Rôle du solaire dans le système énergétique global

UNI GE 19.05.2017

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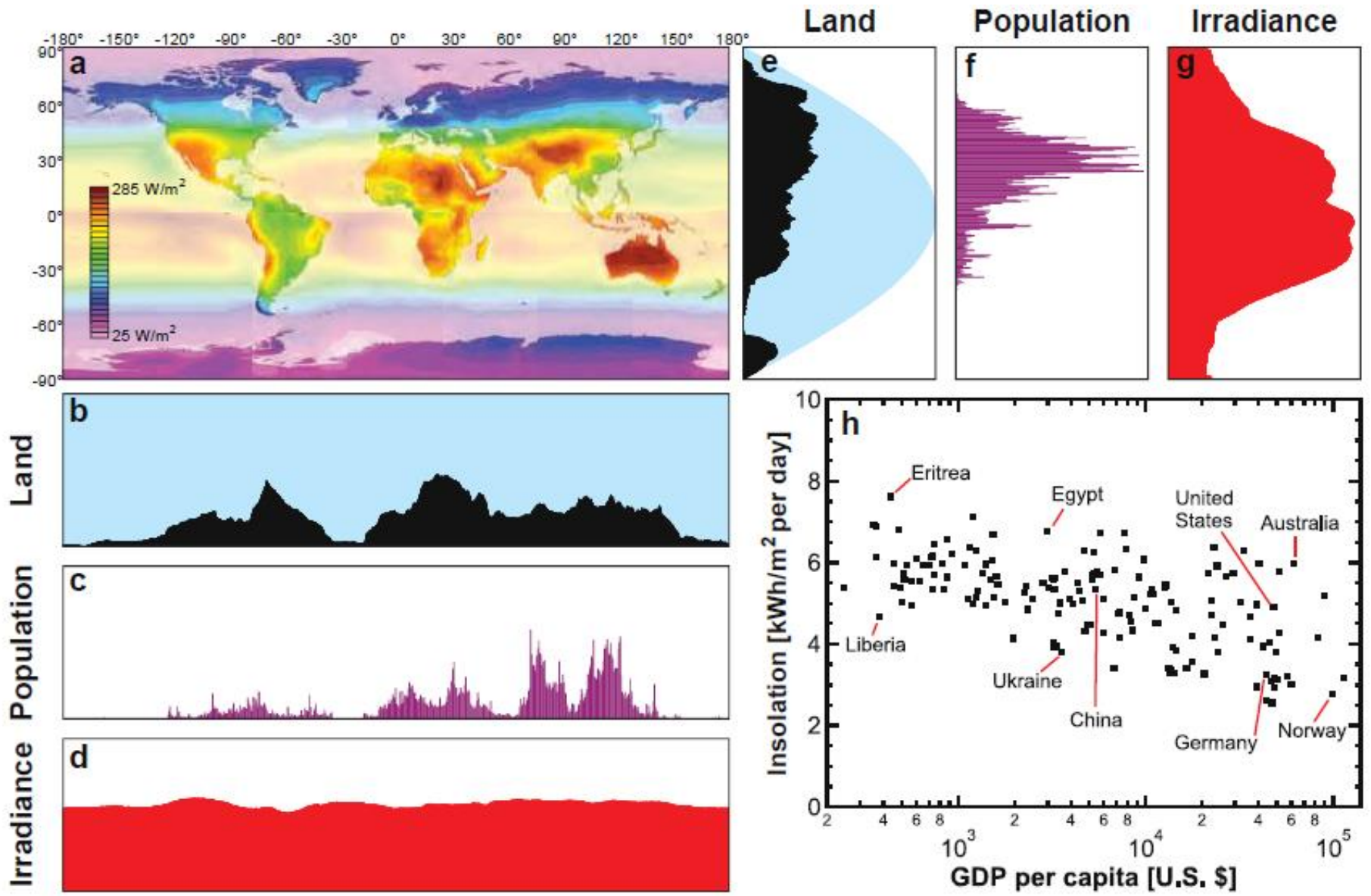
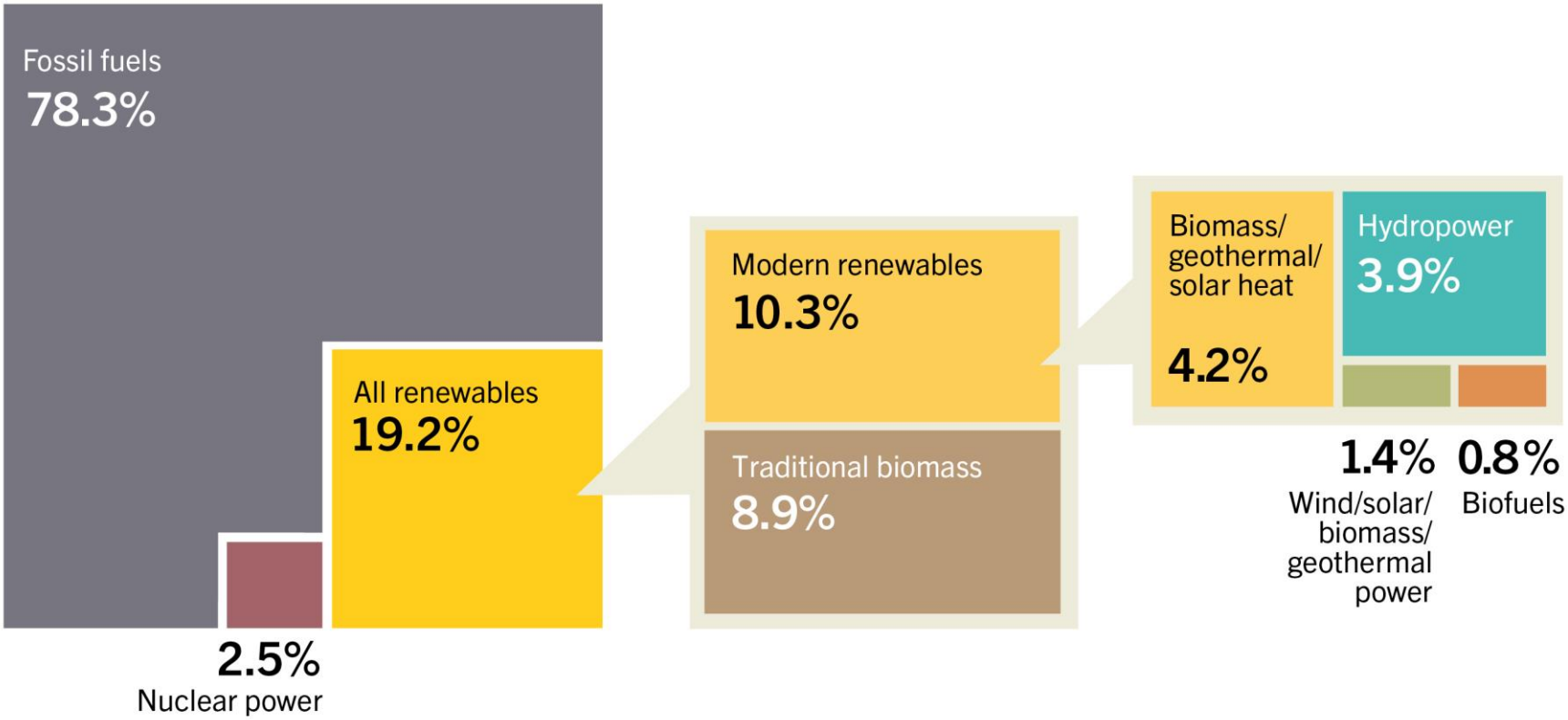
.

- **Une Planète solaire**
- **Solaire thermique**
- **Solaire électrique**
- **Combien de solaire déjà ?**
- **Mais pourquoi ?**
- **Prédictions**

Une planète solaire…peu de soleil chez les riches ?



Estimated Renewable Energy Share of Global Final Energy Consumption, 2014



REN21 *Renewables 2016 Global Status Report*

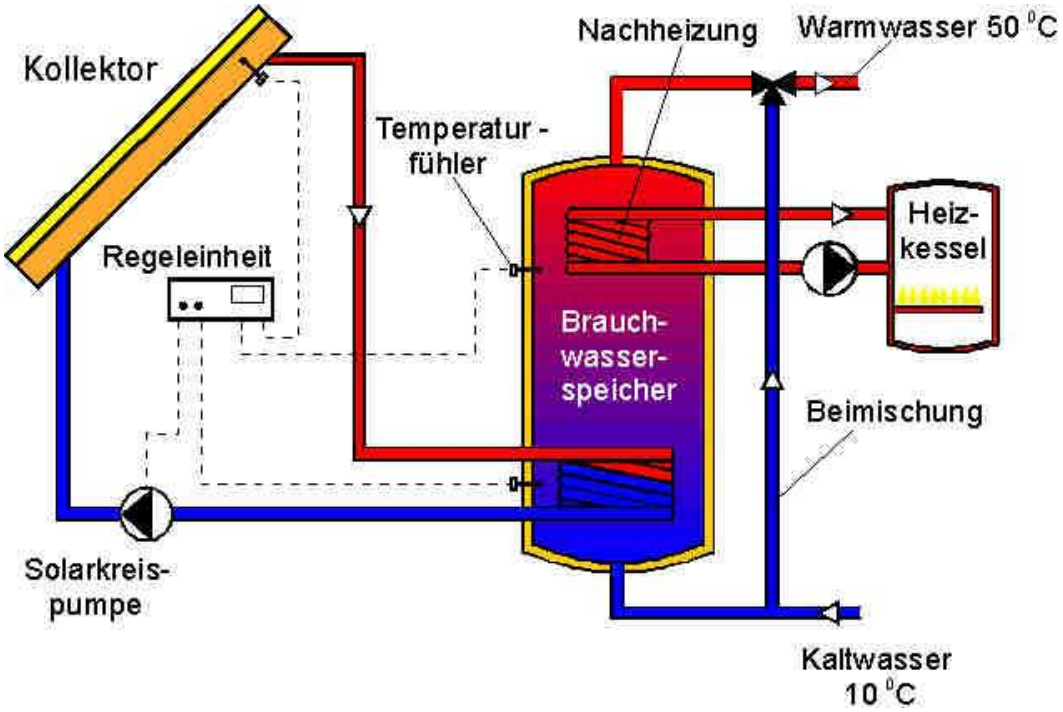
REN21 Renewable Energy Policy Network for the 21st Century

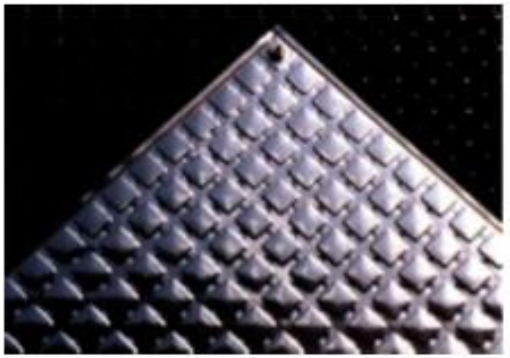
Solaires….

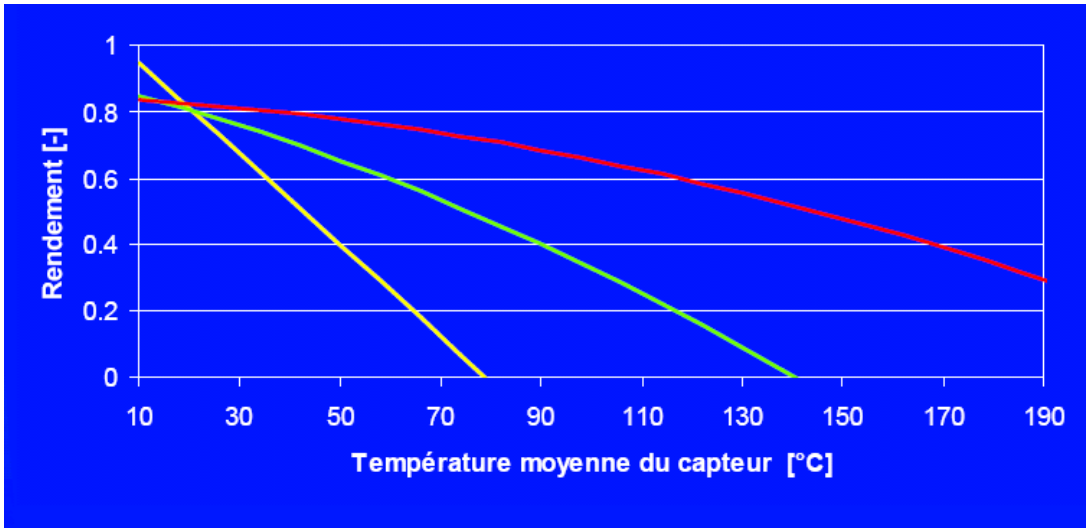
- **Solaire Thermique**
  - Chauffage de locaux
  - Chauffage de piscines
  - Eau chaude sanitaire
  - Processus industriels
  - Cooling
  - Electricité

- **Solaire Photovoltaïque**
  - Electricité
  - Chauffage / refroidissement par PAC ….PVT
  - Processus
  - Mobilité

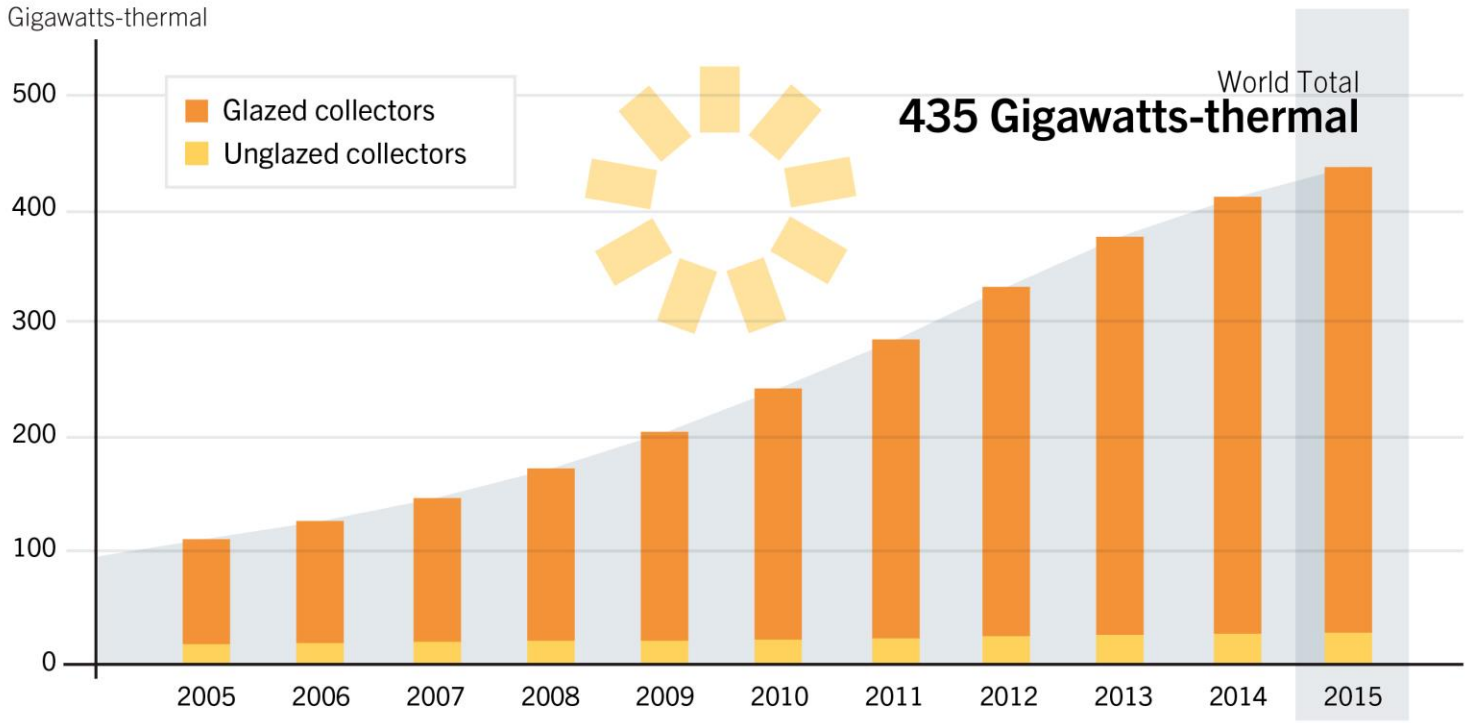
Solaire thermique – ECS







Solar Water Heating Collectors Global Capacity, 2005–2015



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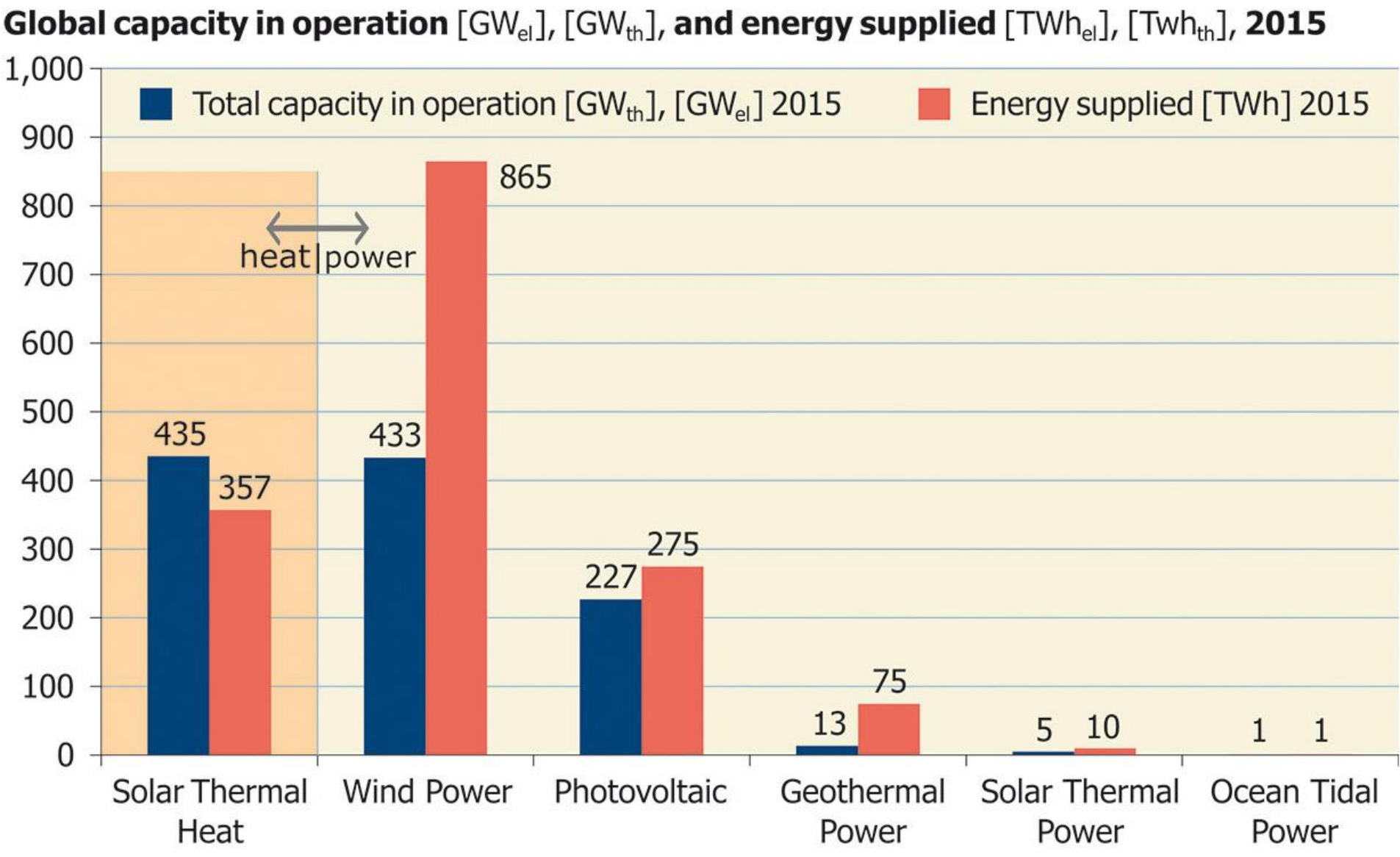
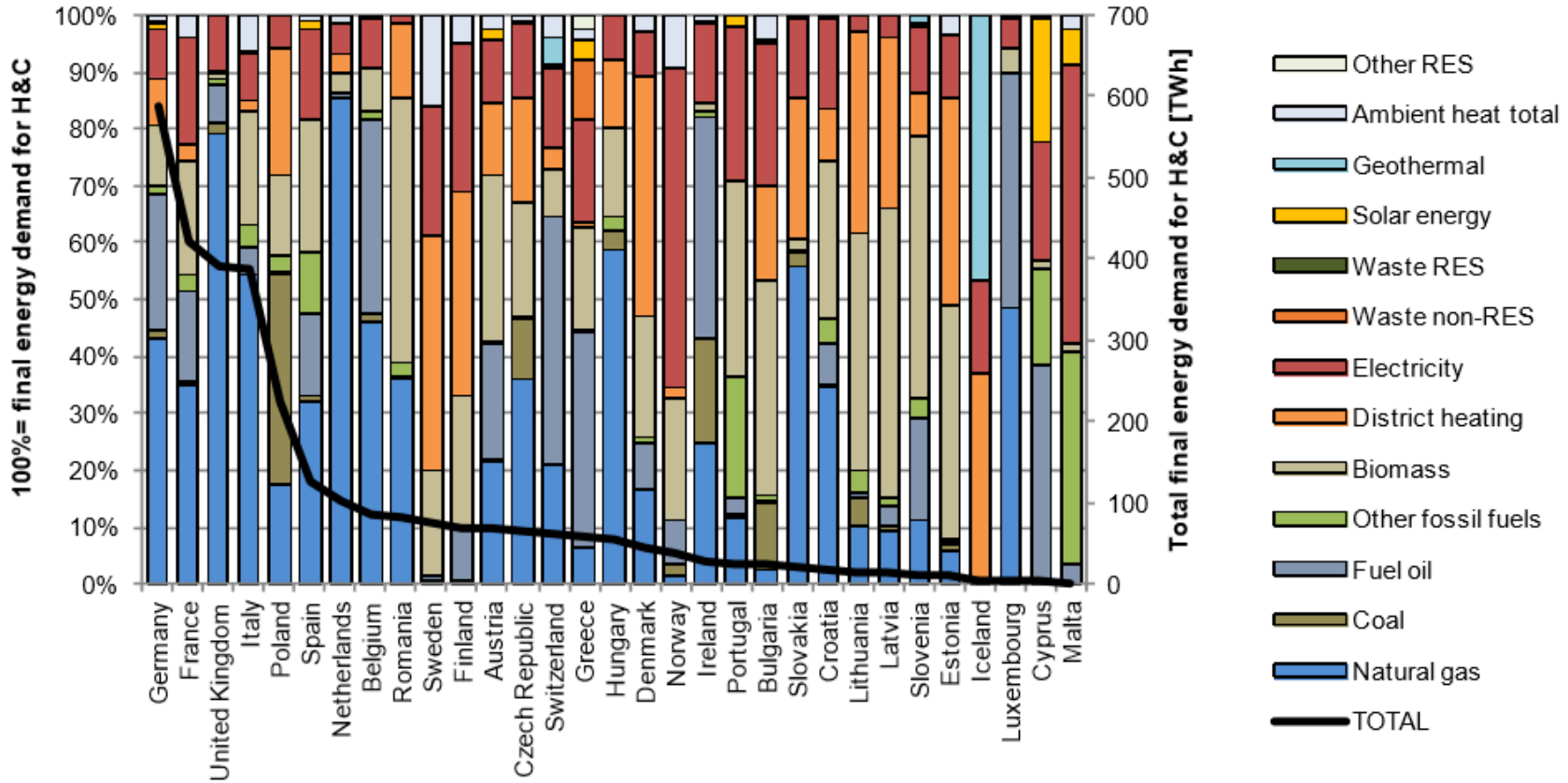
Source: IEA SHC.

Global Capacity in Operation 2015

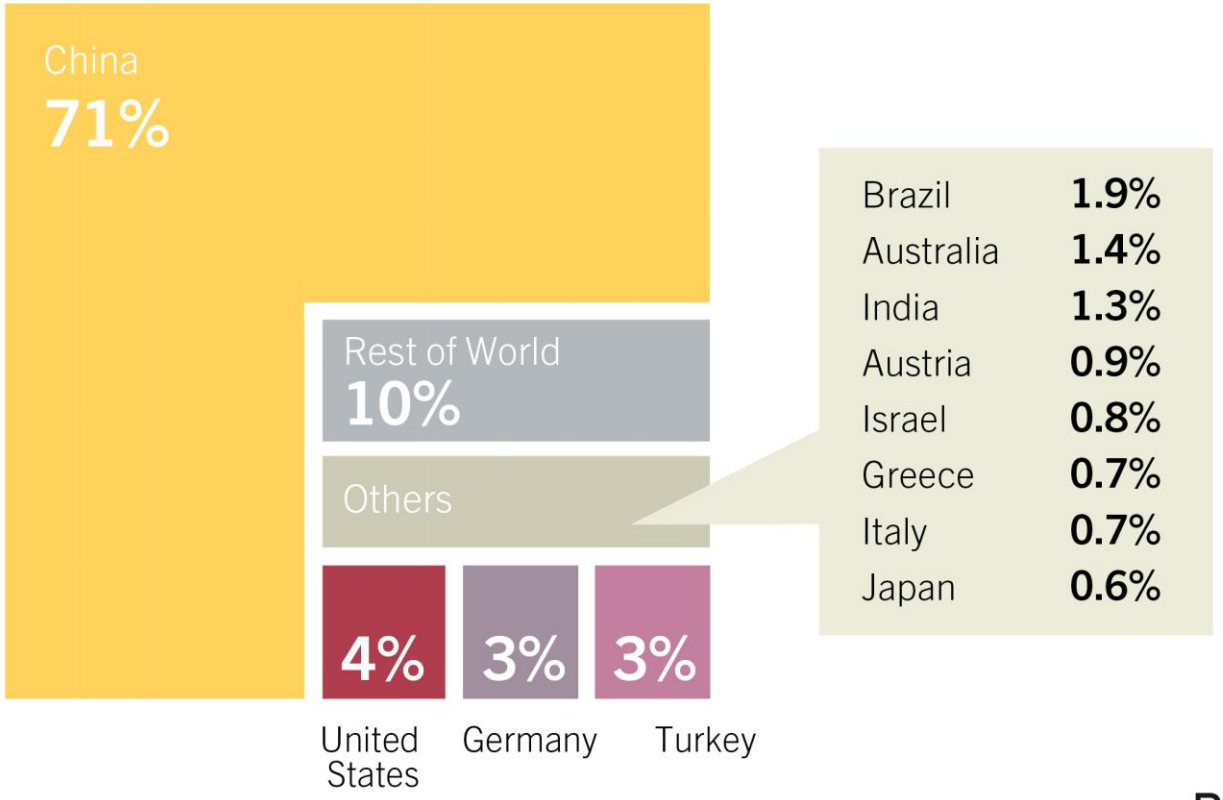


2012: EU… bien peu de solaire

Figure 44: Share of energy carriers on total heating and cooling demand by country



Solar Water Heating Collectors Global Capacity, Shares of Top 12 Countries and Rest of World, 2014



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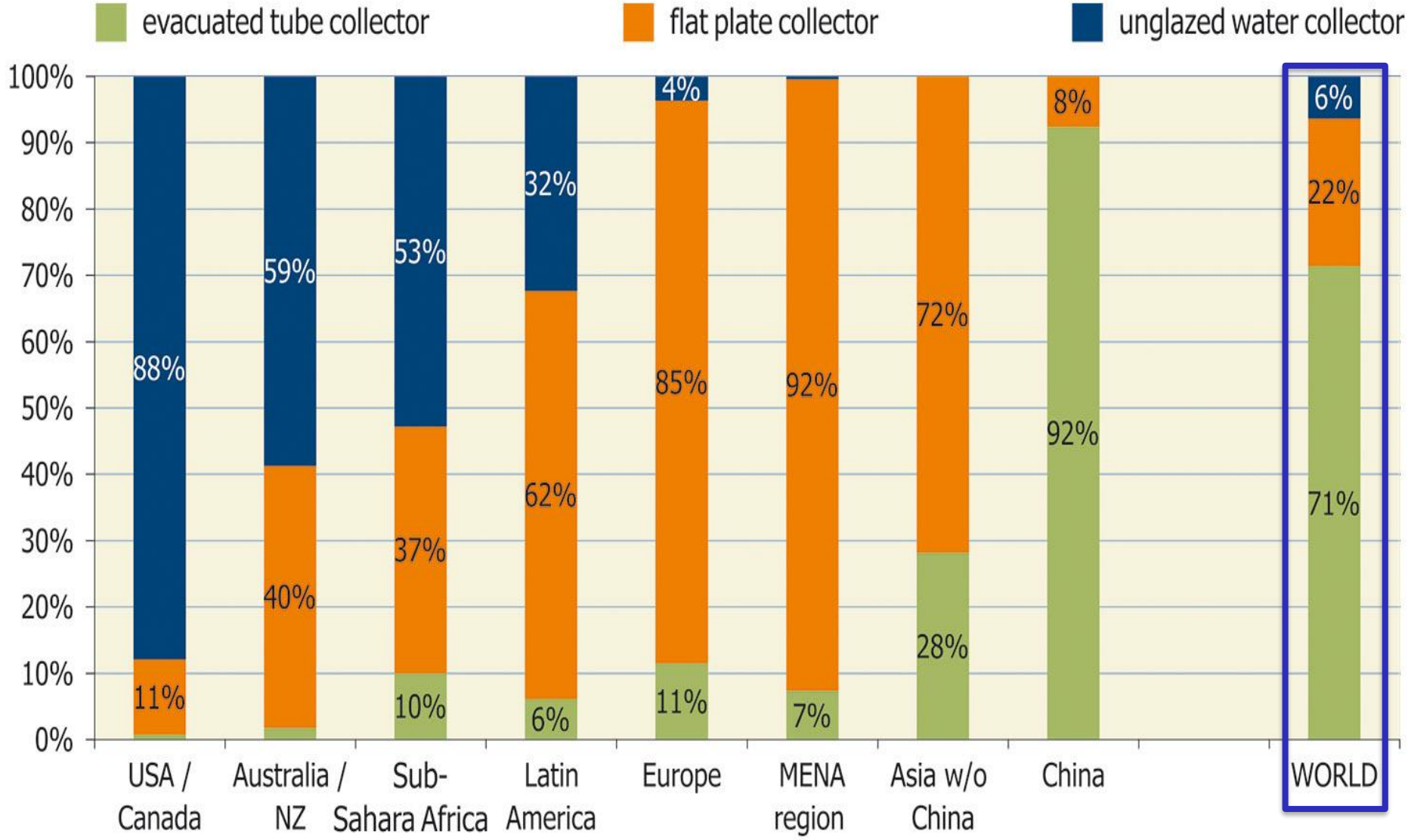
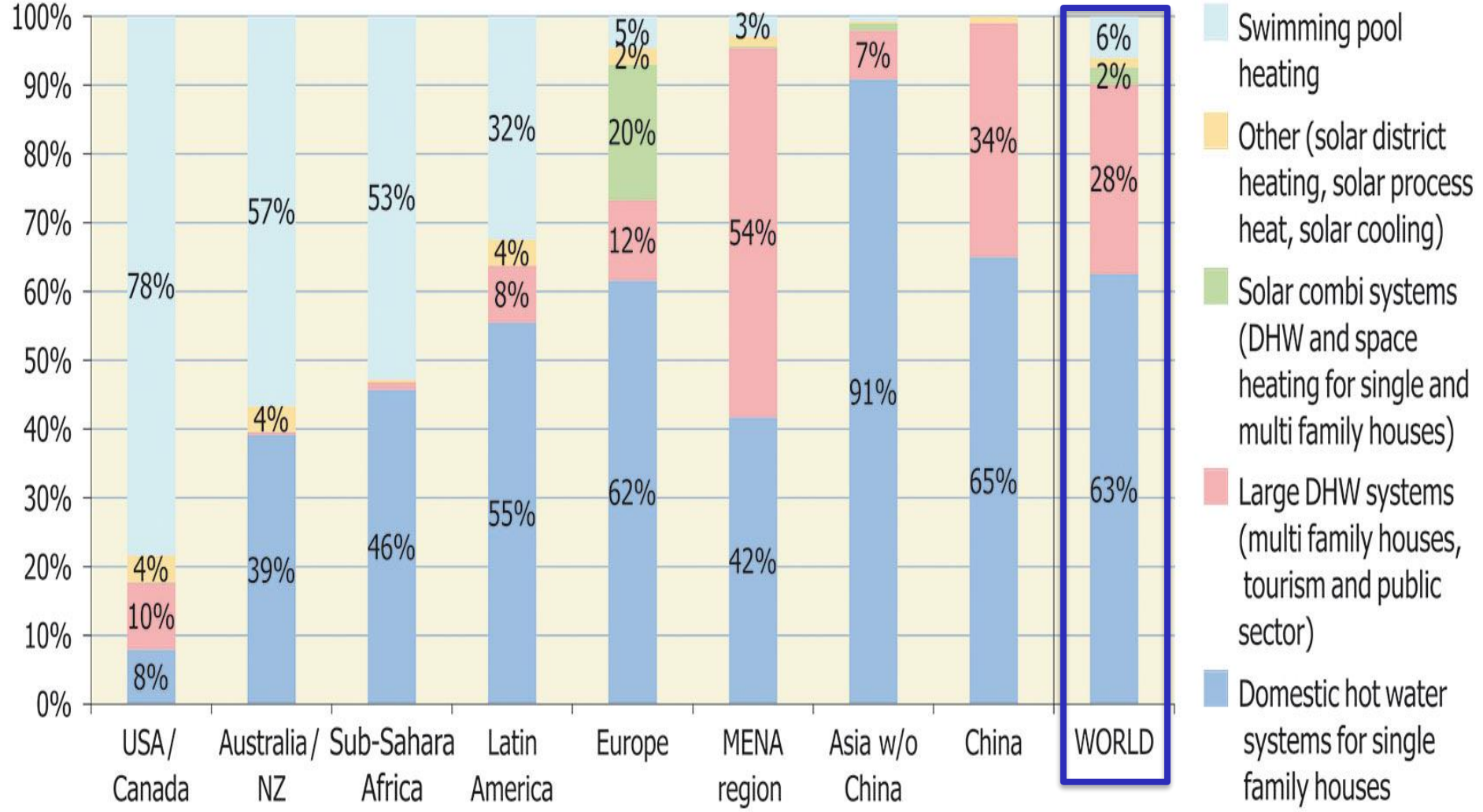
Source: IEA SHC.

Distribution by type of solar thermal collector for the total installed glazed water collector capacity in operation by the end of 2014



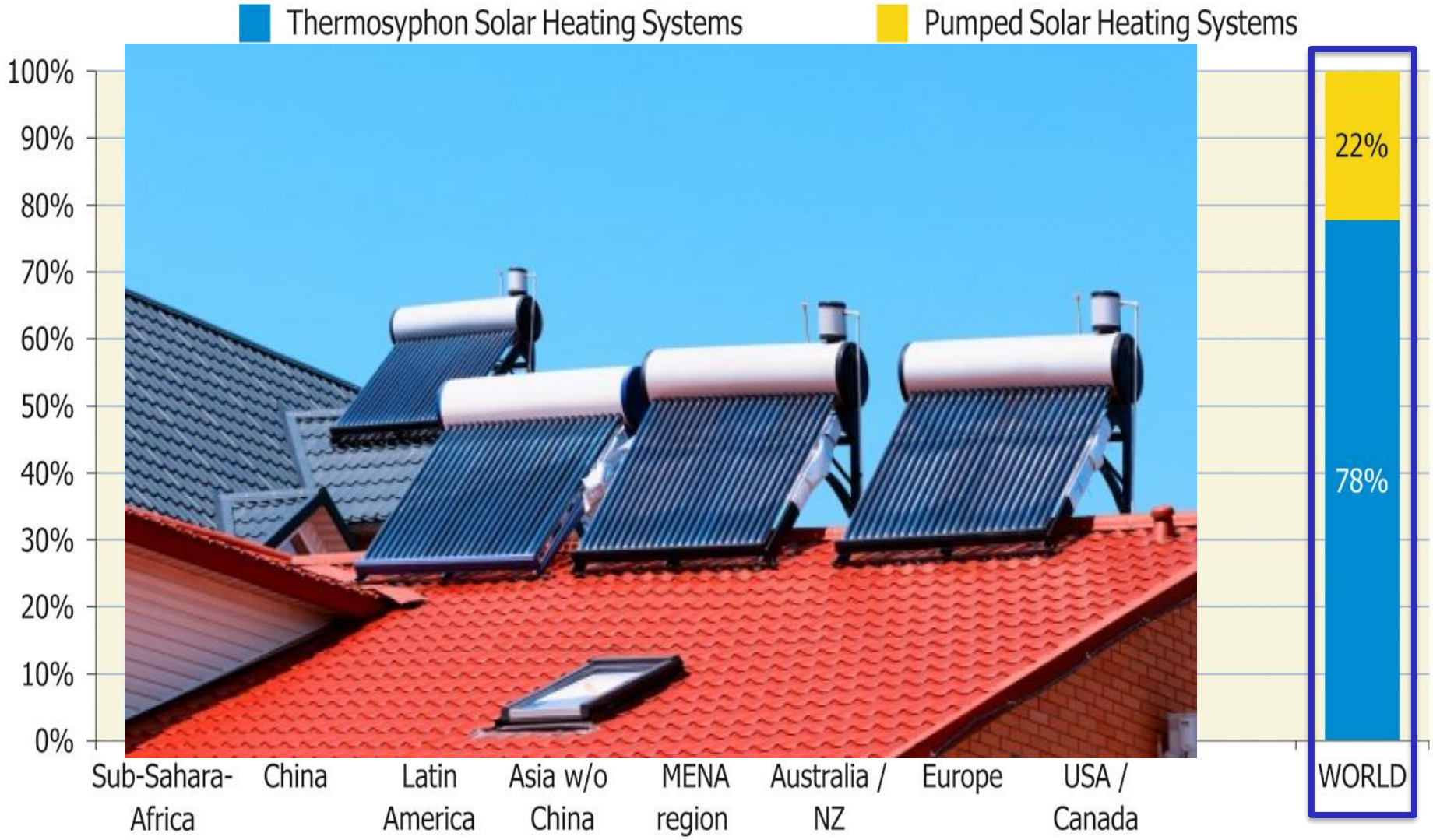
Distribution by application

for the total installed water collector capacity
by economic region in operation by the end of 2014

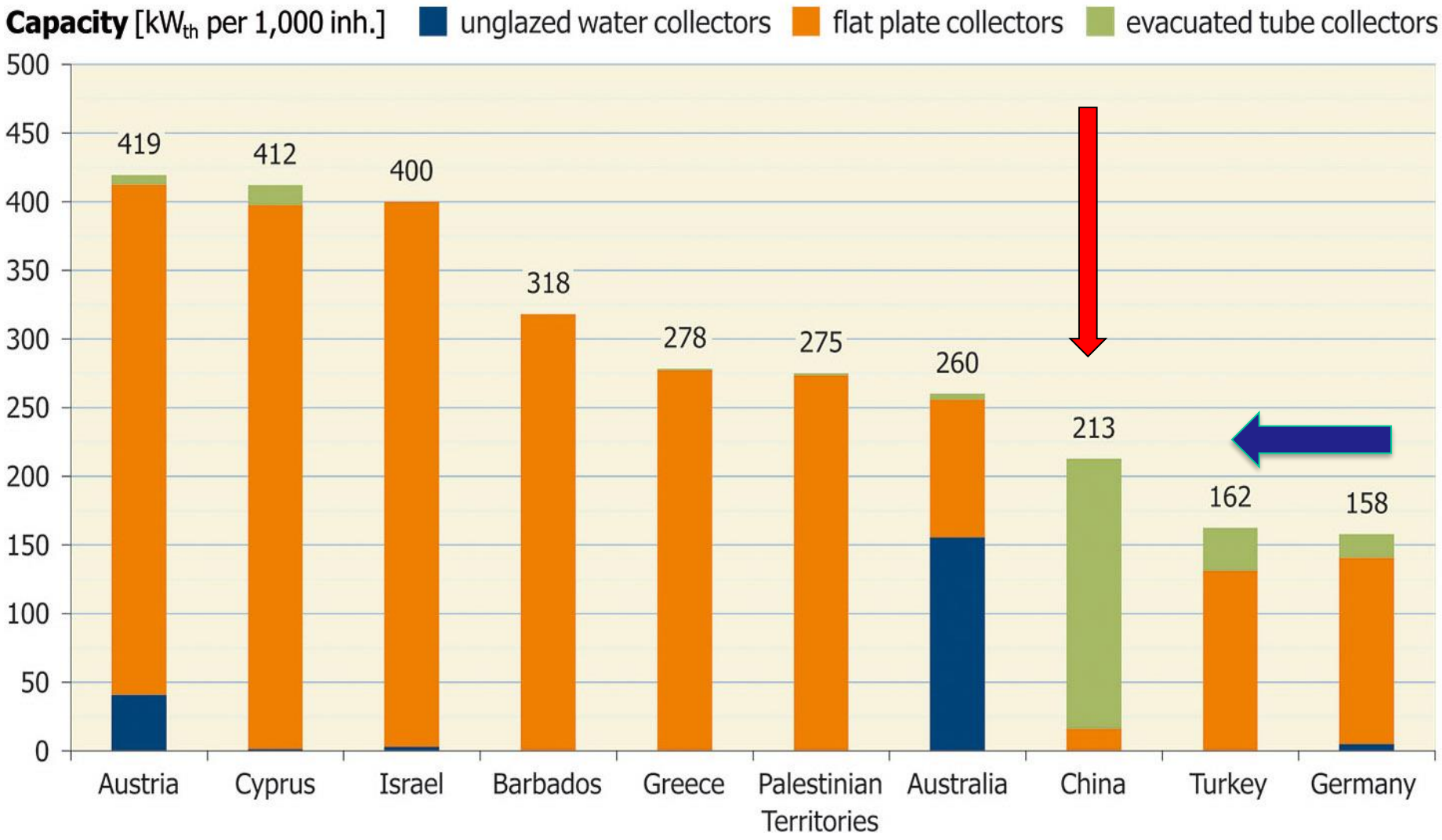


Distribution by type of system

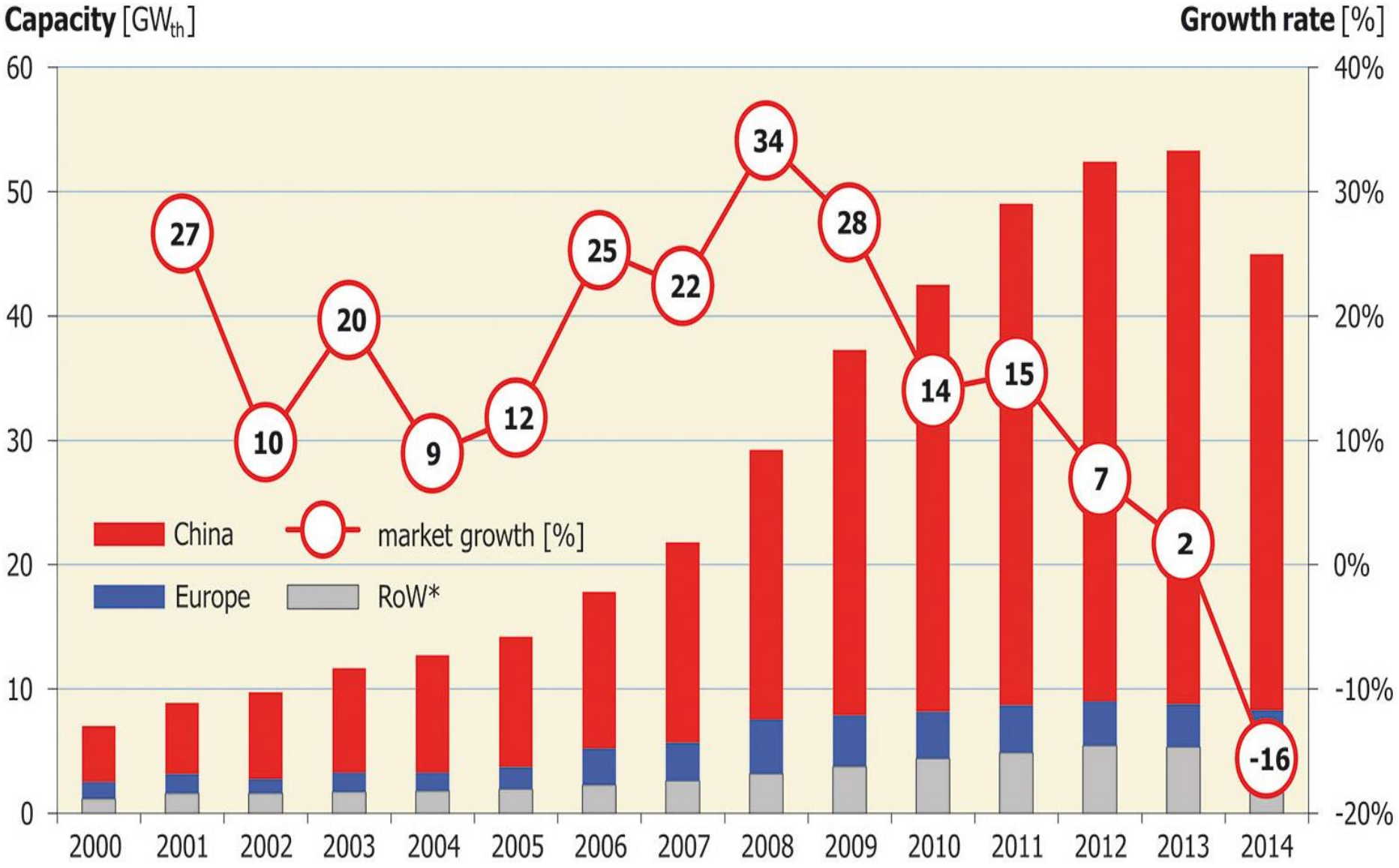
for the total installed glazed water collector capacity in operation by the end of 2014



Top 10: Total capacity of glazed flat plate and evacuated tube collectors in operation in kW_{th} per 1,000 inhabitants by the end of 2014



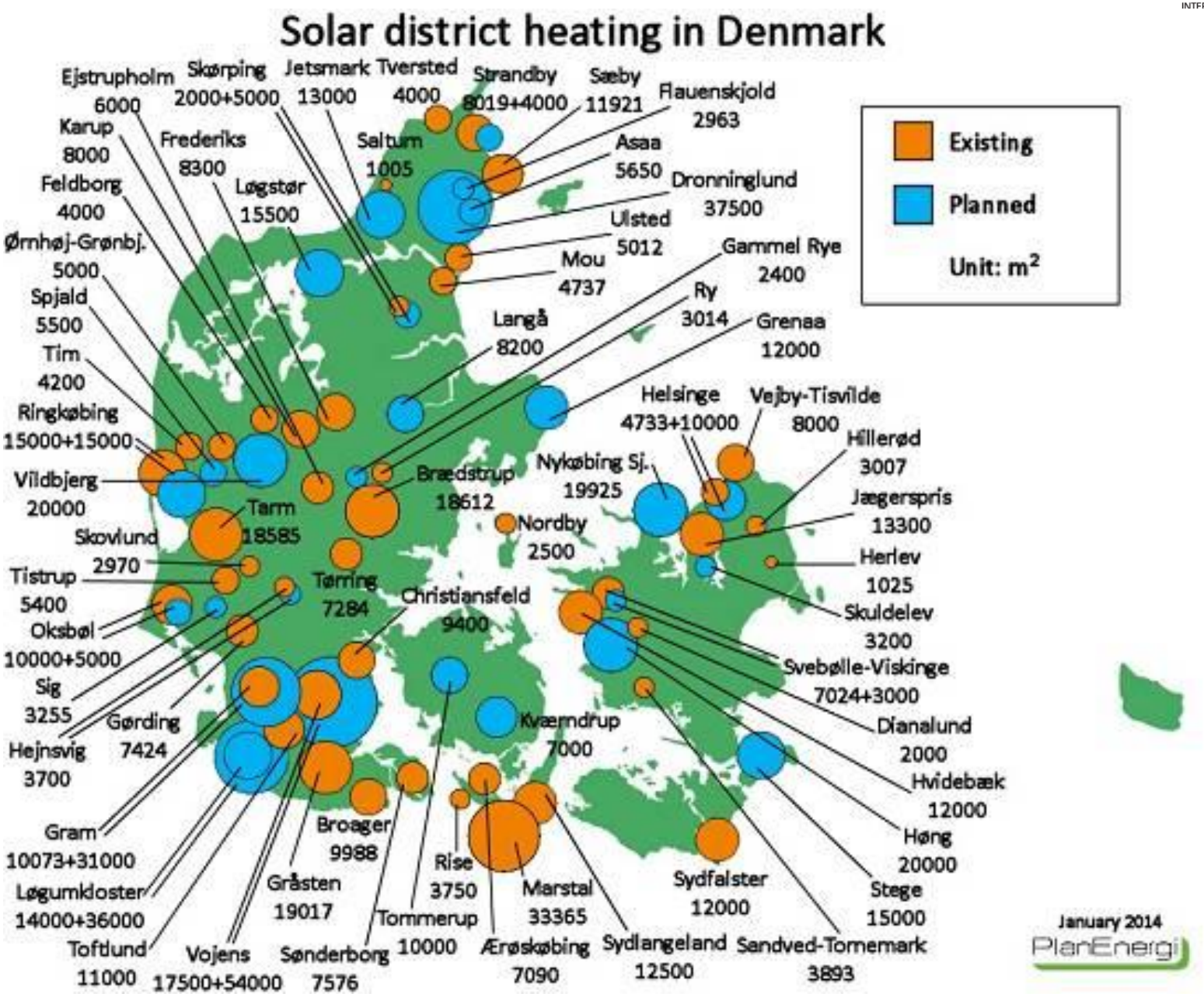
Market development - 2000 to 2014



Denmark large systems ***Silkeborg***

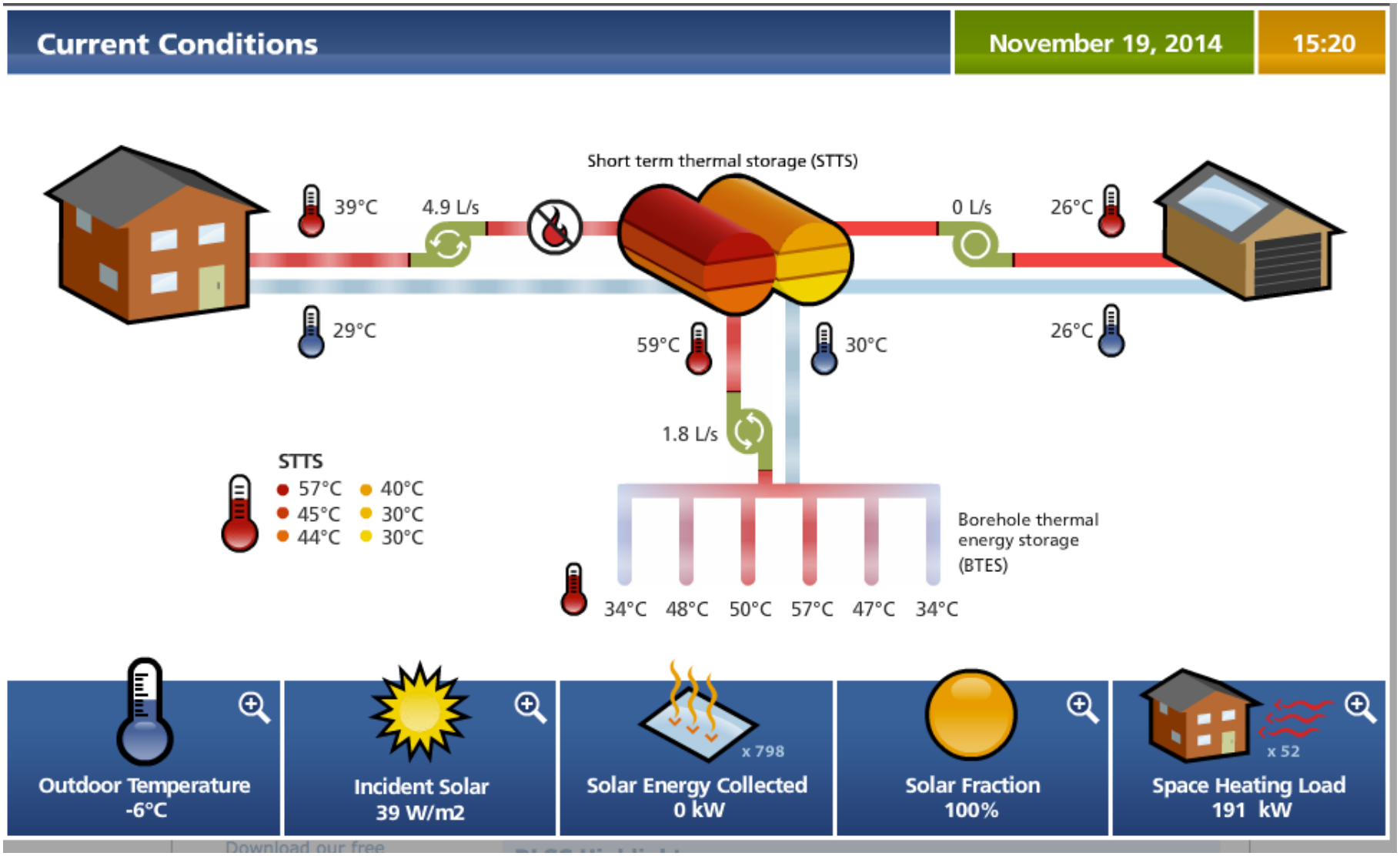
Dec 2016 - 156’694 m2 - 110 MWth - 80.000 MWh

Plus de 100 grandes installations



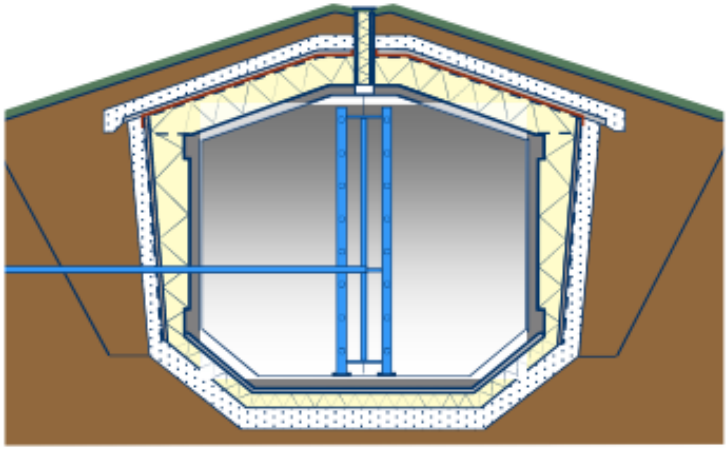
Solaire thermique – Réseau BT ?

Solaire thermique – Stockage saisonnier sans PAC ! Canada

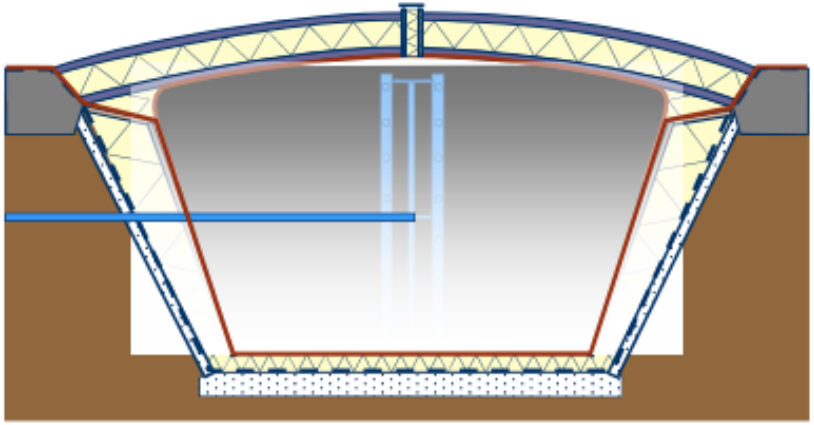


Solaire thermique – Stockage saisonnier

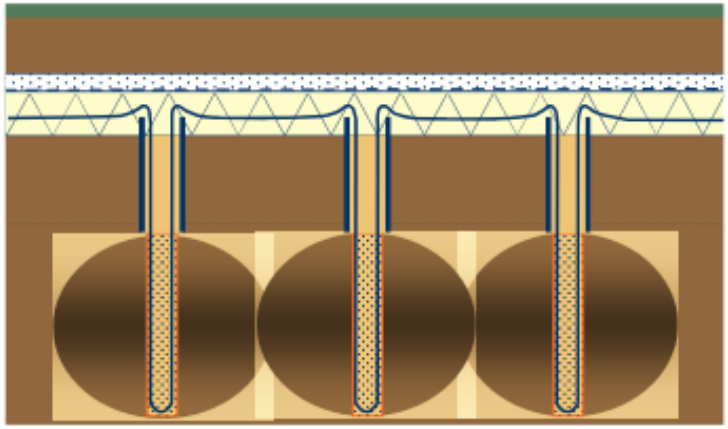
Accumulateur d'eau chaude
(60 à 80 kWh/m³)



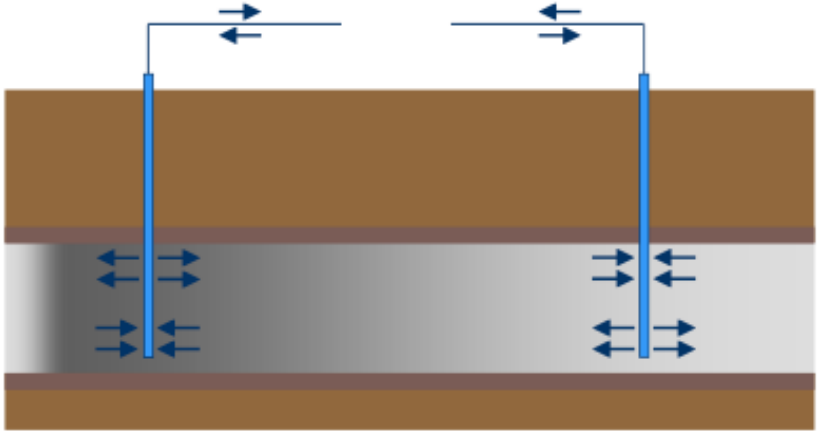
Accumulateur citerne souterraine
(60 à 80 kWh/m³)



Accumulateur par sonde terrestre
(15 à 30 kWh/m³)



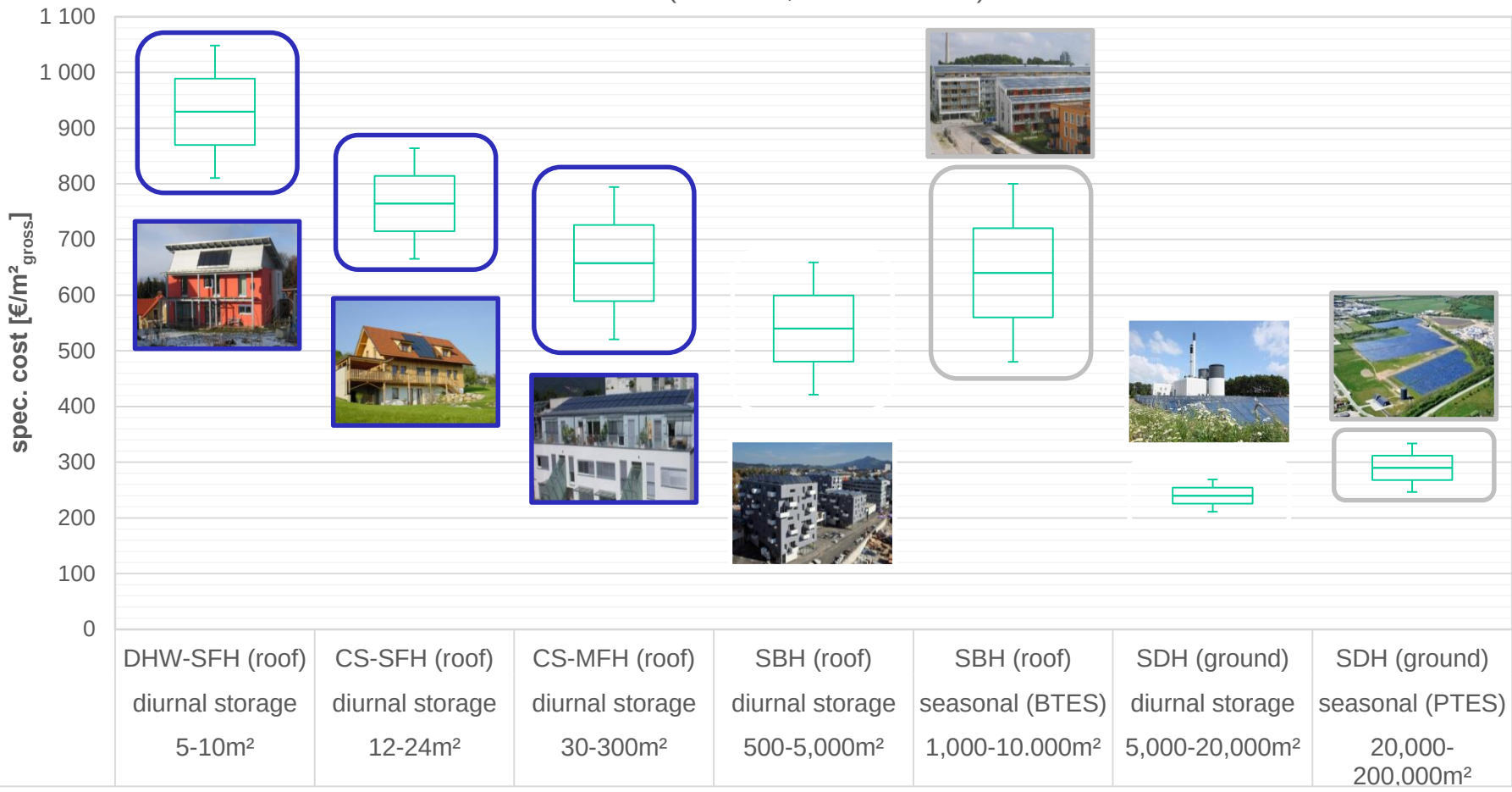
Accumulateur aquifer
(30 à 40 kWh/m³)



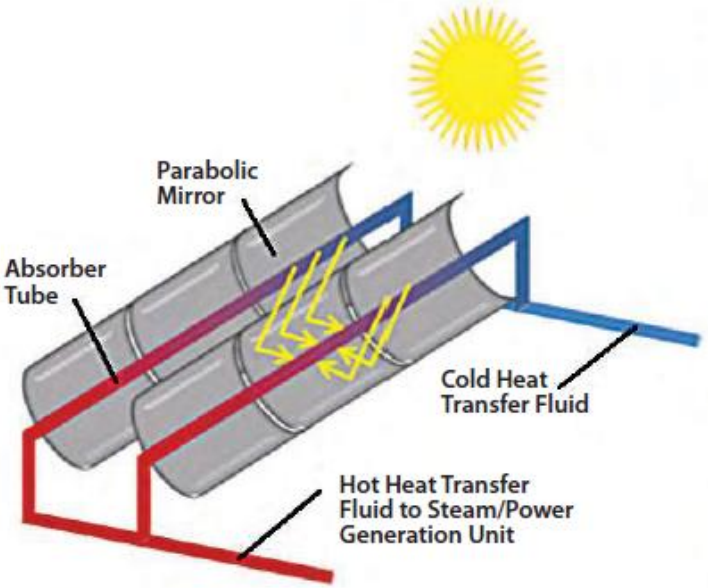
Réduire les coûts !

Specific solar thermal system cost ready installed

(excl. VAT, excl. subsidies)

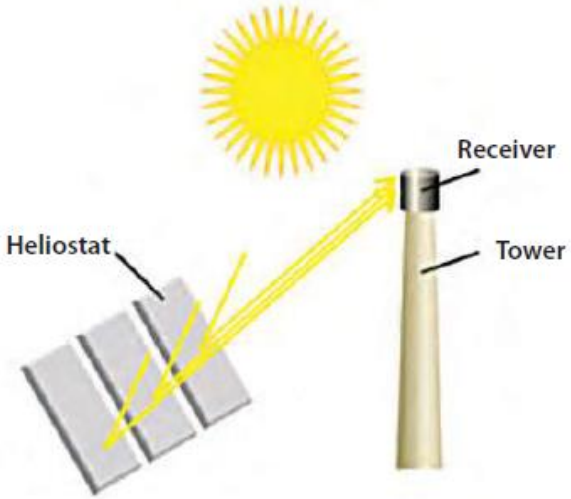


Source: Task 53, Franz Mauthner, AEE INTEC


Parabolic
Mirror
Absorber
Tube
Cold Heat
Transfer Fluid
Hot Heat Transfer
Fluid to Steam/Power
Generation Unit

(a)

(b)


Receiver
Heliostat
Tower

(a)

(b)

Table 3.1 Total Available Land Area and Corresponding Capacity Potential for CSP in the Southwestern United States

State	Available Area (mi²)	Capacity (GW)
Arizona	19,300	2,468
California	6,900	877
Colorado	2,100	272
Nevada	5,600	715
New Mexico	15,200	1,940
Texas	1,200	149
Utah	3,600	456
Total	53,900	6,877

Data from Mehos and Kearney[2]

Figure 3.2 Efficiency of a Typical CSP Plant[iv]

Segments de marché

- **Solaire Thermique**
  - Chauffage de locaux
  - Chauffage de piscines
  - Eau chaude sanitaire
  - Processus industriels
  - Cooling
  - Electricité

- **Solaire Photovoltaïque**
  - Electricité
  - Chauffage / refroidissement par PAC ….PVT
  - Processus
  - Mobilité

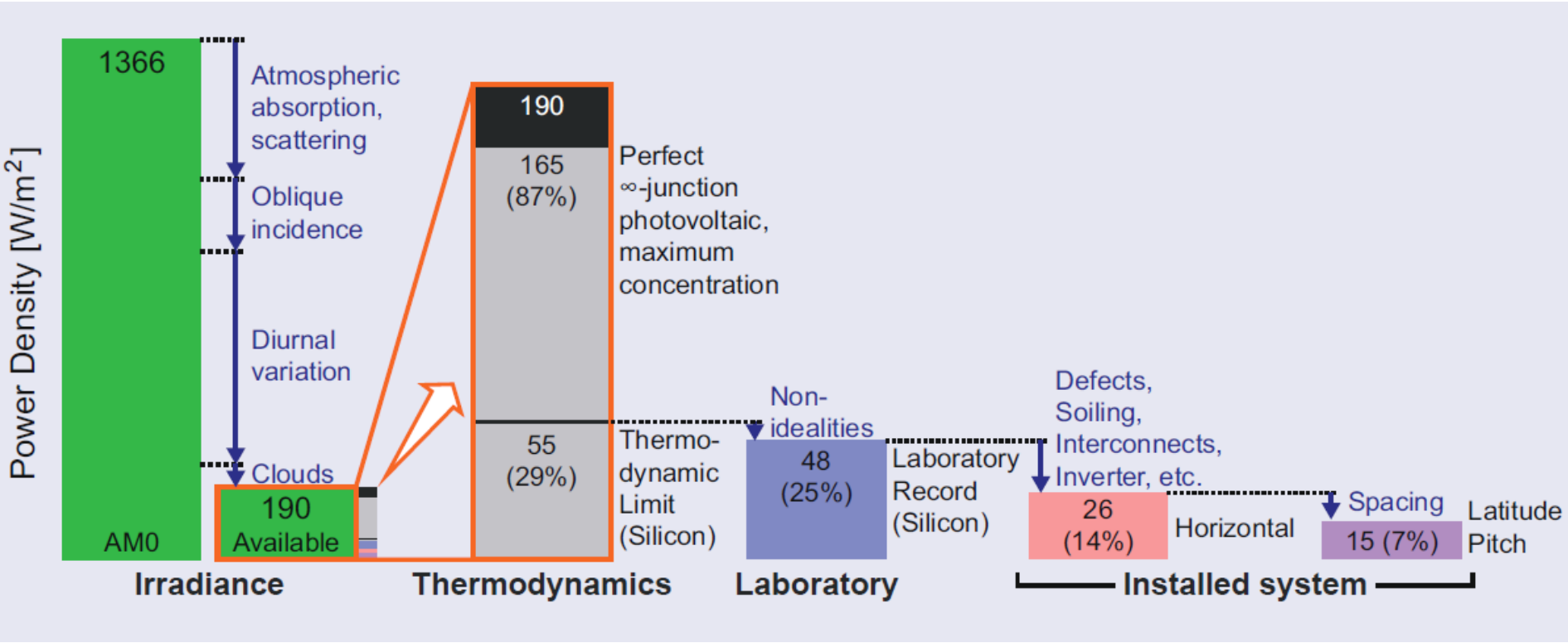
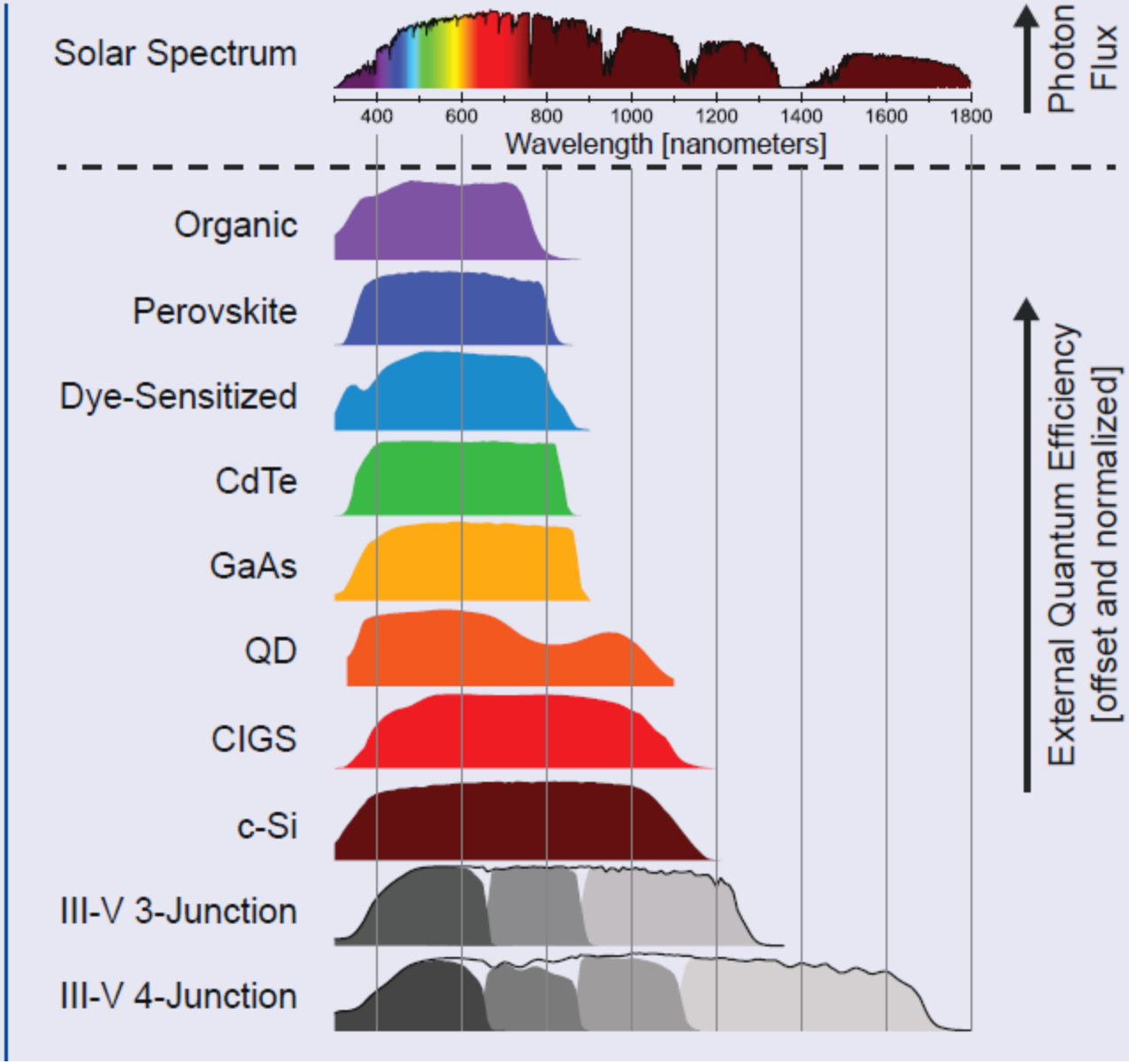
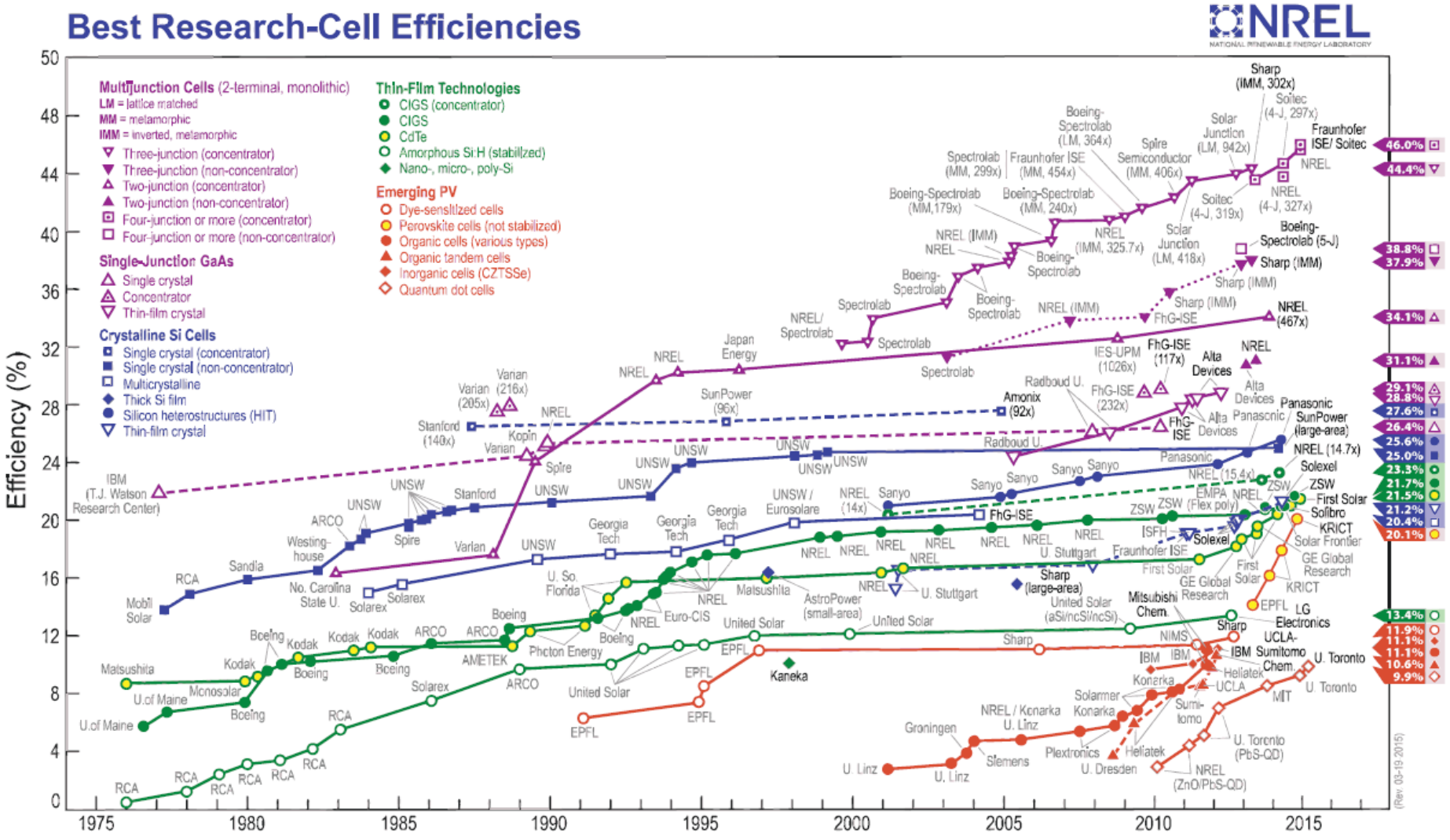

Power Density [W/m²]
1366
AM0
Atmospheric absorption, scattering
Oblique incidence
Diurnal variation
Clouds
190
Available
Irradiance
190
165 (87%)
55 (29%)
Perfect ∞-junction photovoltaic, maximum concentration
Thermo-dynamic Limit (Silicon)
Thermodynamics
Non-idealities
48 (25%)
Laboratory Record (Silicon)
Laboratory
Defects, Soiling, Interconnects, Inverter, etc.
26 (14%)
Horizontal
Spacing
15 (7%)
Latitude Pitch
Installed system

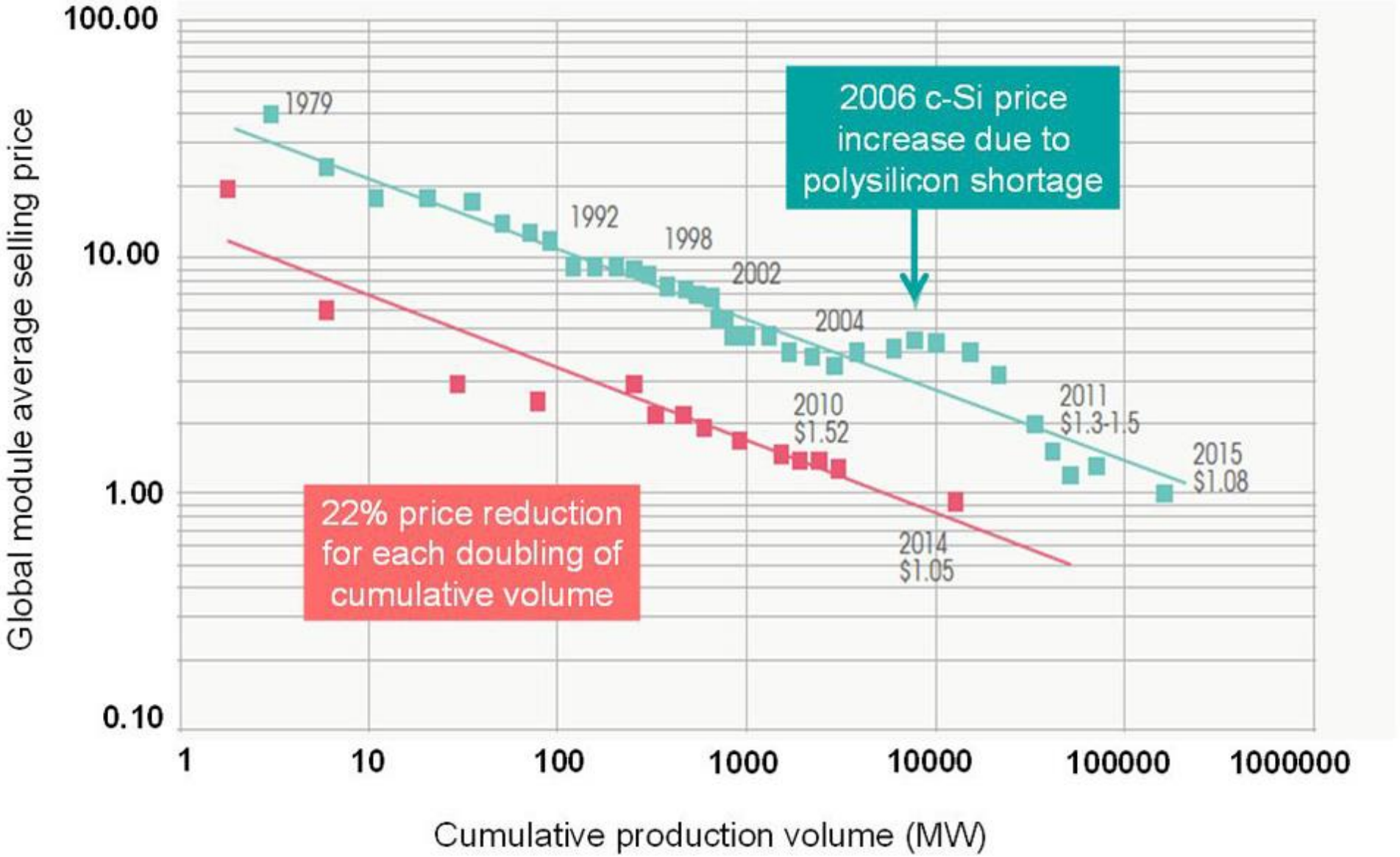
Figure B.8 Solar Photon Flux at the Earth's Surface and Normalized EQE Spectra for Different Types of Solar Cells [19, 20, 21, 22, 23, 24]



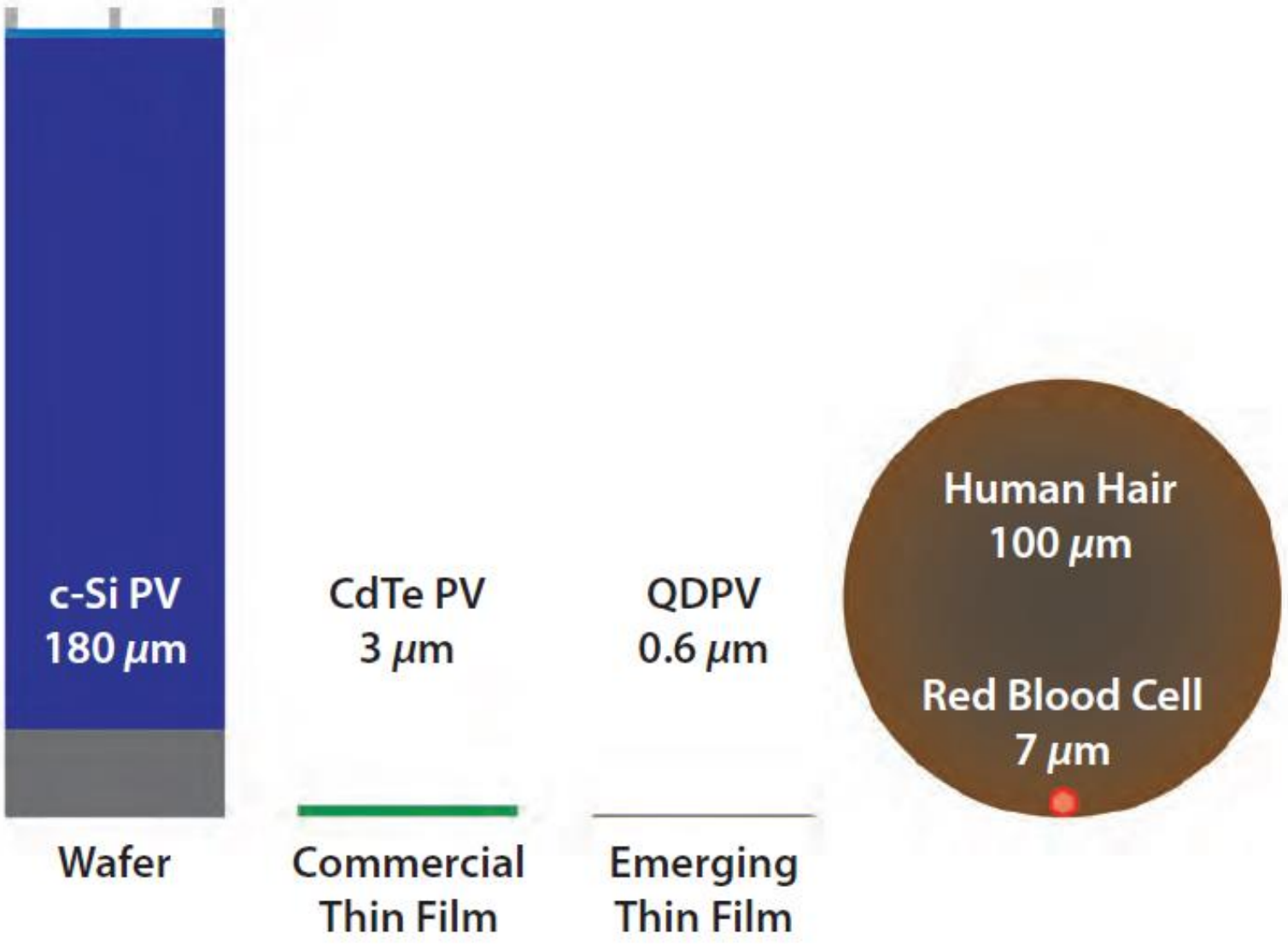
Toujours plus efficace…



Learning curve: R&D and Mass prod



Moins de matière…



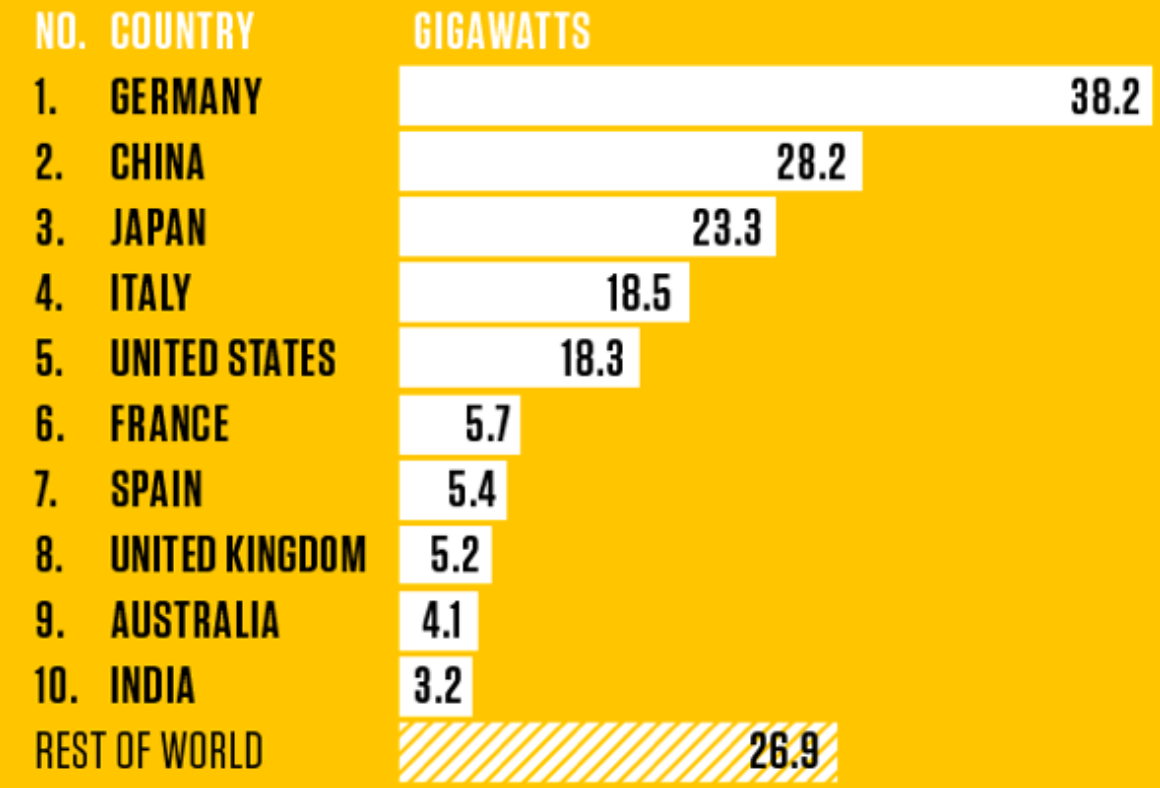
Solaire PV – Champ / Ajouté / Intégré

En Allemagne …

TOP 10 SOLAR COUNTRIES

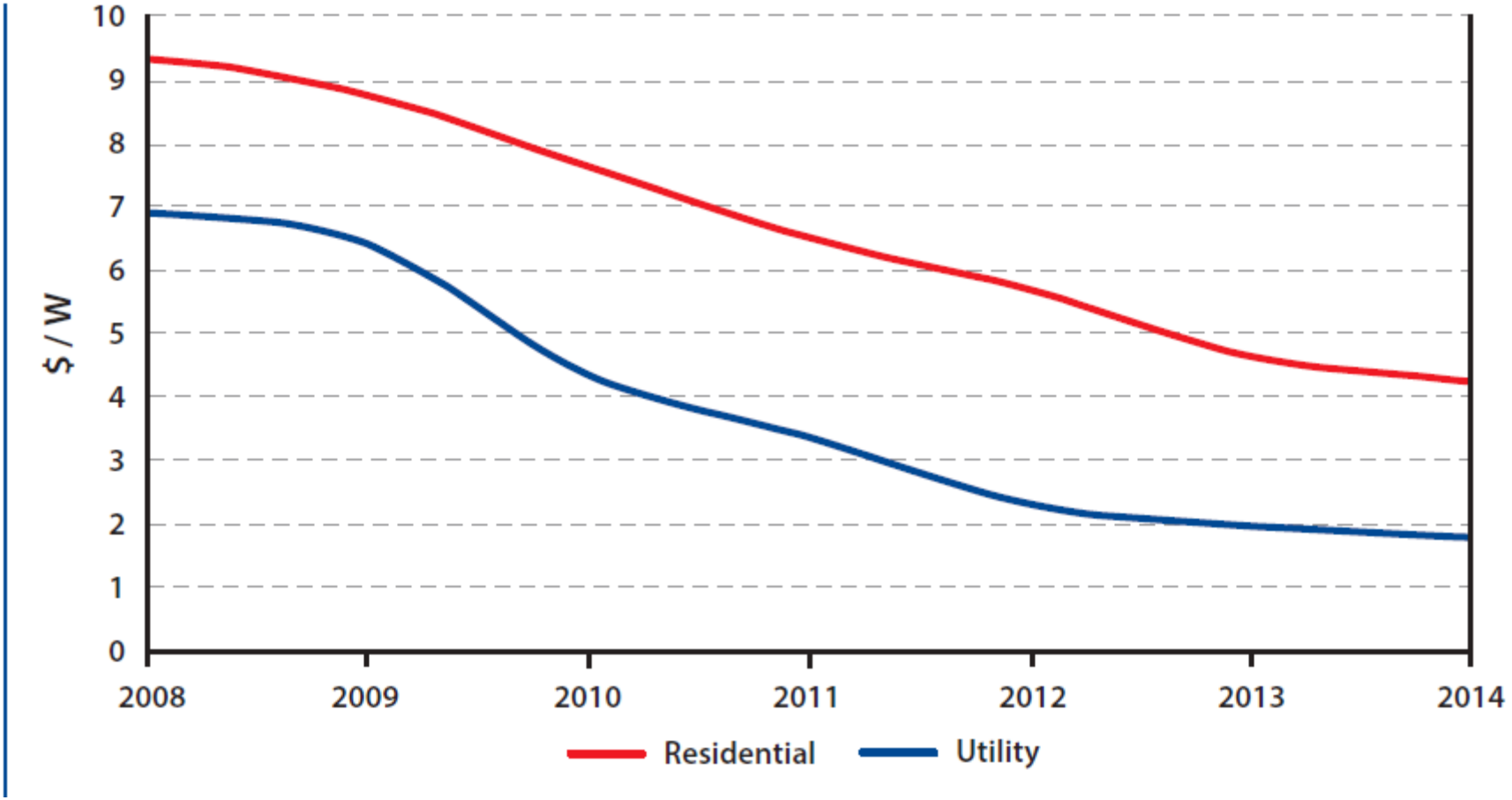
Total Global Solar PV Capacity at the End of 2014

Adapted from REN21 Renewables 2015 Global Status Report

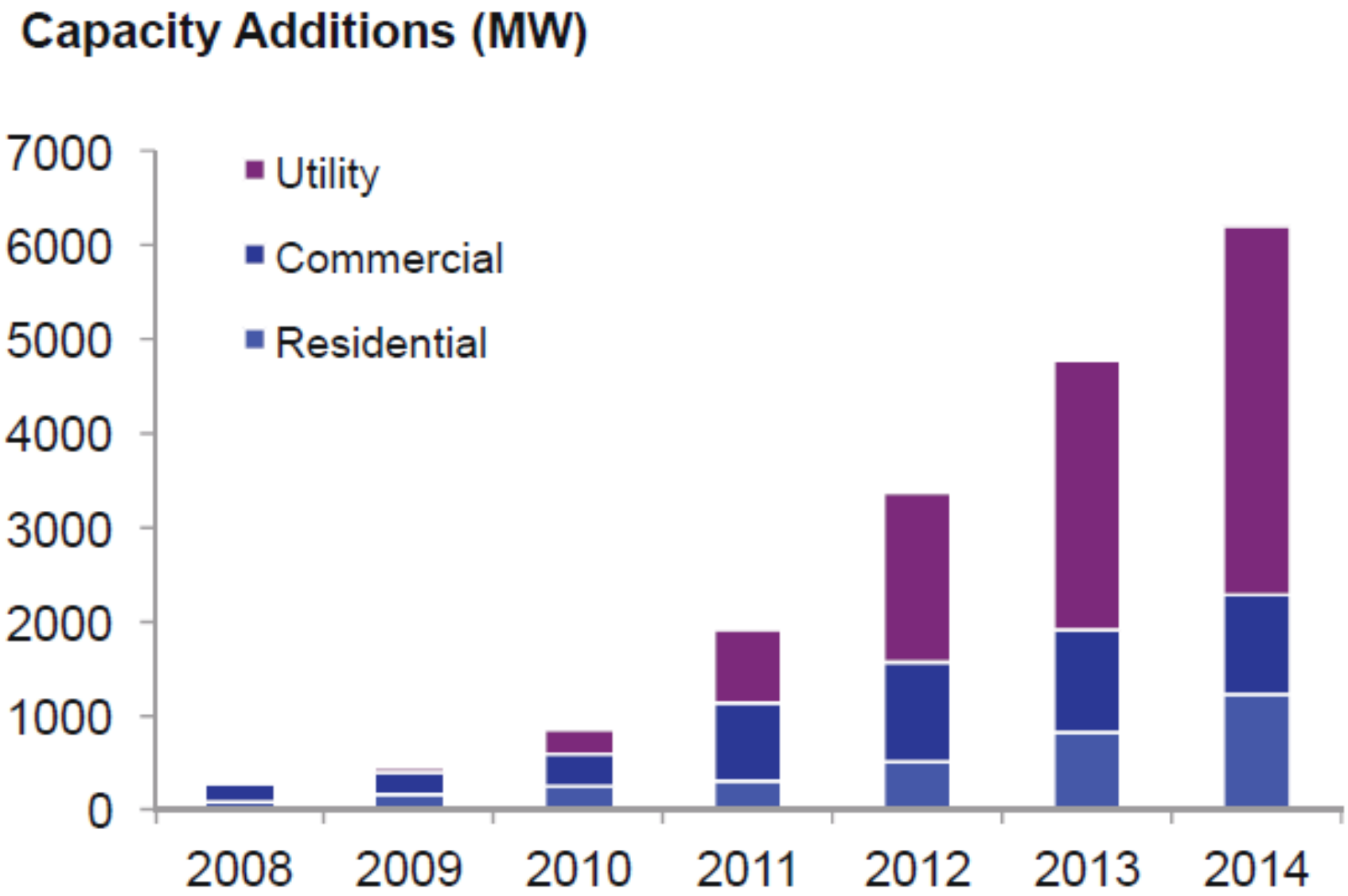


Pakistan 2015 100 MW – 400’000 modules – 30 pers

Figure 4.4 Average U.S. Prices for Residential and Utility-Scale PV Systems[ii]



US: PV for utilities…



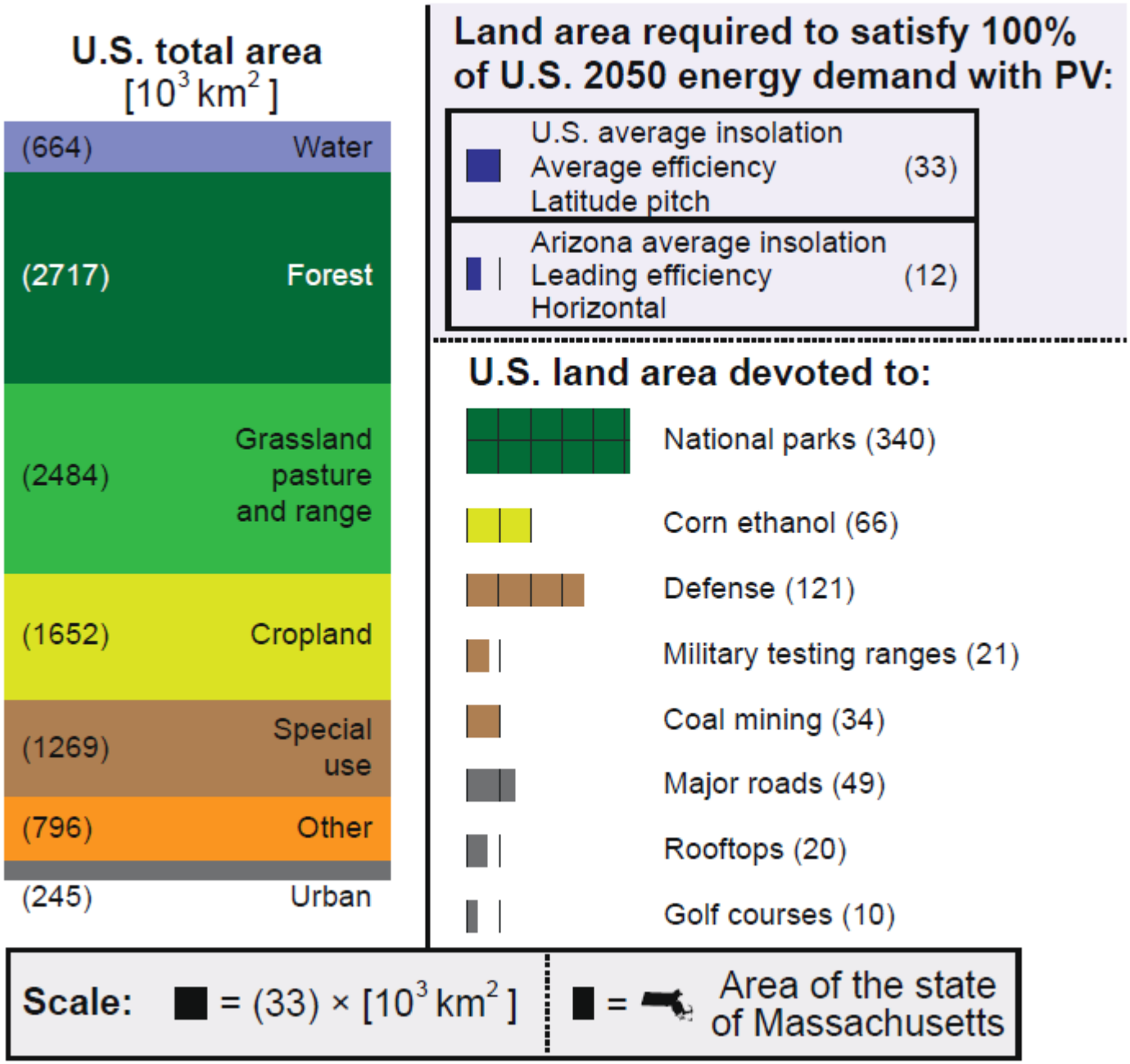
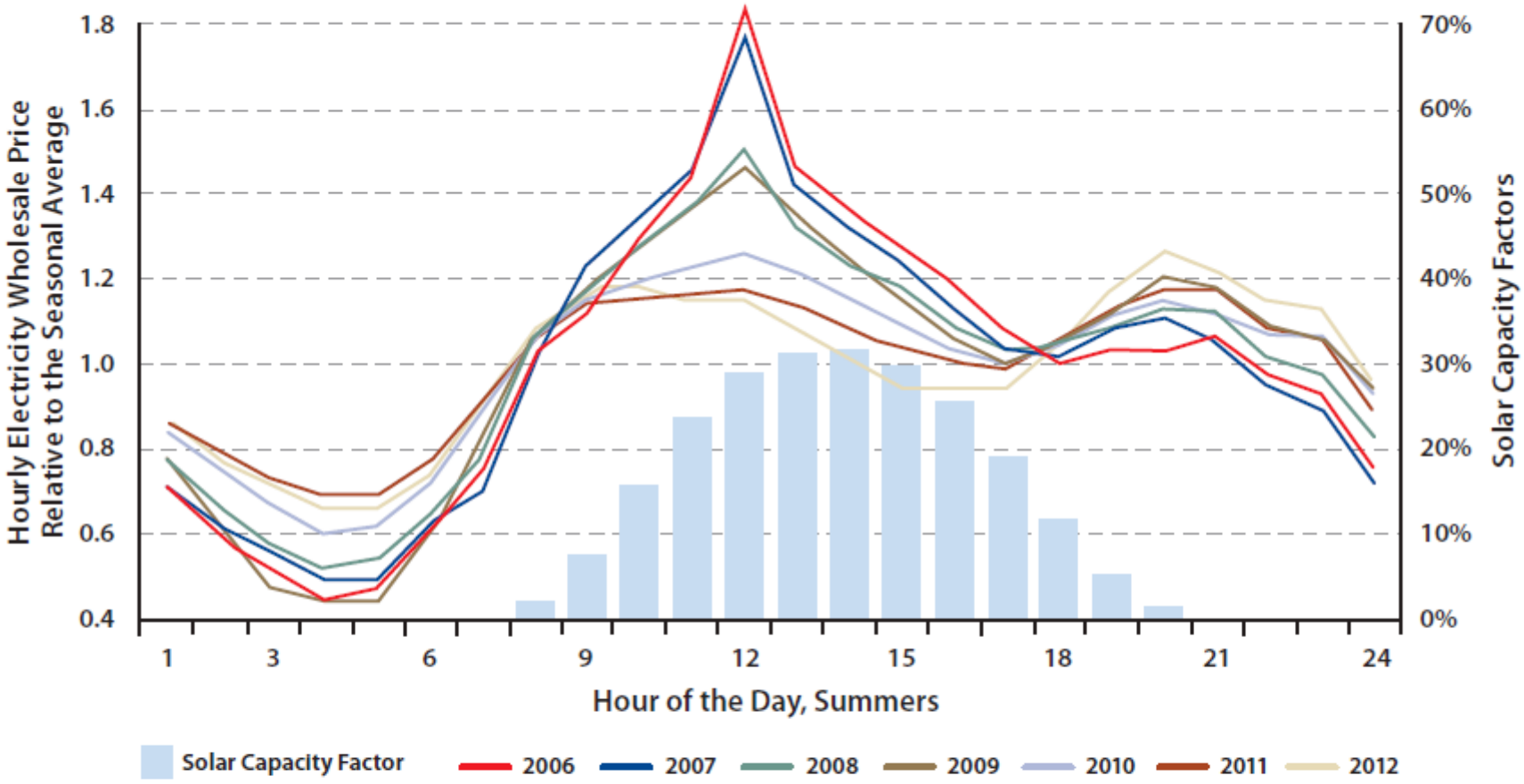

U.S. total area
[10^3 km^2]
(664) Water
(2717) Forest
(2484) Grassland pasture and range
(1652) Cropland
(1269) Special use
(796) Other
(245) Urban
Land area required to satisfy 100% of U.S. 2050 energy demand with PV:
U.S. average insolation
Average efficiency
Latitude pitch
(33)
Arizona average insolation
Leading efficiency
Horizontal
(12)
U.S. land area devoted to:
National parks (340)
Corn ethanol (66)
Defense (121)
Military testing ranges (21)
Coal mining (34)
Major roads (49)
Rooftops (20)
Golf courses (10)
Scale: ■ = (33) × [10^3 km^2]
■ = Area of the state of Massachusetts

Figure 5.1 Summertime Hourly Electricity Wholesale Prices Relative to Seasonal Average Price in Germany 2006–2012



Note: Lines show hourly wholesale prices relative to the seasonal average price for different years for the period 2006–2012, a time when installed solar capacity in Germany increased by 30 GW. The bars show the time profile of solar generation in Germany measured as the capacity factor for installed generation for 2006 to 2012.[12]

EN CALIFORNIE, L'ÉNERGIE SOLAIRE EST VICTIME DE SON SUCCÈS

mer 12 avr 2017 RENOUVELABLES , BRÈVE

La Californie a produit pour la première fois, au mois de mars dernier, près de 40% de son électricité grâce à son énergie solaire. Un record pour cet état de l'ouest des Etats-Unis qui n'est toutefois pas dénué d'effets pervers pour les producteurs. Le succès croissant des énergies renouvelables dans la région et la forte production d'électricité solaire ont en effet poussé les tarifs vers le négatif pendant quelques heures.

Nouveaux modèles à inventer dans un smart ? grid

Figure 8.7 Changes in Total Short-Term Thermal Costs as a Consequence of Solar PV Penetration

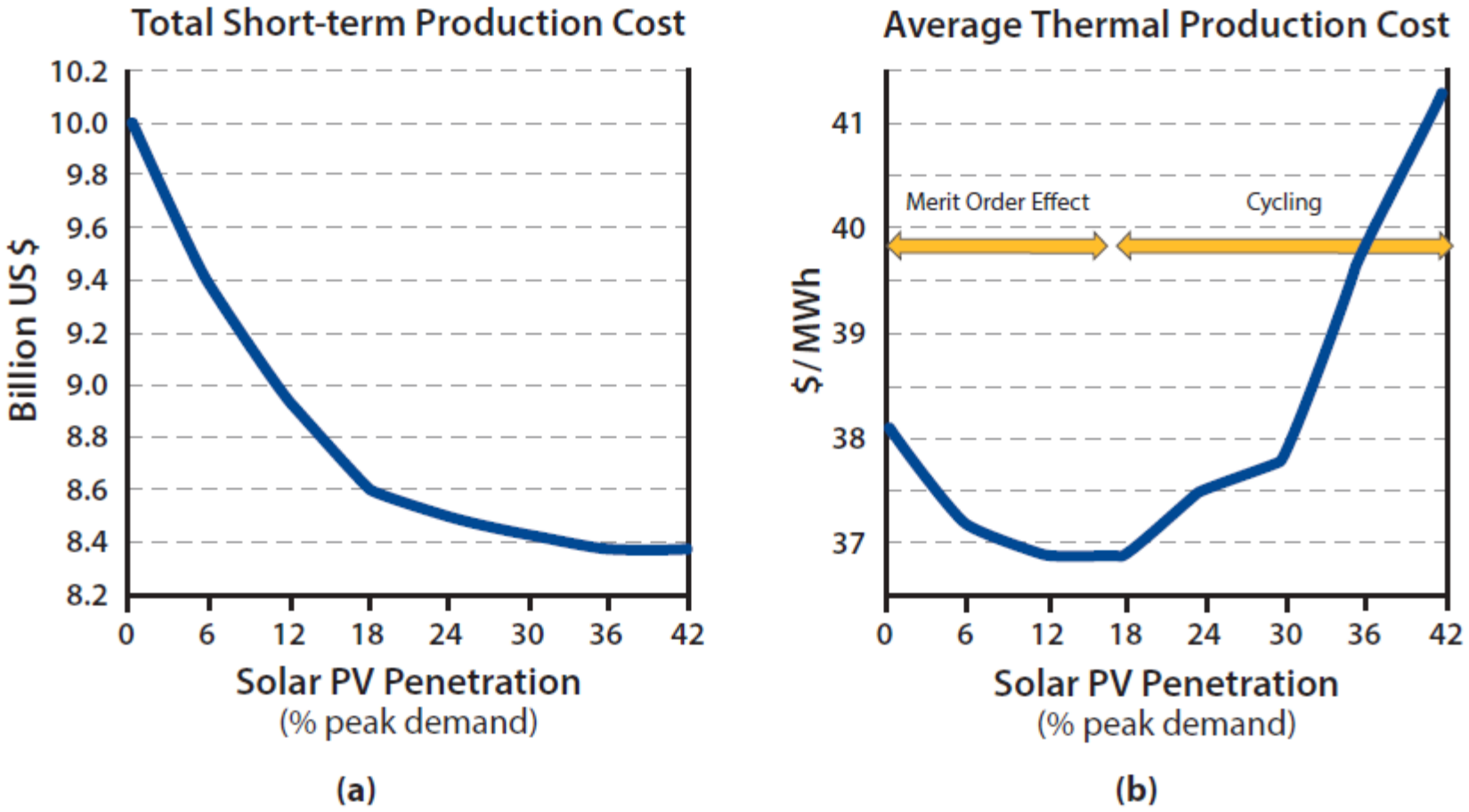
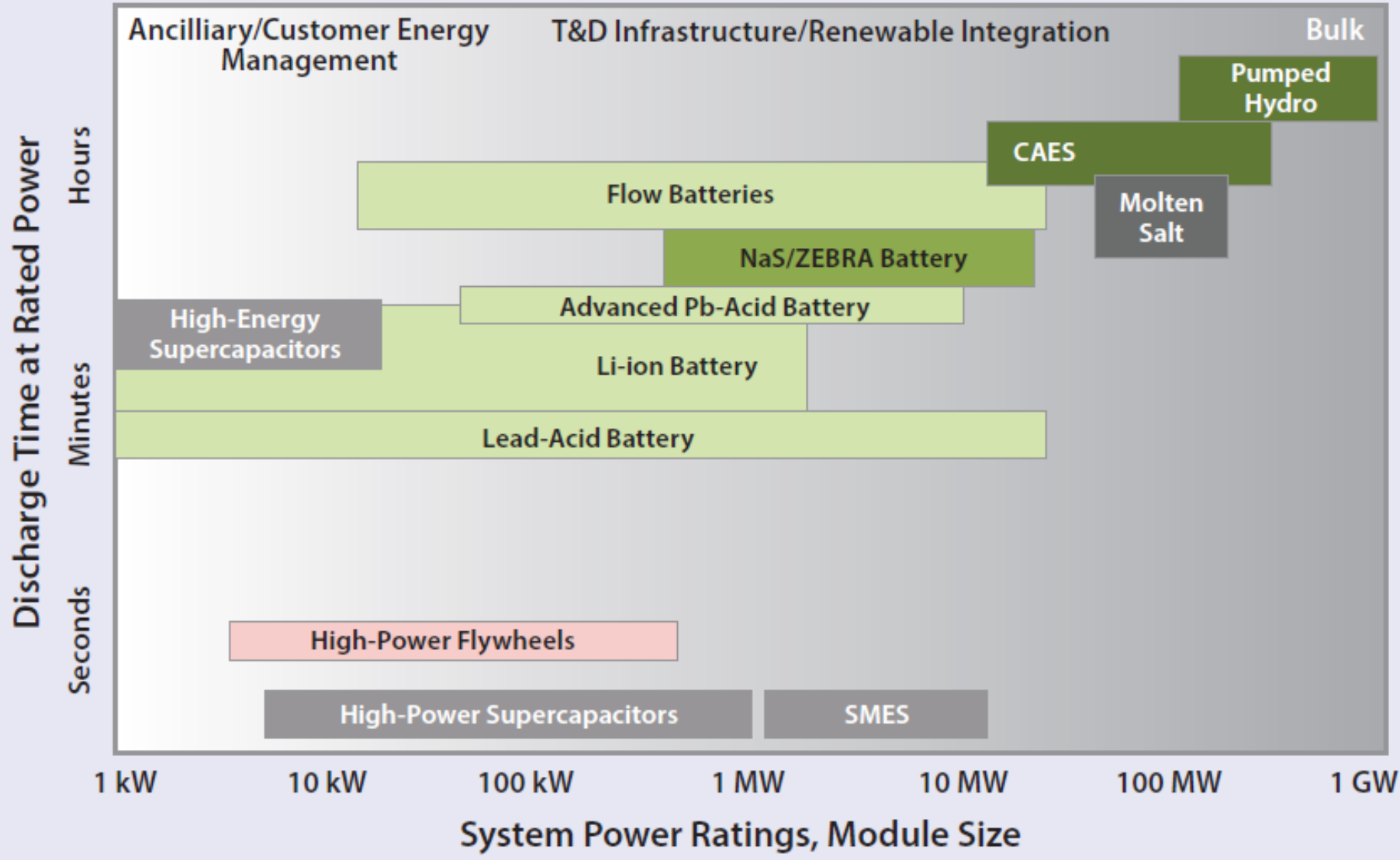
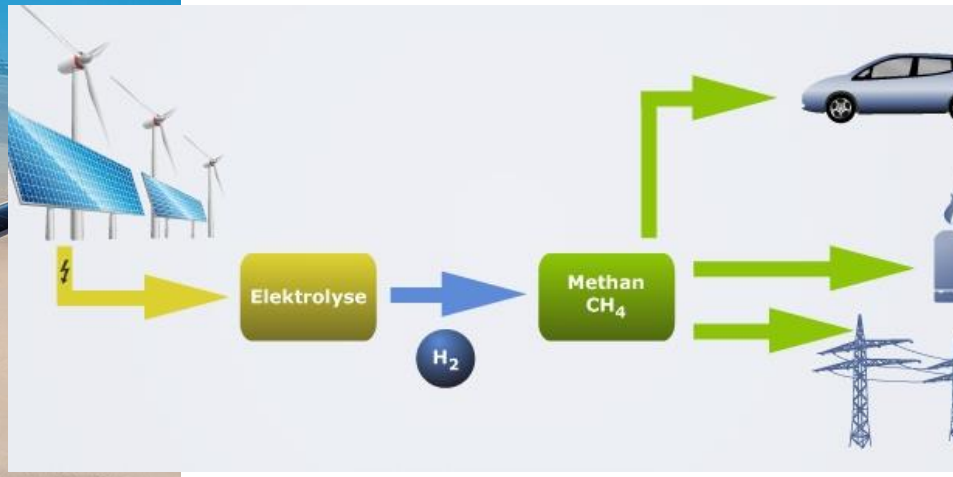


Figure C.2 ESS Technologies and Associated Applications

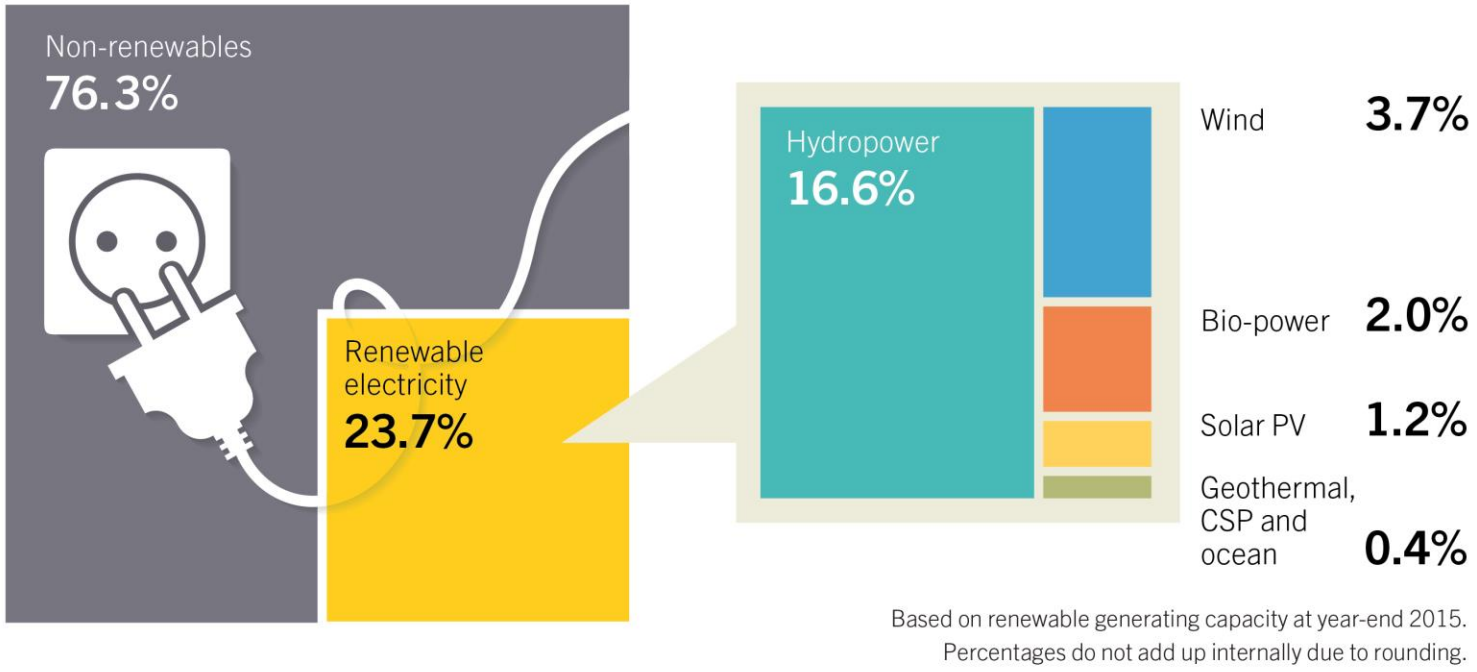


Et la mobilité ?



Le solaire a démarré comme new tech ?

Estimated Renewable Energy Share of Global Electricity Production, End-2015



Based on renewable generating capacity at year-end 2015.
Percentages do not add up internally due to rounding.

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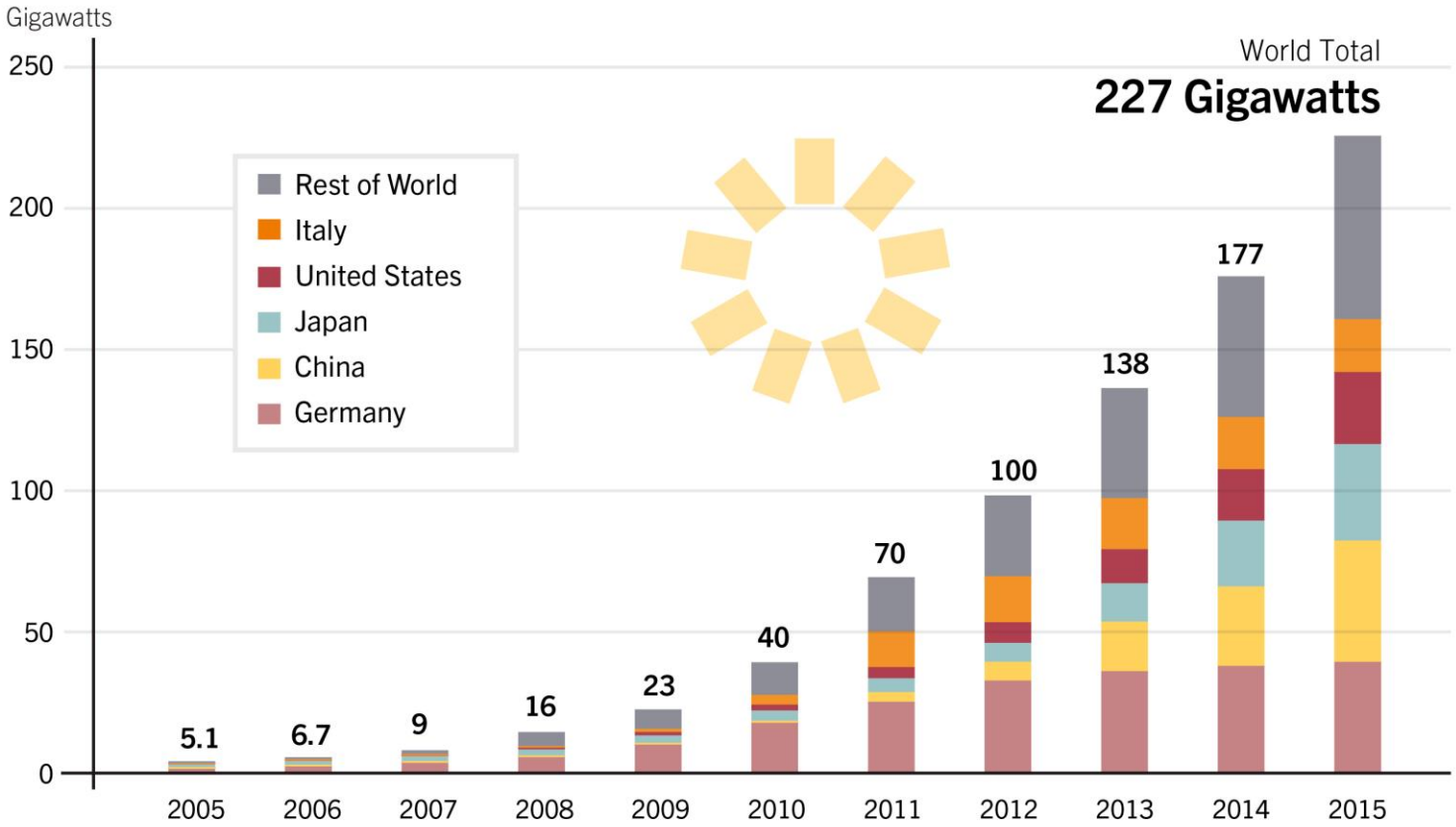
Chez les autres mieux !

Solar PV Global Capacity, by Country/Region, 2005–2015



Grand avenir pour le solaire… mais ?

SunPower Corporation
NASDAQ: SPWR - 5 mai à 17:14 UTC−4

6,91 USD ↑0,23 (3,44 %)
Après la clôture: 6,90 ↓0,14 %

1 jour | 5 jours | 1 mois | 3 mois | 1 an | 5 ans | max

Ouverture	6,71	Capitalis.	899,19 M
+Haut	6,94	Cours/bén.	-
+Bas	6,53	Rend. div.	-

SunPower
Entreprise

Création : 1985

Sièges sociaux : San José, Californie, États-Unis

Filiales : Tenesol, SunPower Philippines Manufacturing Ltd, plus…

Clause de non-responsabilité *Commenta*

Un gros potentiel mais pourquoi pas plus…

- **Energie diffuse ET intermittente**
- **Pouvoirs diffus**
- **Investissements > 3000 CHF/kW**
- **Cycle des moyens de production de 30 ans**
- **Temps de retour des énergies CAPEX trop longs**
- **Technologie: depuis 1970 seulement**
- **Efficacité 2017 :**
  - T 40% T 60% avec stockage
  - PV 20 % et stock infini
- **Le stockage !**
- **Culture de centralisation depuis 1800**
- **Mondialisation…défavorable… ?**

Et pourtant il y a des forces qui devraient pousser

- **Sociologie: Illich, Hulot, Onfray**
- **Risques à la concentration: mines, marée noire, Fukushima,…**
- **CO2 et réchauffement ?**
- **Guerre des ressources…**
- **Emploi local**

Les investissements dans le solaire

- **En hausse**

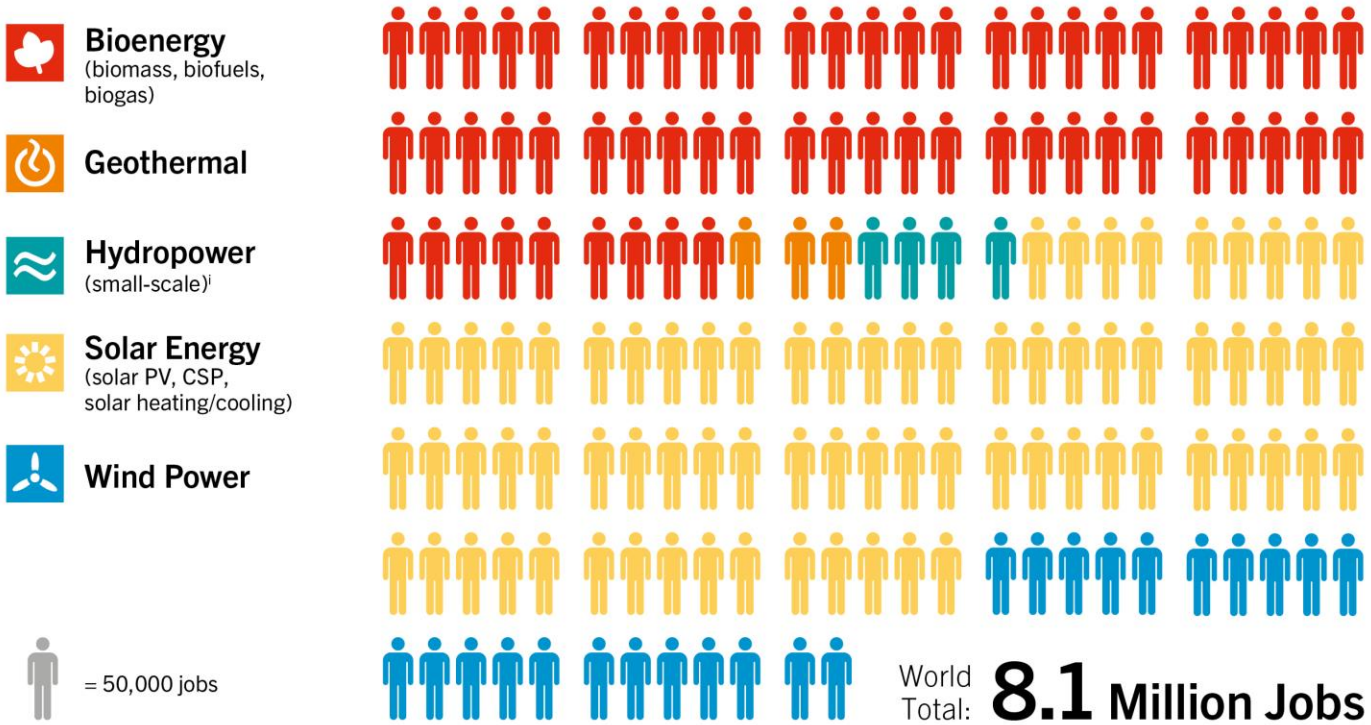
- Renewable energy investments of USD 313 billion (1/6 of all energy) accounted for nearly **a fifth of total energy spending** last year, establishing renewables as the largest source of power investment.

- While spending on renewable power capacity was flat between 2011 and 2015, electricity generation from the new capacity rose by one third, reflecting the **steep cost declines in wind turbines and solar PV.**

- The investment in renewable power capacity in 2015 generates **more** than enough to cover global electricity **demand growth**.

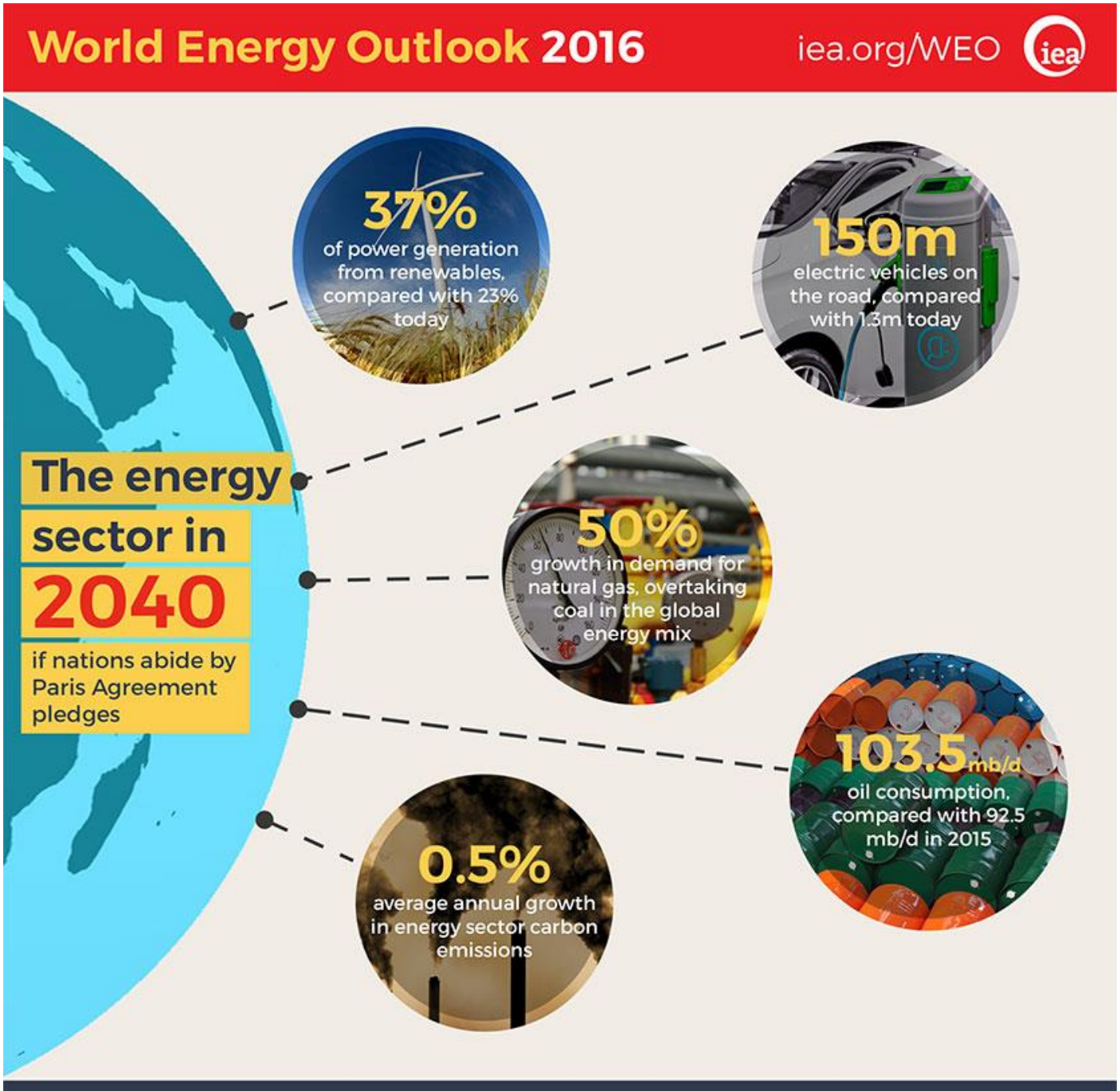
- Global gas-fired power generation investment declined by nearly 40%

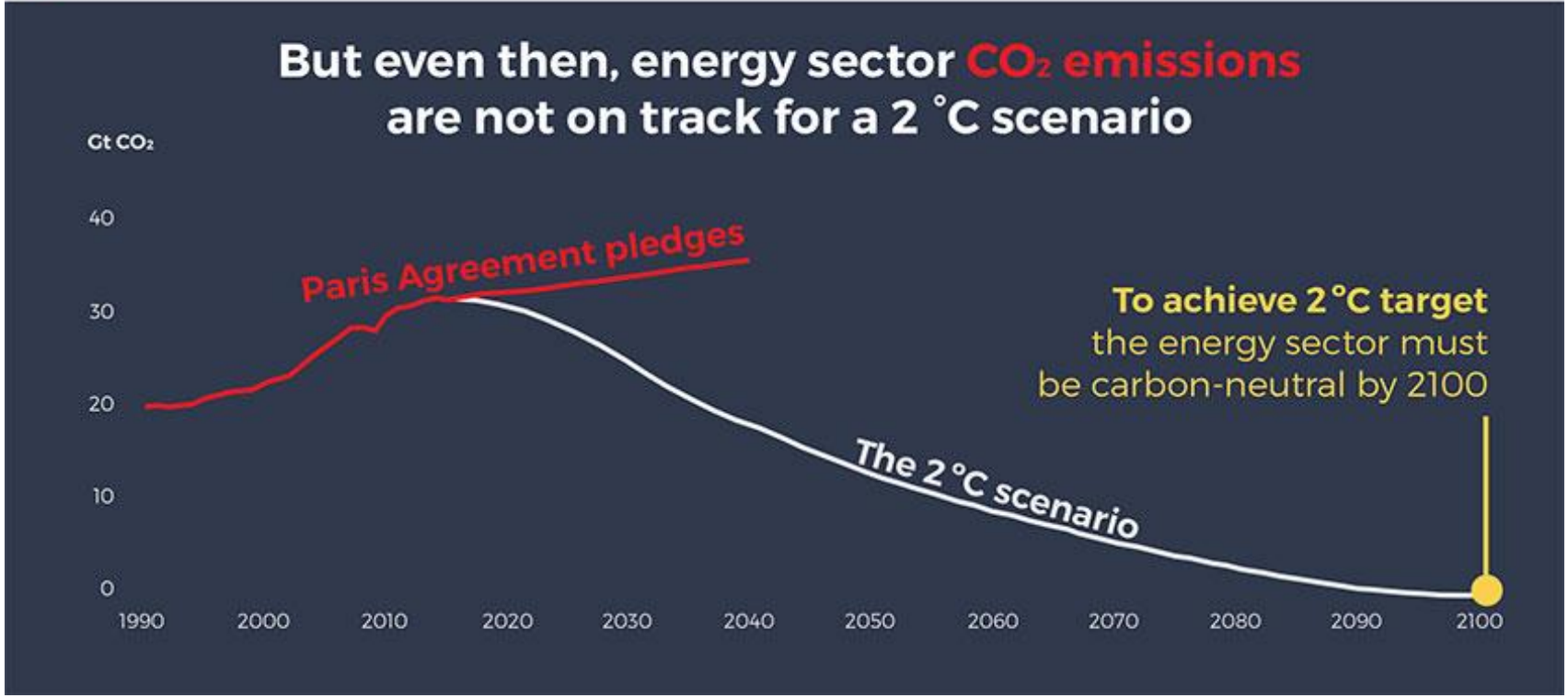
Jobs in Renewable Energy



Source: IRENA

i Employment for large-scale hydropower not included.


World Energy Outlook 2016
iea.org/WEO
37%
of power generation from renewables, compared with 23% today
150m
electric vehicles on the road, compared with 1.3m today
The energy sector in 2040
if nations abide by Paris Agreement pledges
50%
growth in demand for natural gas, overtaking coal in the global energy mix
103.5 mb/d
oil consumption, compared with 92.5 mb/d in 2015
0.5%
average annual growth in energy sector carbon emissions


But even then, energy sector CO2 emissions are not on track for a 2 ˚C scenario
Gt CO2
40
30
20
10
0
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Paris Agreement pledges
To achieve 2 °C target
the energy sector must
be carbon-neutral by 2100
The 2 °C scenario

Prédiction 21ème sicèle

- **Forte croissance du PV**
- **Mobilité sans solaire…. ?**
- **Hybrid or Power to gas: le stockage !**
- **Chauffage avec du PV ? PVT !**
- **Autoconsommation**
- **Cooling avec du PV…**
- **Redécouverte du thermique si stockage saisonnier**

- **Demande par unité de prestation réduite**
- **100% solaire! (et ses dérivés…) en 2099…**