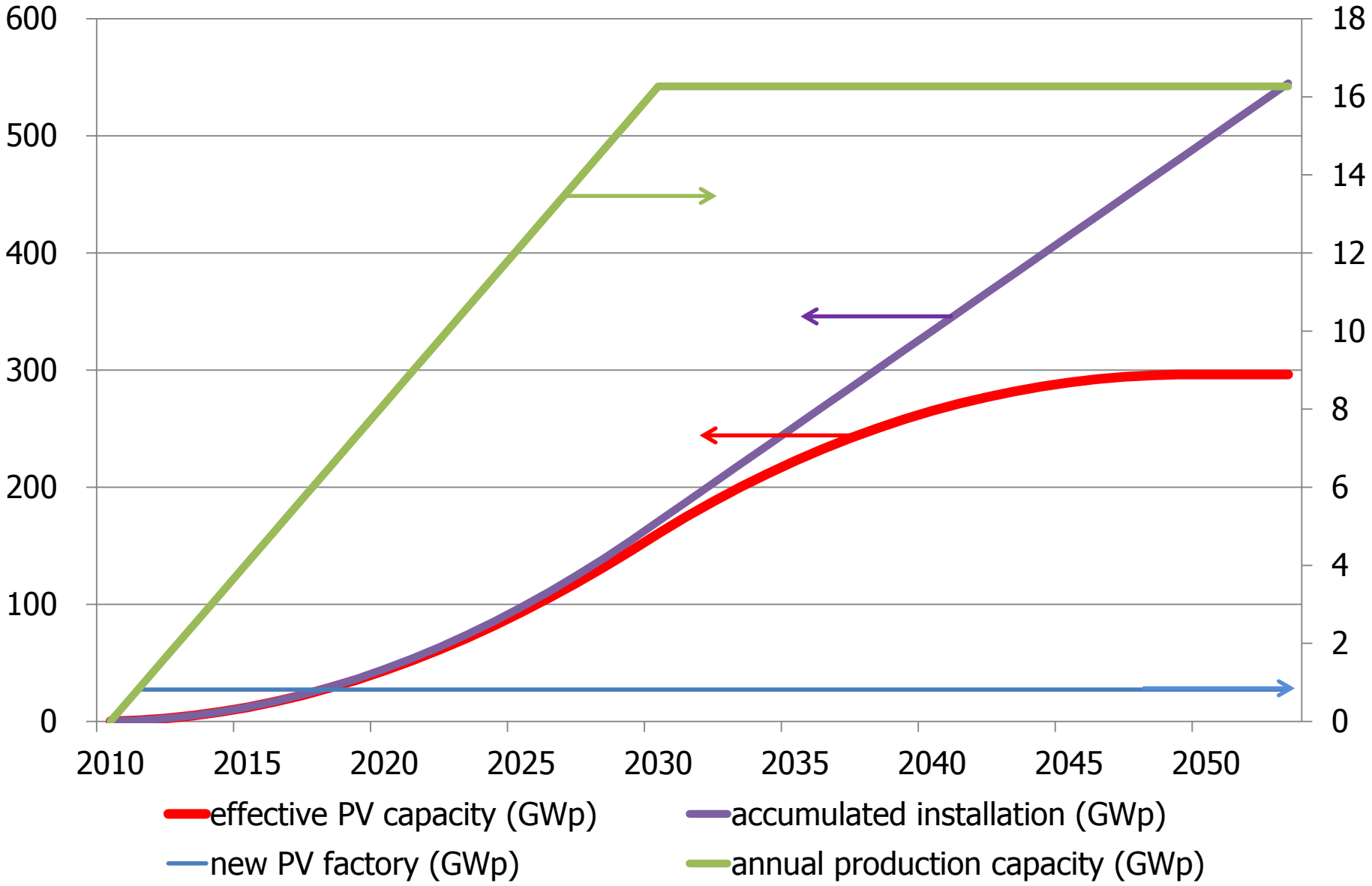
Energy mix transition (nuclear substitution)



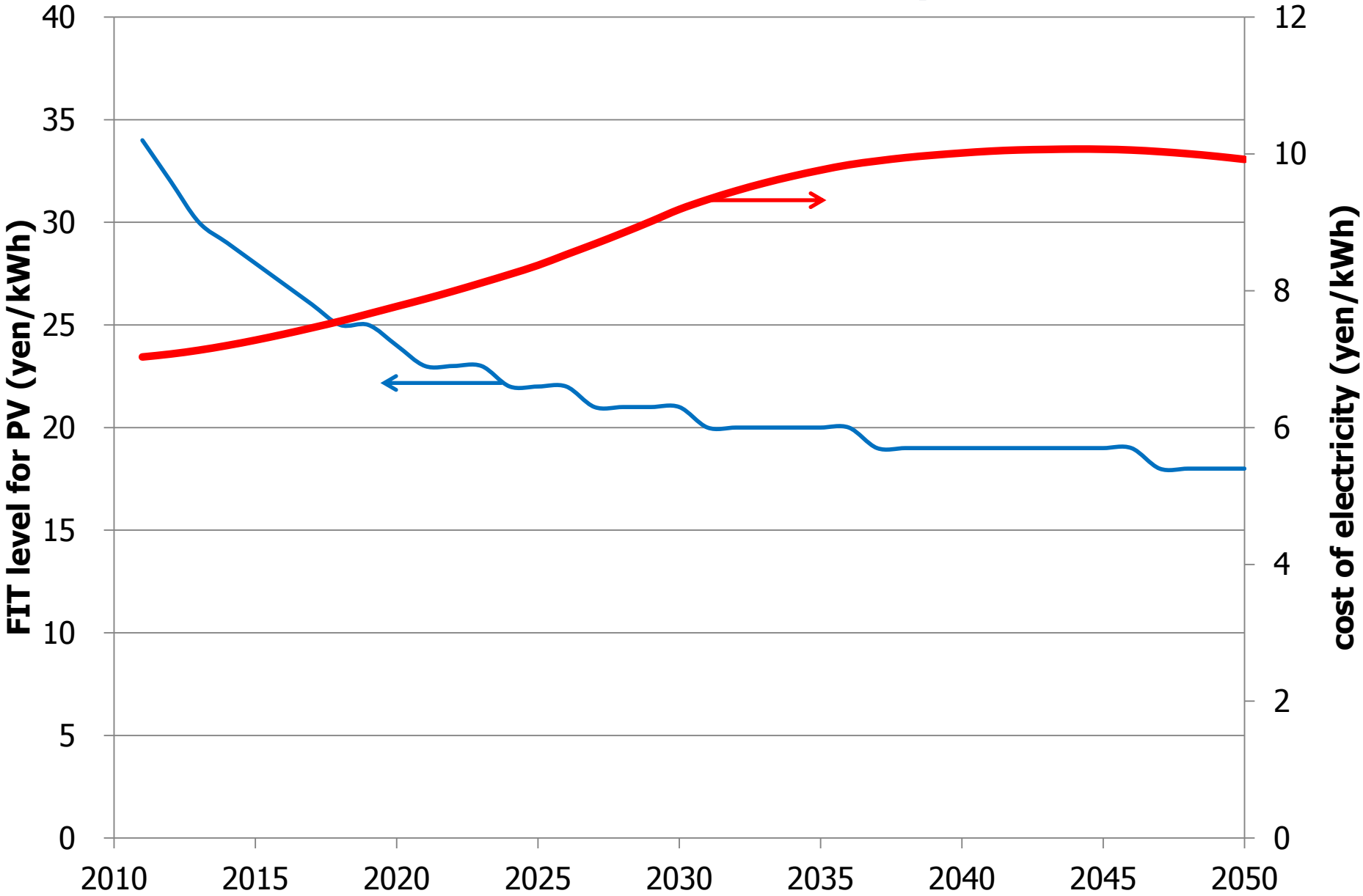
Energy mix transition (thermal substitution)



PV installation scenario



Cost of electricity



Economic ripple effect of PV installation

Assumptions

	nuclear	PV substitution	in 2050
Case 1	abandon	nuclear	thermal+PV
Case 2	maintain	thermal	nuc+thermal+PV
Case 3	maintain	no	nuc+thermal+PV

nuclear substitution (million yen)

Case1 - Case3	2020	2025	2030	2035
PV industry	1,660,819	2,814,336	3,921,488	5,104,335
coal/oil	173,504	639,762	714,979	786,552
manufacturing	-322,362	-584,705	-825,351	-1,094,244
chemical goods	-60,598	-95,017	-119,974	-157,251
electrical equipment	-290,647	-560,417	-822,645	-1,094,695
architecture/civil	720,529	1,087,566	1,464,856	1,845,406
utility	-340,640	-1,220,312	-1,347,233	-1,471,897
計	1,540,605	2,081,213	2,986,120	3,918,206

thermal substitution (million yen)

Case2 - Case3	2020	2025	2030	2035
PV industry	1,660,819	2,814,336	3,921,488	5,104,335
coal/oil	175,837	641,845	1,319,786	2,246,455
manufacturing	-322,369	-584,706	-825,351	-1,094,244
chemical goods	-60,601	-95,018	-119,974	-157,251
electrical equipment	-290,647	-560,417	-822,645	-1,094,695
architecture/civil	720,720	1,087,657	1,464,112	1,844,918
utility	-340,667	-1,220,313	-2,482,637	-4,199,151
計	1,543,092	2,083,384	2,454,779	2,650,367

Applied general equilibrium model analysis

- Assumptions:

- Global energy scenario: Blueprints
- Investment/consumption: 0.2528%
  - (average during 1991-2010)
- Power plant investment/Investment: 0.0581% (at 2009)
  - Coal thermal : Gas thermal = 50 : 50
  - PV (PR 0.83) : Wind (PR 0.93)= 80 : 20
- Annual facility depletion
  - PV (0.05)･Wind (0.066)
  - All others (0.025)

results

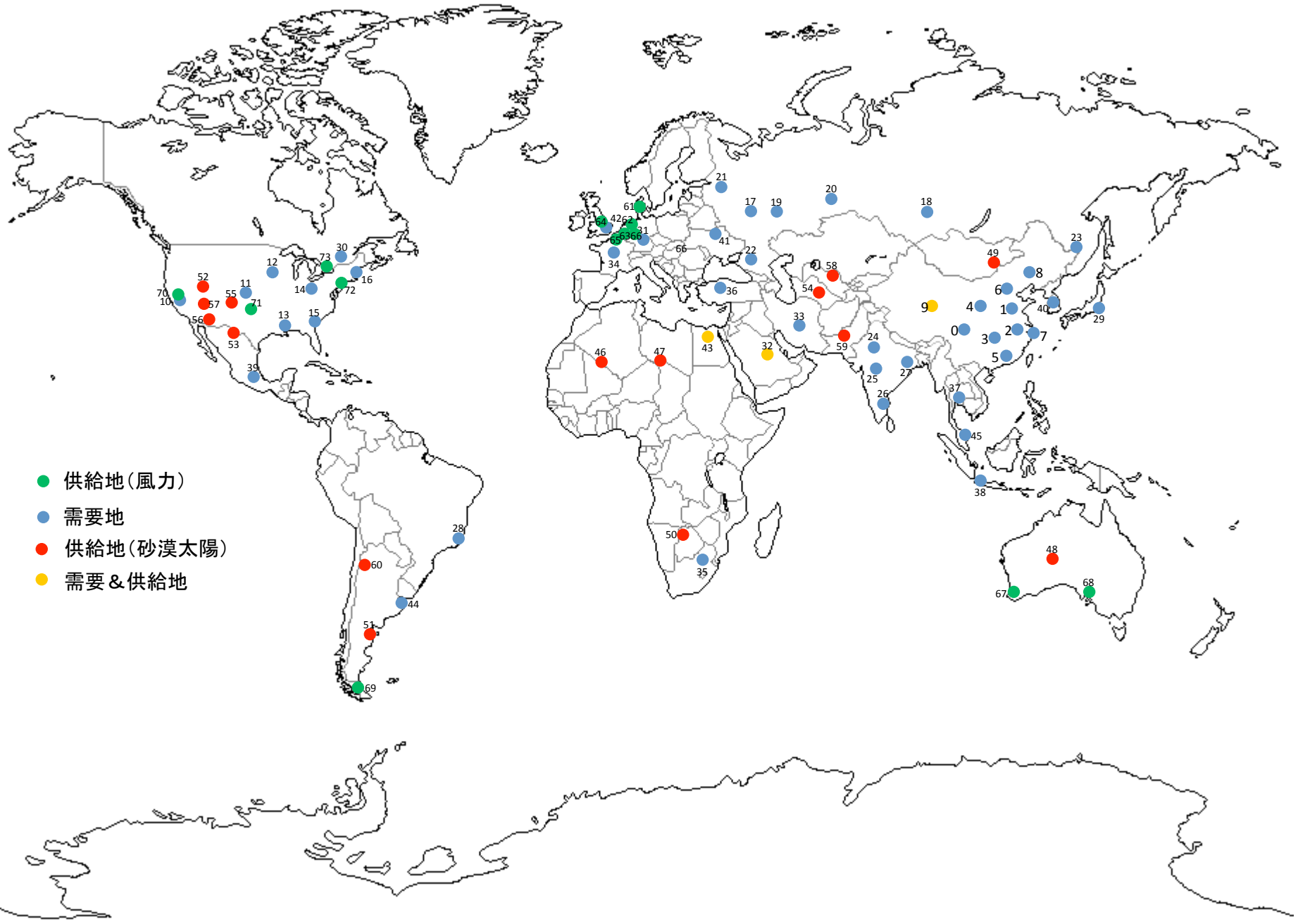
Scenario	investment timing				real GDP	real GDP	2009 base	
	2010	2015	2020	2025	average growth	(million$ in 2030)	real GDP	per capita
1	50	50	50	50	-0.80%	4,900,743	0.85	0.91
2	0	50	50	50	-0.40%	5,329,412	0.93	0.99
3	0	0	50	50	-0.12%	5,656,224	0.99	1.05
4	0	0	0	50	0.07%	5,890,493	1.03	1.09
5	0	0	0	0	0.28%	6,144,264	1.07	1.14

Scenario	generated power (TWh at 2030)	2009 base	max cost (2009 base)	PV TWh in 2030	PV+wind TWh in 2030
1	1,230.1	1.11	1.34	296.5 (24.1%)	478.1 (38.9%)
2	1,338.5	1.20	1.34	320.0 (23.9%)	516.2 (38.6%)
3	1,416.0	1.27	1.33	326.4 (23.1%)	527.7 (37.3%)
4	1,462.1	1.31	1.32	280.4 (19.2%)	455.6 (31.2%)
5	1,470.9	1.32	1.26	0.0 (0.0%)	0.0 (0.0%)

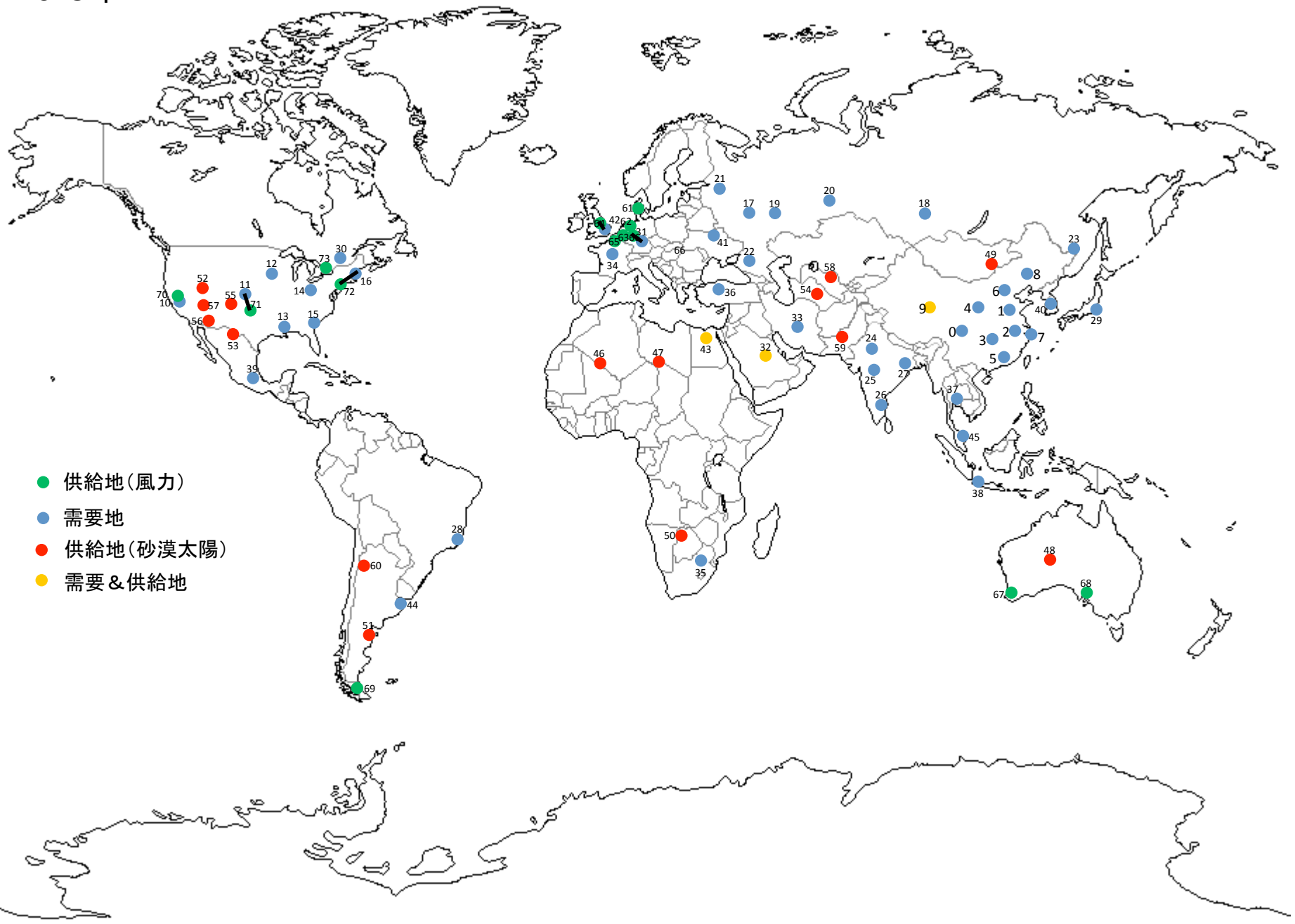
Global Solar^{+} Initiative

Will energy prices converge to the cost of solar power?

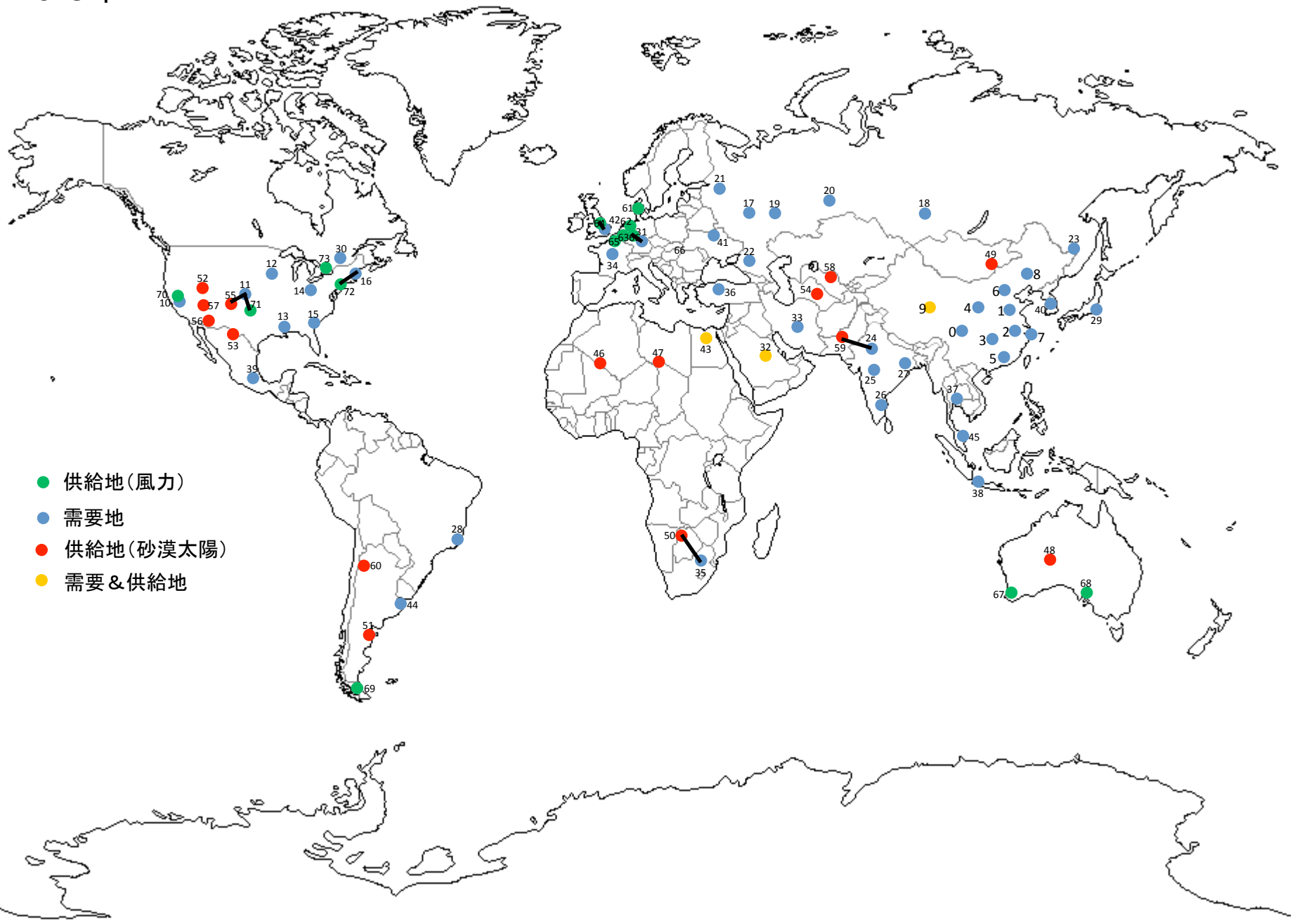
Global super grid delusion


供給地（風力）
需要地
供給地（砂漠太陽）
需要＆供給地

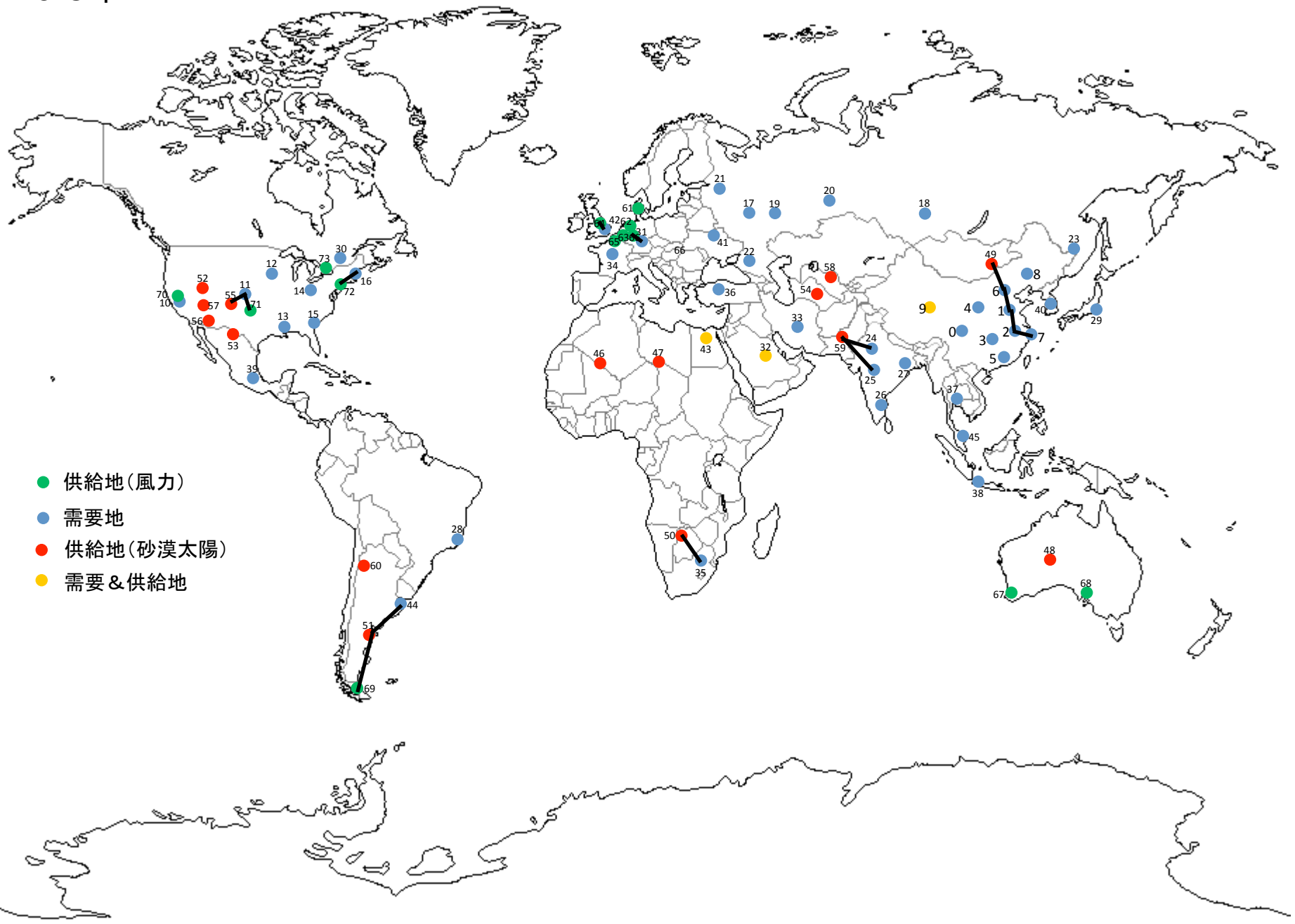
2013年



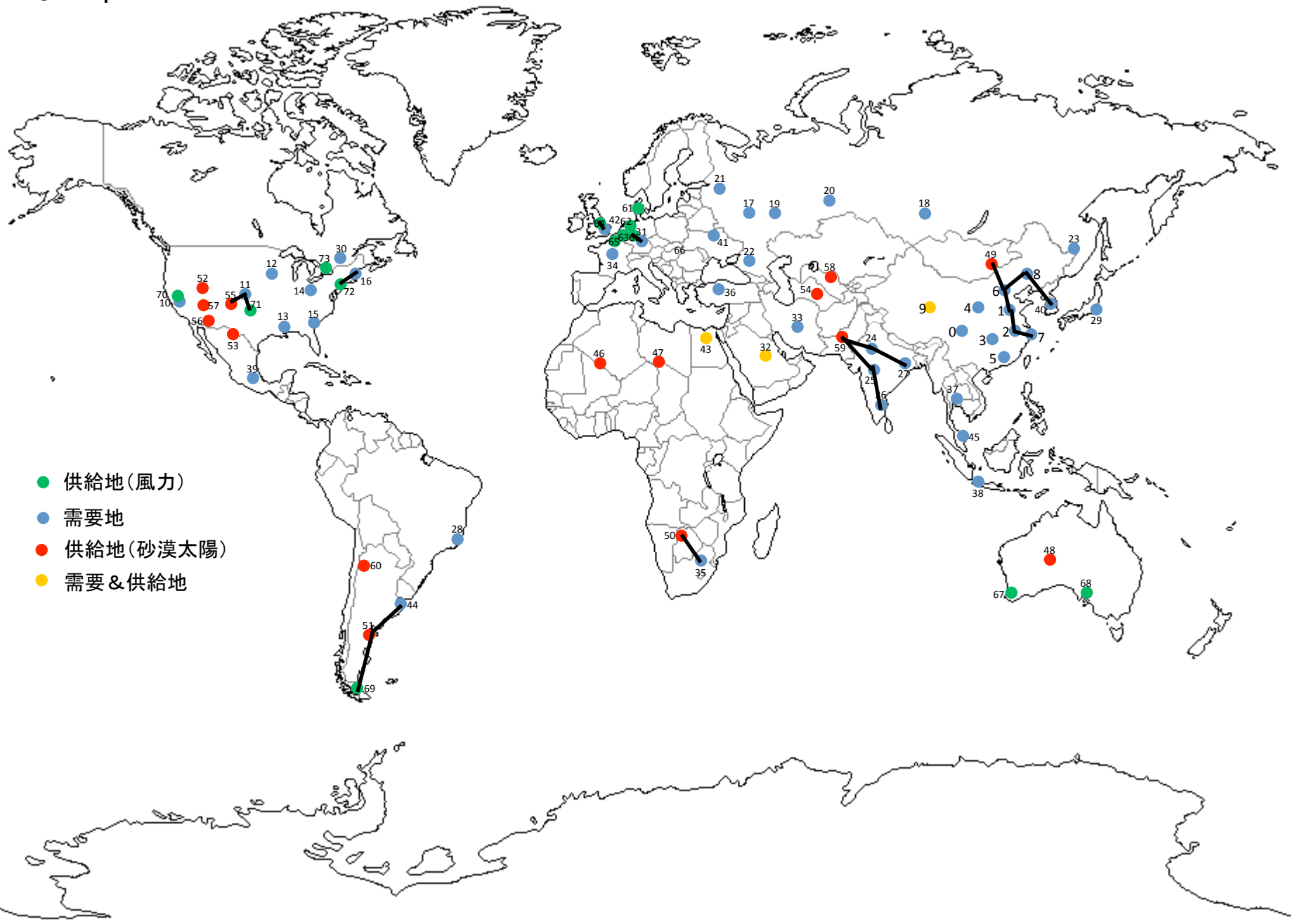
2015年



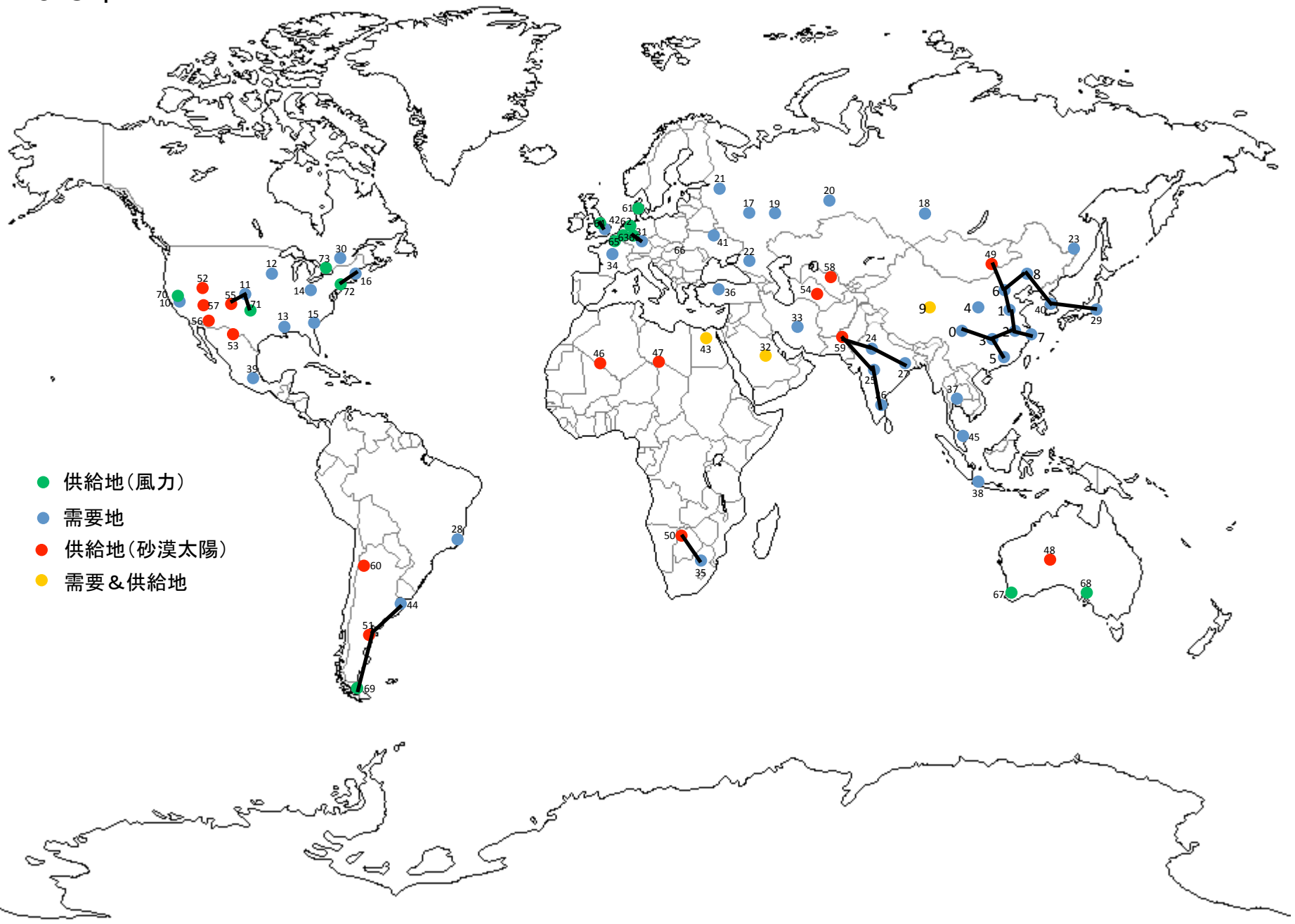
2019年



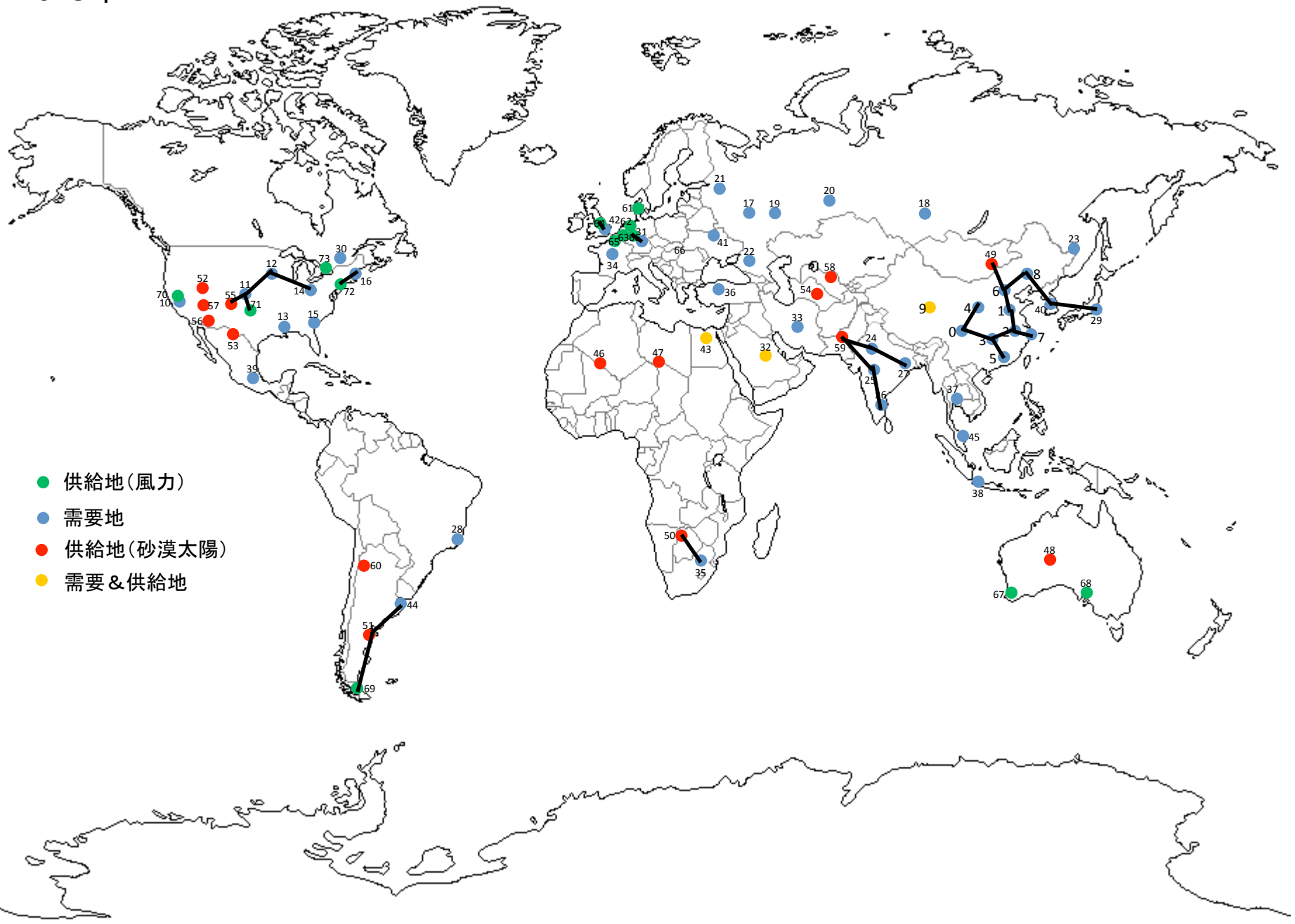
2022年



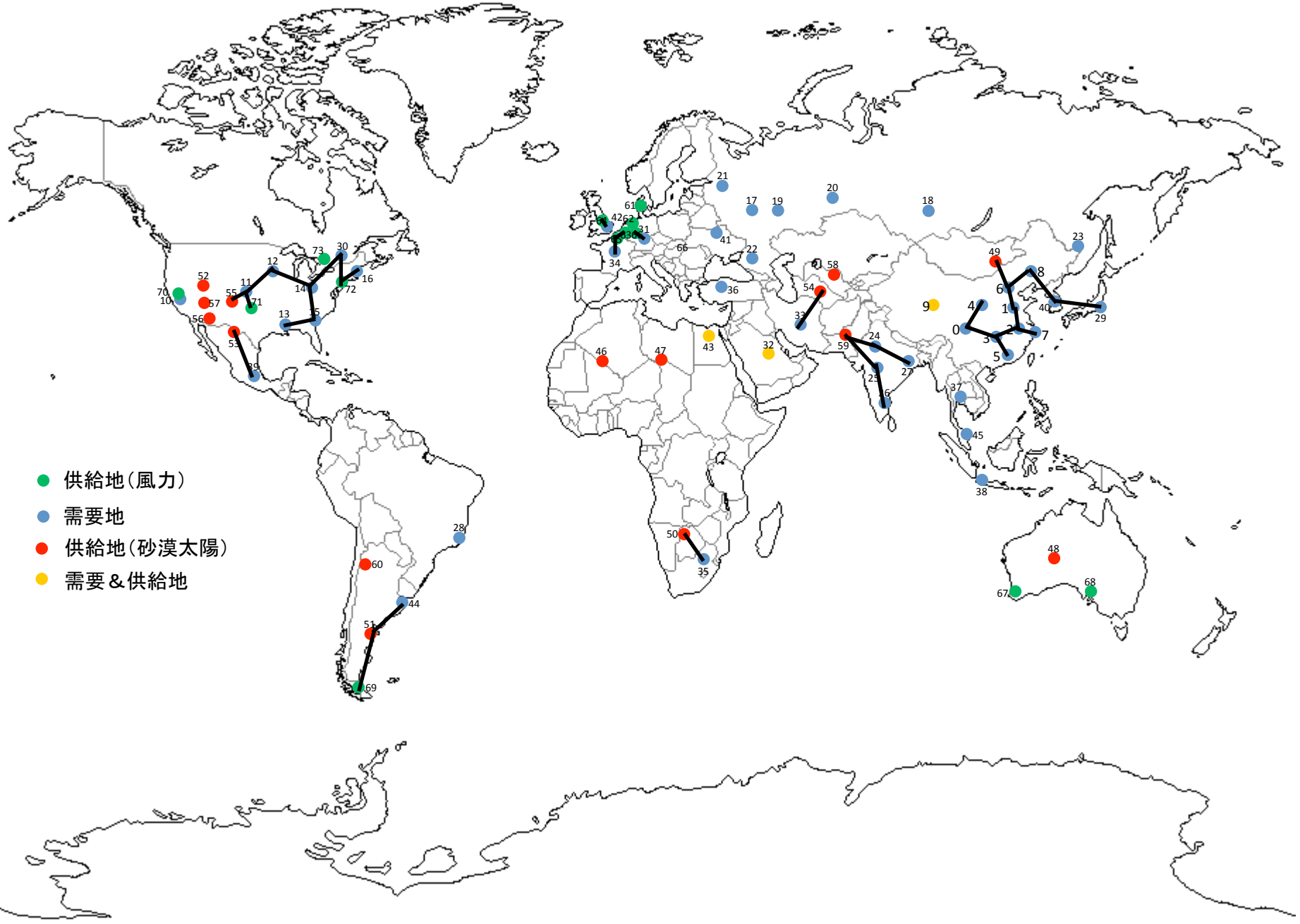
2025年



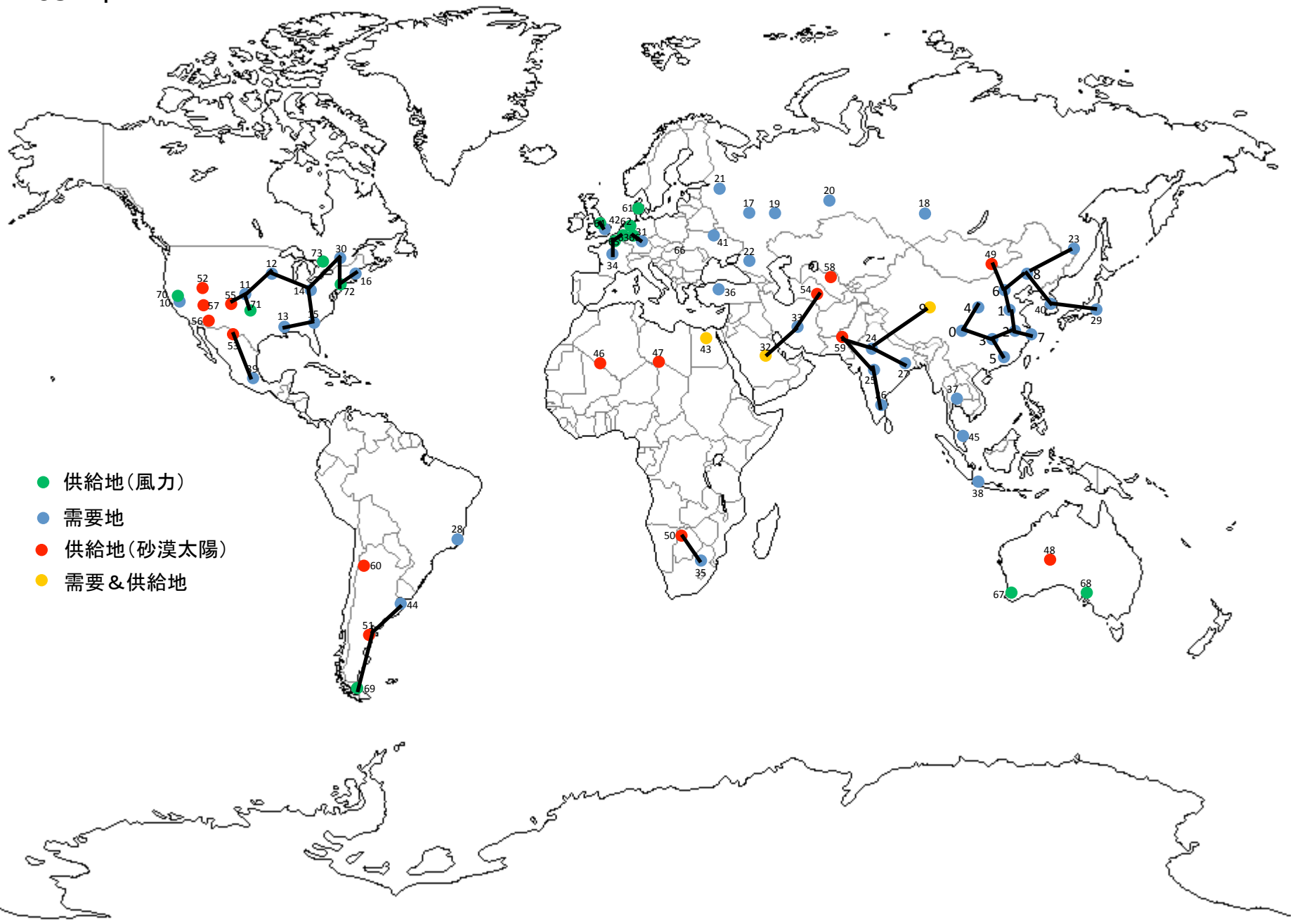
2028年



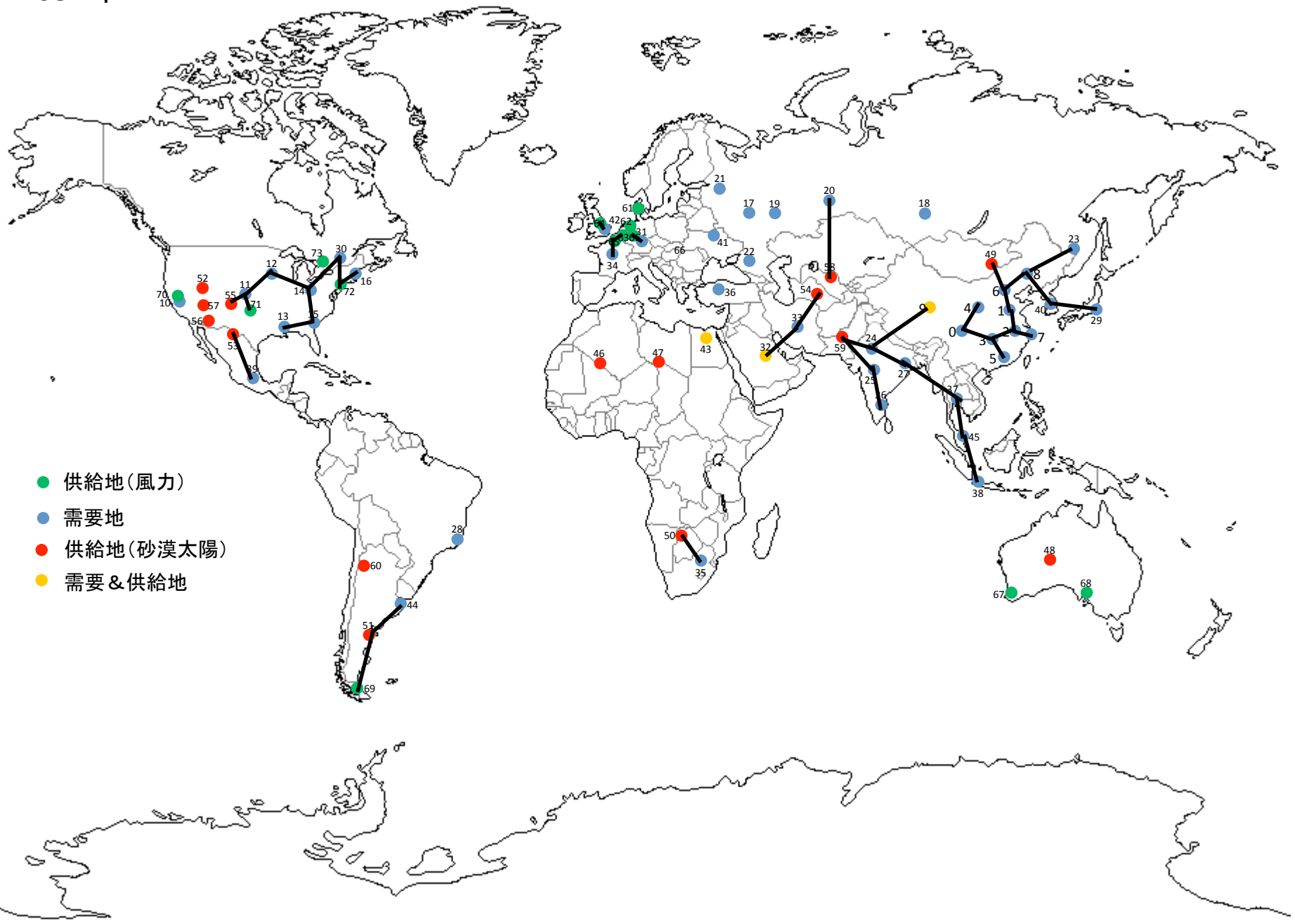
2031年



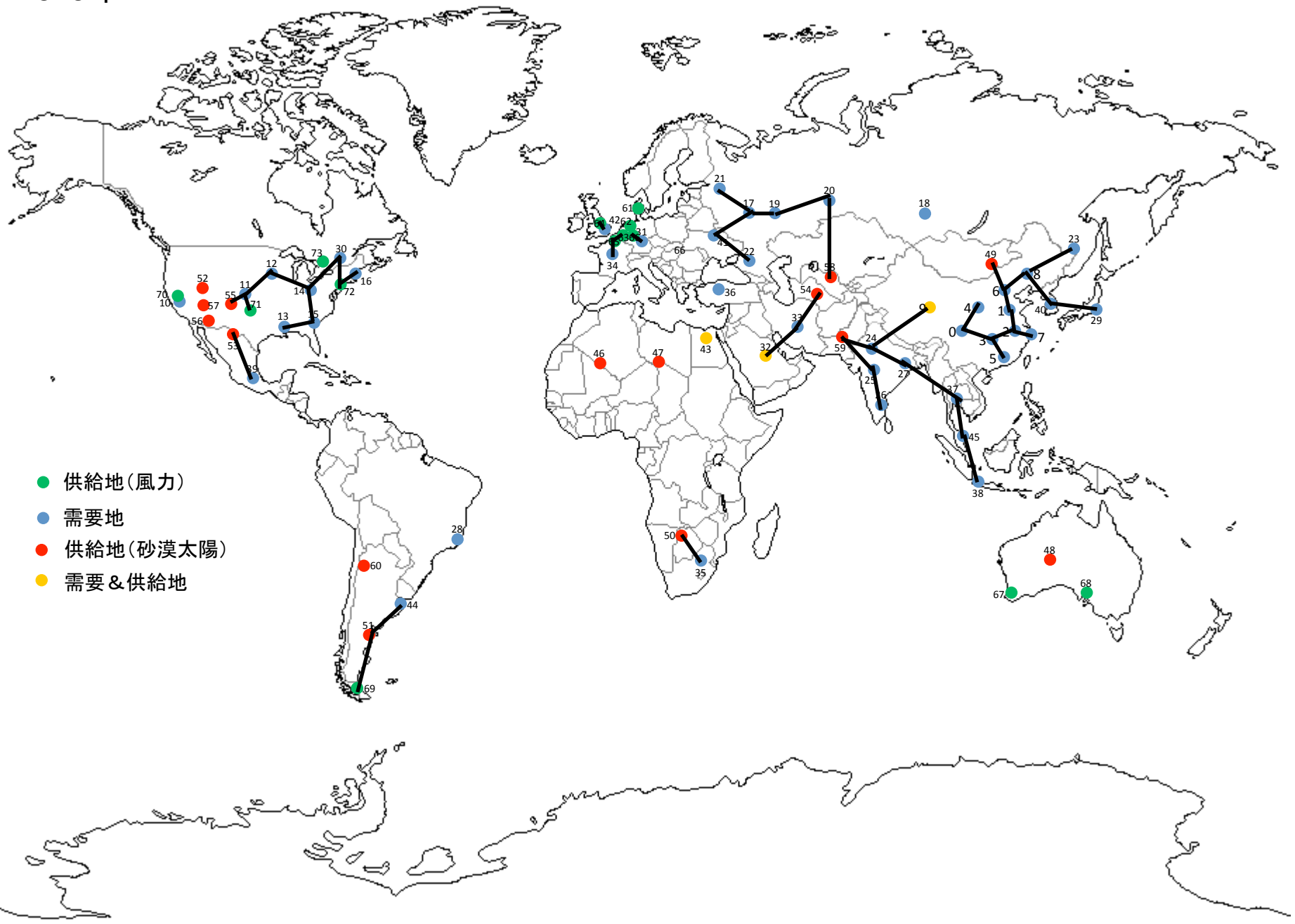
2034年



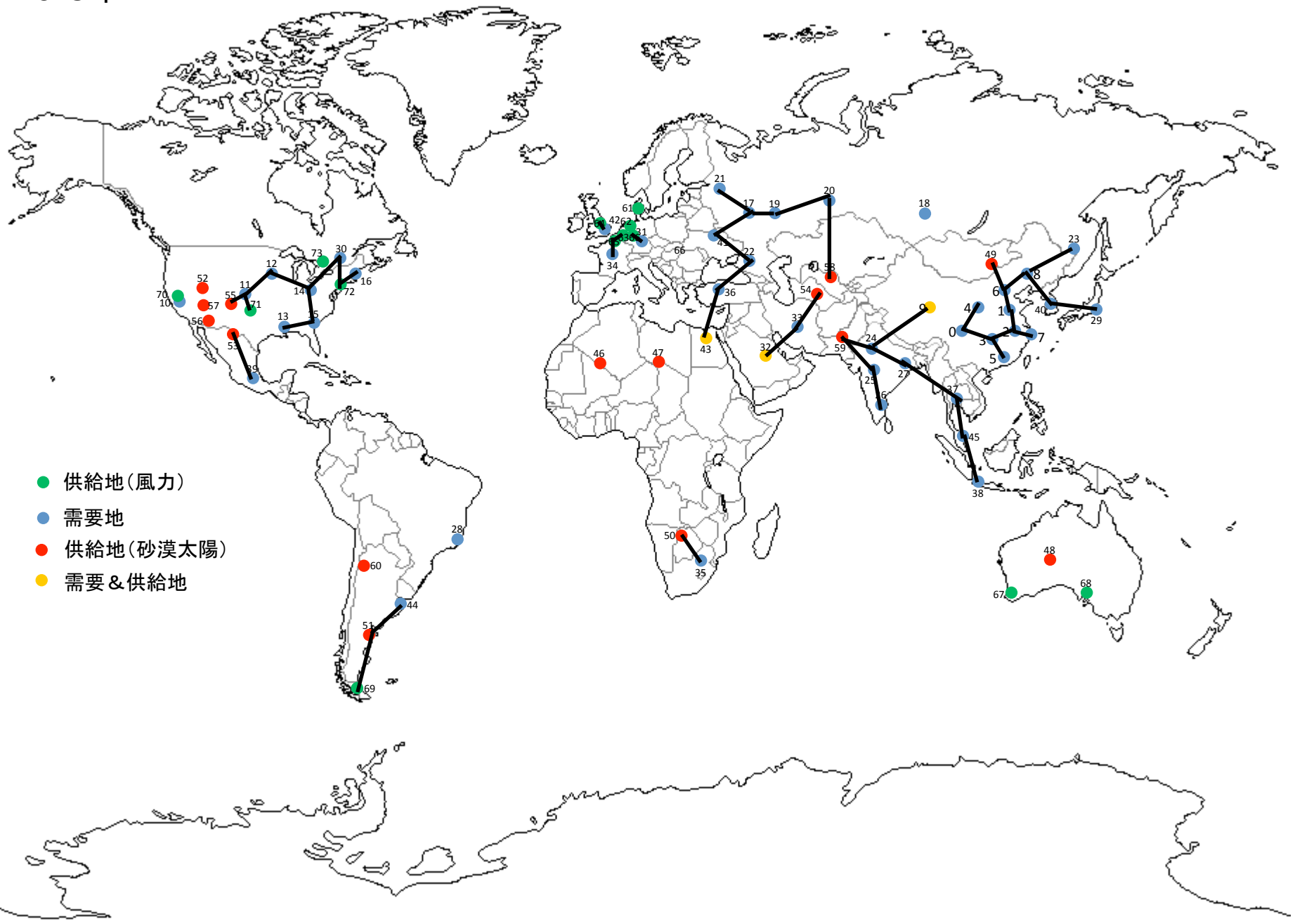
2037年



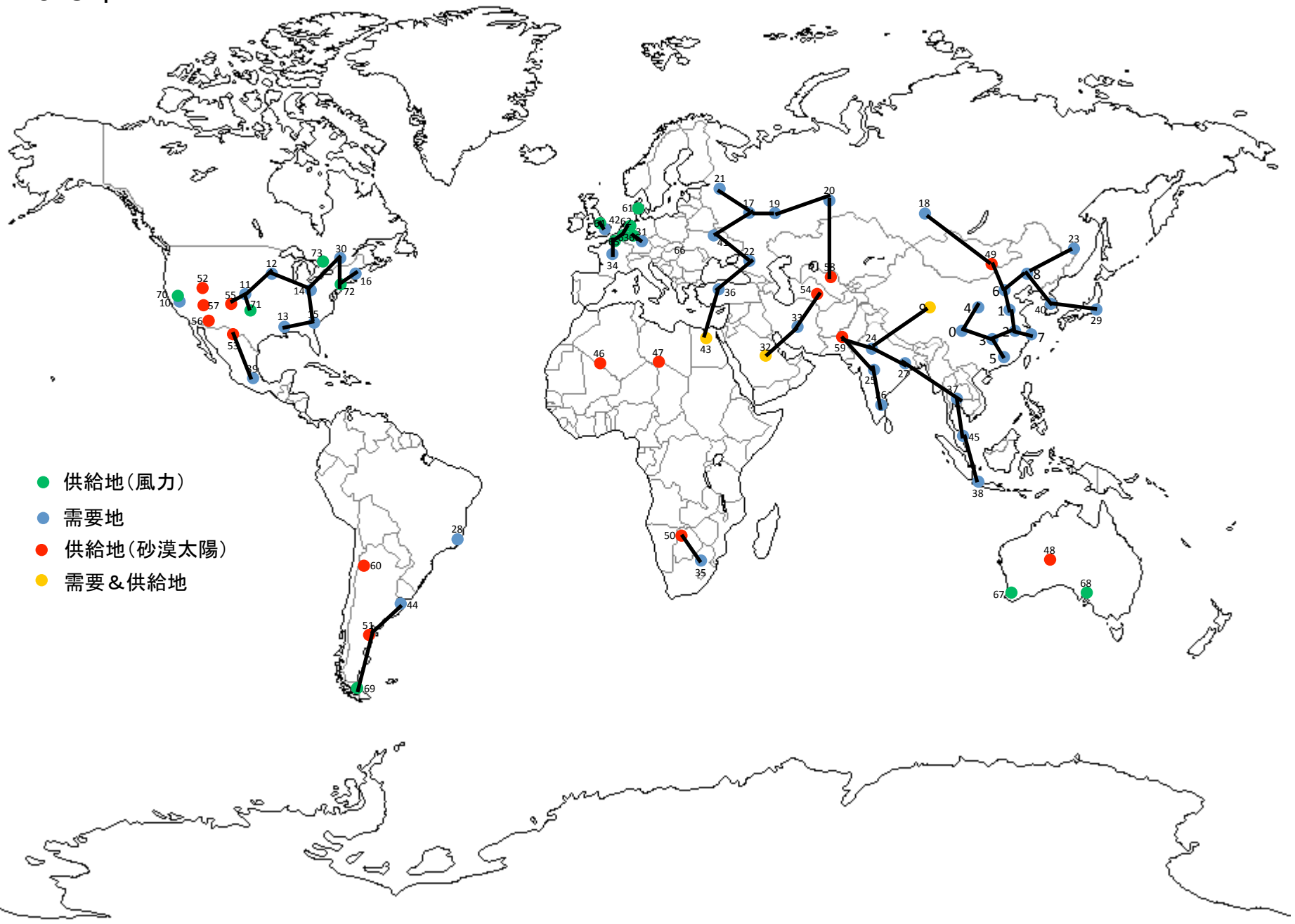
2040年



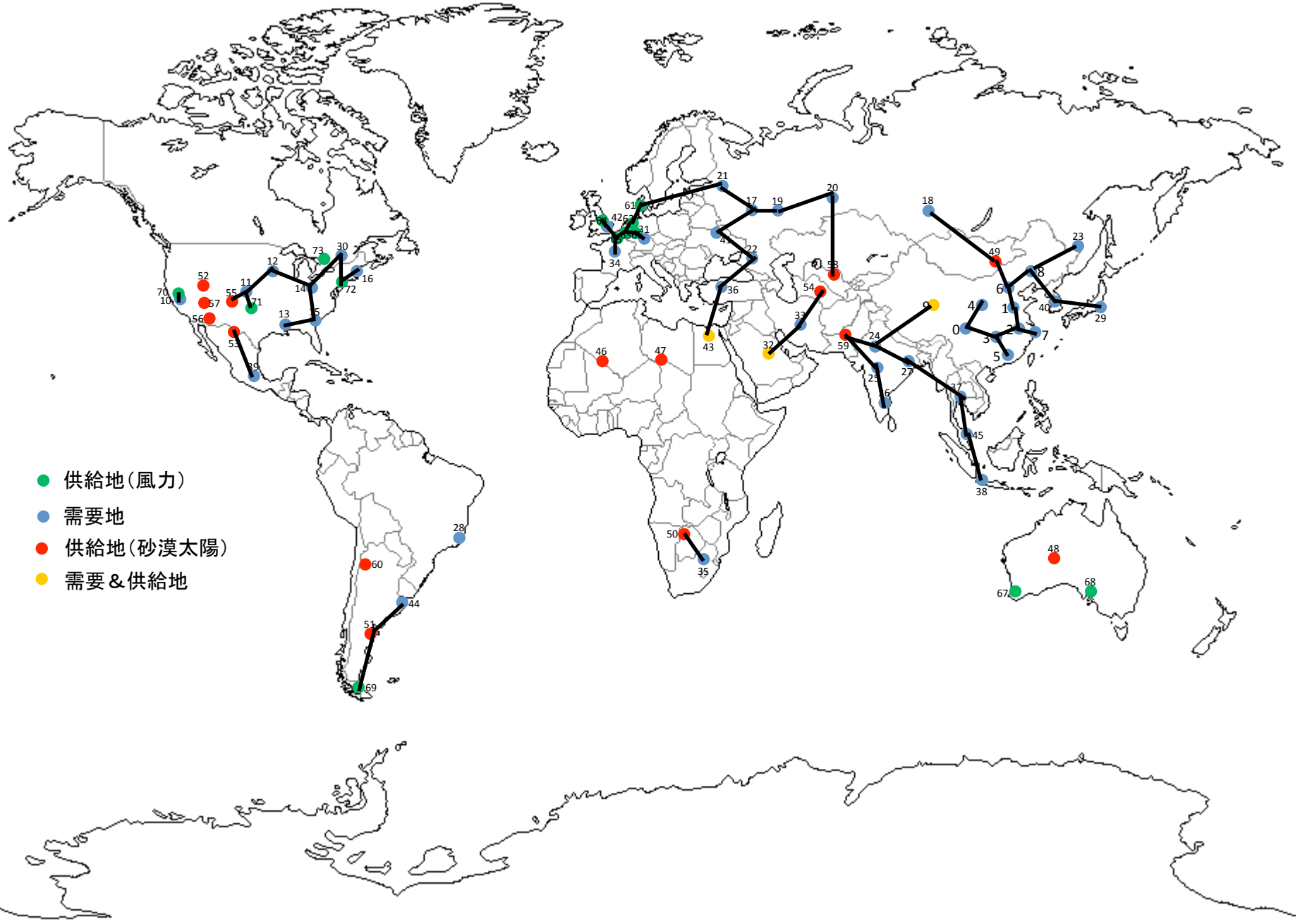
2043年



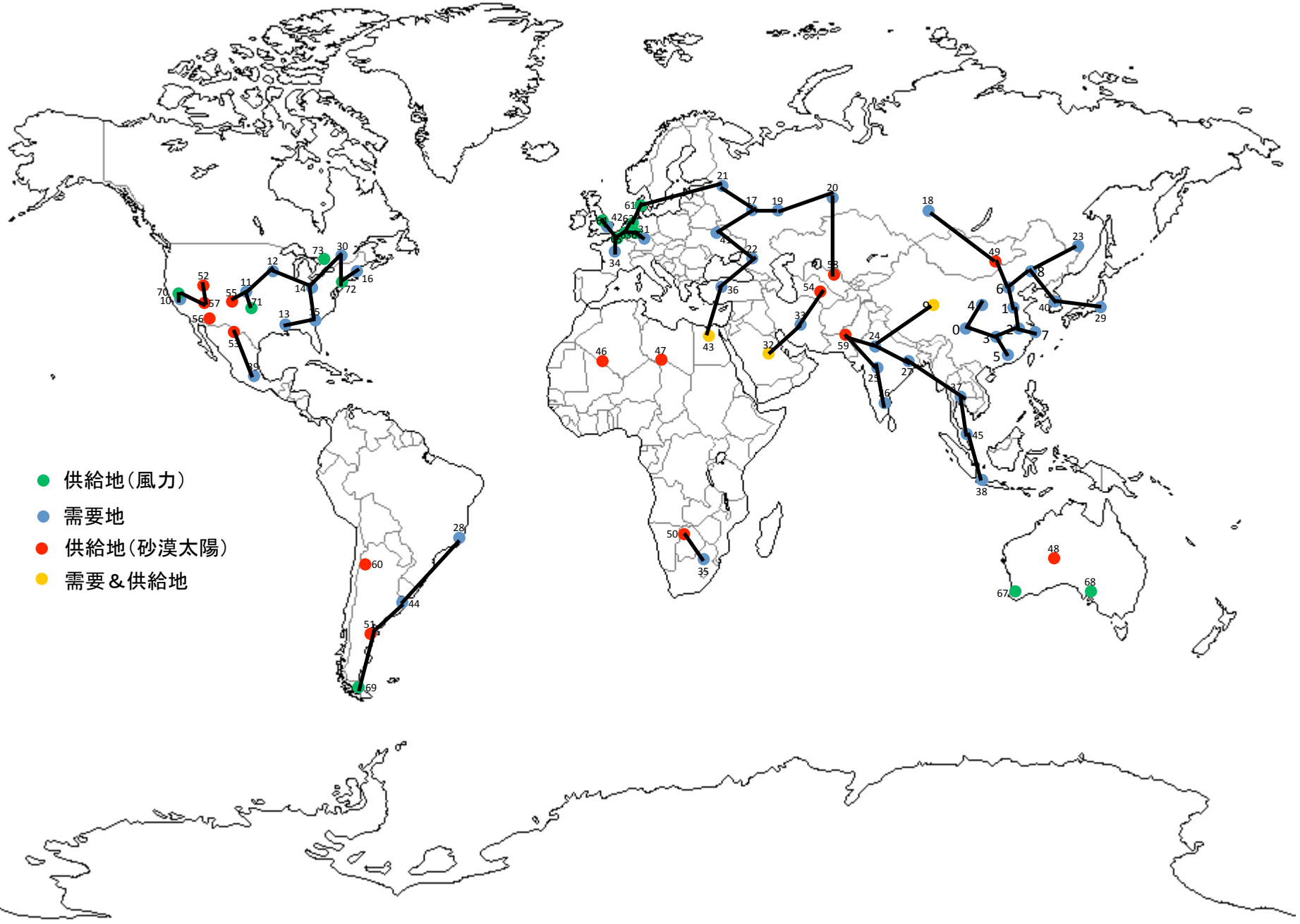
2045年



2047年



Ultimate limit due to Silver reserves constraints



Will this Century the Century of solar?