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IEA Technology Roadmaps: Energy Efficient Building Envelopes and Energy Storage

Cecilia Tam
International Energy Agency

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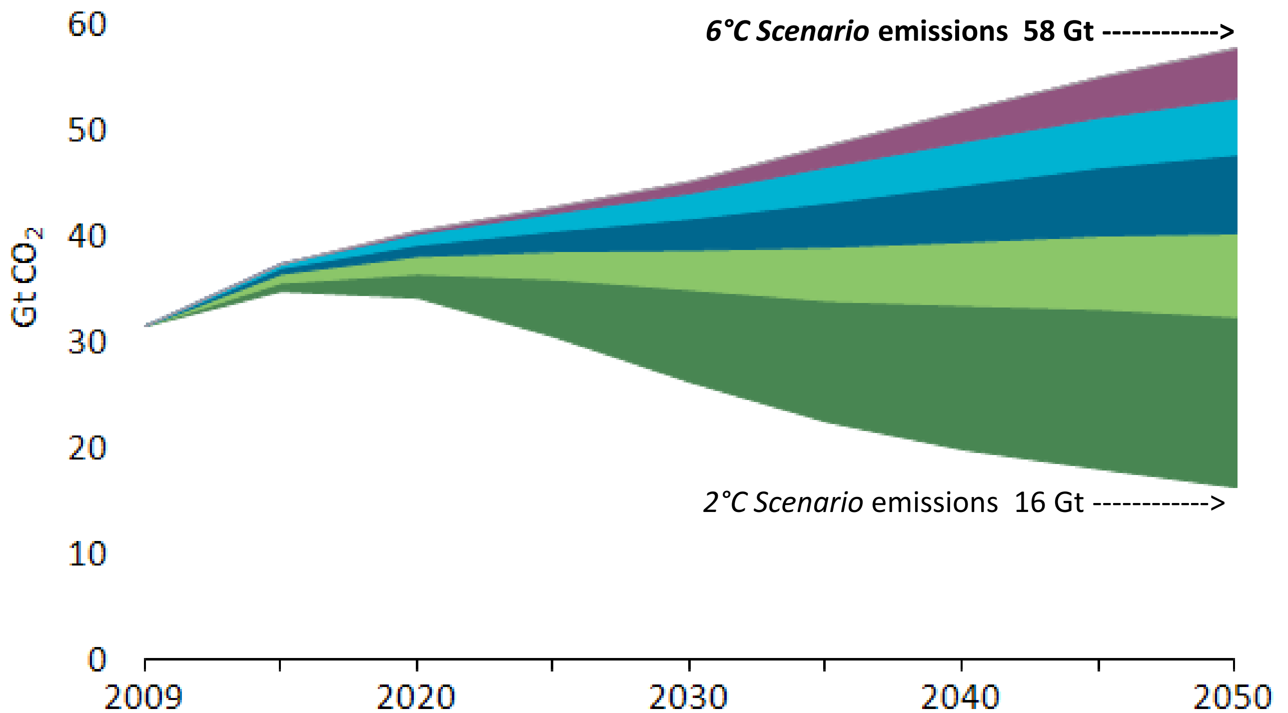
IEA Flagship Publication, Energy Technology Perspectives



Source: Energy Technology Perspectives 2012

- **6°C Scenario – business-as-usual; no adoption of new energy and climate policies**
- **2°C Scenario - energy-related CO_2-emissions halved by 2050 through CO_2-price and strong policies**

ETP 2014 – Release May 2014

Technology roadmaps provide answers

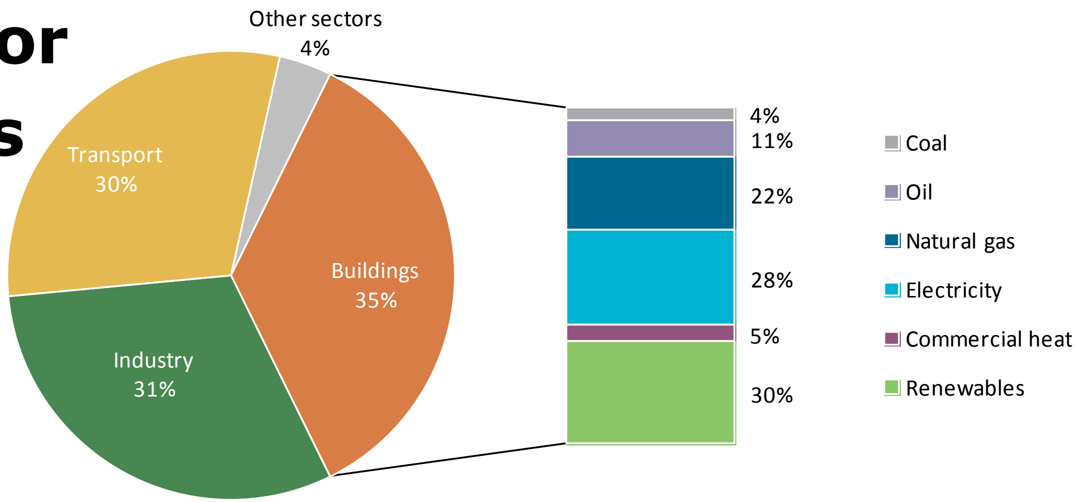
- Engage cross-section of stakeholders
- Identify a baseline
- Establish a vision

- Identify technical, regulatory, policy, financial, public acceptance barriers

- Develop implementation action items for stakeholders

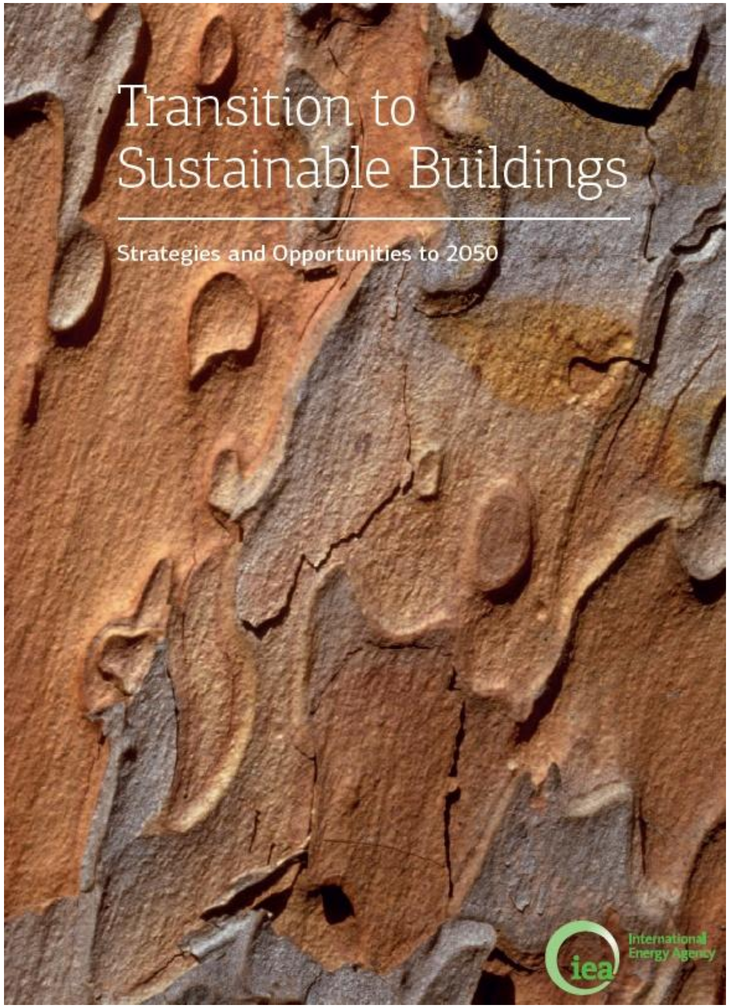
Importance of Buildings Sector

- Largest end-use sector
- 1/3 carbon emissions
- 50% of electricity
- Major portion of GDP
- Stock opportunities:
  - 75% - 90% of OECD building stock still in service by 2050
  - Large population growth in developing world will drive new floor area that needs to be efficient



Transition to Sustainable Buildings:
Strategies and Opportunities to 2050

- The overall ETP strategy for buildings
- Global and regional analysis, energy savings and emissions reduction forecasts
- Technical opportunities and recommendations: envelope; heating and cooling; appliances, lighting and cooking
- Policies to transform buildings



Making buildings more energy efficient

- Construction transformation strategy
- Provides technical, economic and strategic framework
- Assessment of high priority areas for 12 regions of the world
- Policy criteria and evaluation

Transformation to Low-Energy Buildings

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Transforming construction to low energy buildings

Inefficient – still common and old stock

- Single pane windows.
- No insulation.
- High air leakage.

Typical building code in advanced regions

- Low-e double glaze windows.
- High levels of insulation.
- Low air leakage.

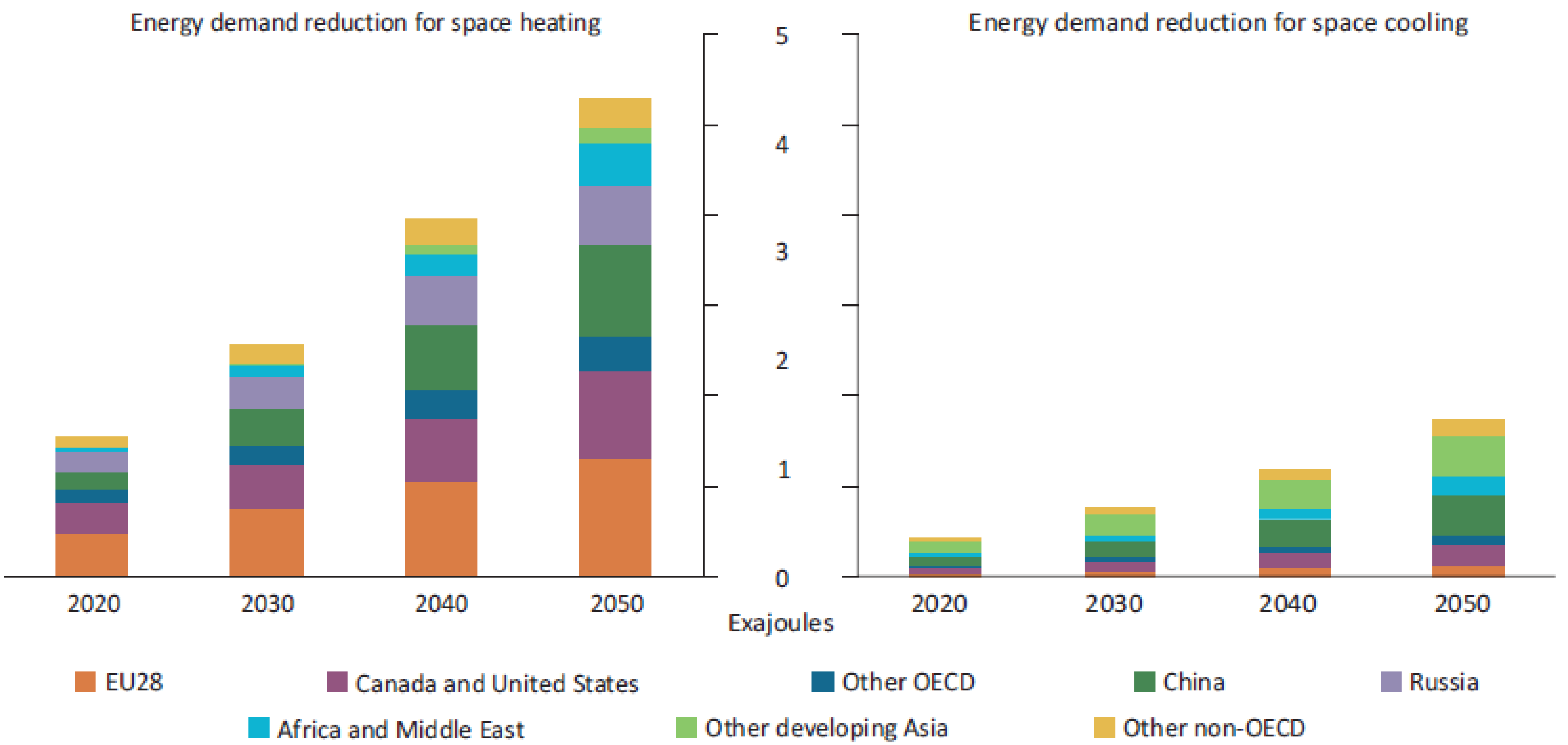
Zero-energy buildings

- Highly insulated windows and dynamic solar control.
- Optimised designs and orientations.
- Daylighting.

KEY POINT: the world needs to shift from very old buildings to modern buildings, and then to low-energy or zero-energy buildings.

Envelope Savings Potential

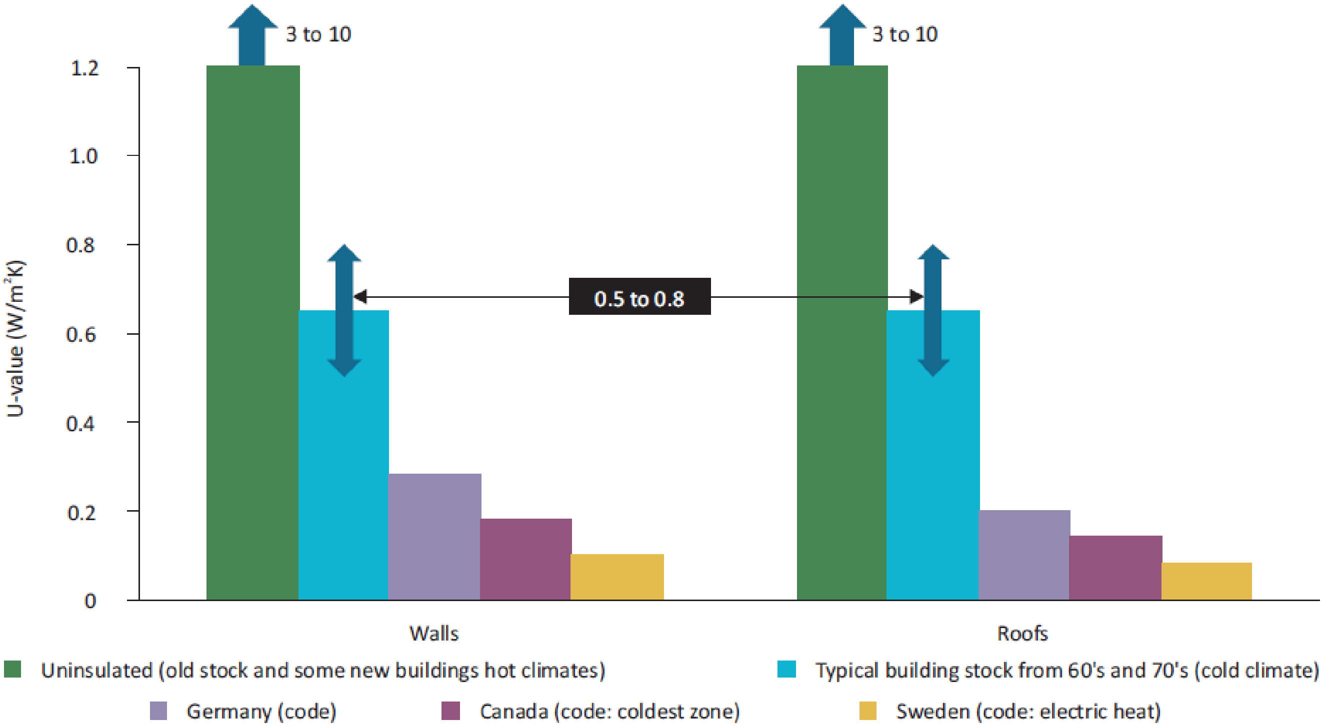
Figure 8: Energy reductions from improvement in building envelopes between the 6DS and 2DS



KEY POINT: building-envelope energy savings under the 2DS are significant, with heating savings around four times higher than cooling savings.

Insulation Opportunity

- **Very stringent U-values for electric resistance heaters in Sweden, and Canada's coldest climate zone**
- **IEA recommending goal for average wall and roof U-values ≤ 0.15 W/m2K cold climate, ≤ 0.35** W/m²K hot climate based on LCC



Source: Adapted from IEA (2013a), "Transition to Sustainable Buildings: Strategies and Opportunities to 2050", Organisation for Economic Co-operation and Development (OECD) Publishing, Paris.

KEY POINT: levels of insulation vary widely for the existing stock of buildings, as well as for new construction.

Windows Opportunity

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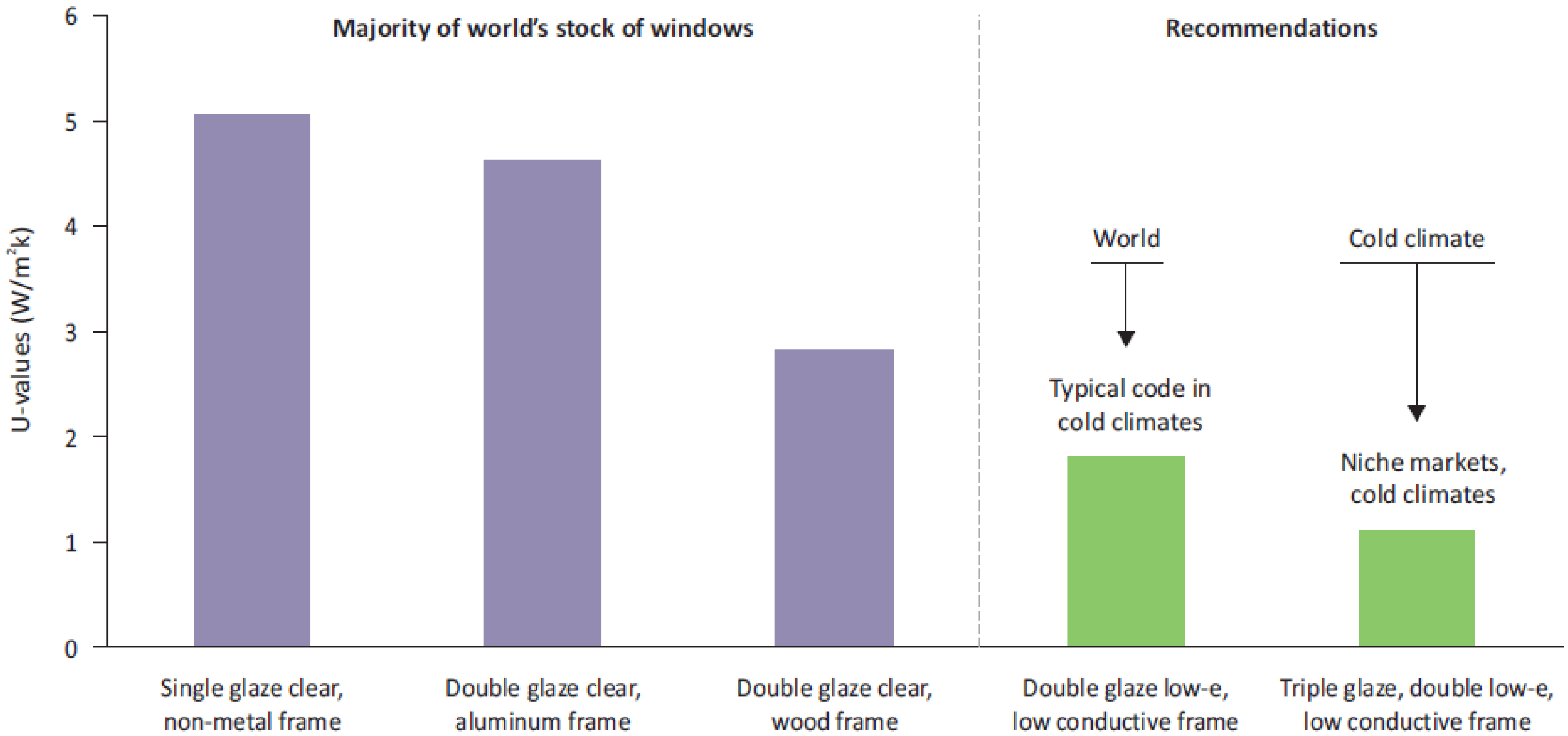
Figure 3: Most common types of windows in service and being sold today



Note: U-values presented in this roadmap represent whole-window performance unless noted in accordance with ISO 15099, thus an ISO 10077 standard of 1.0 W/m²K is roughly equal to 1.1 W/m²K per ISO 15099.

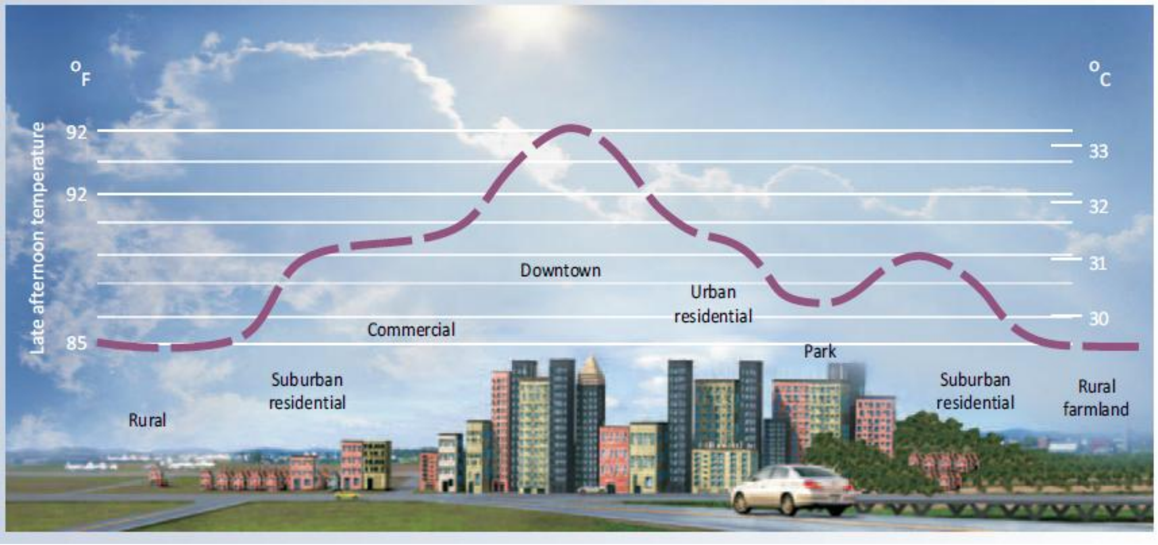
KEY POINT: the majority of the world's installed windows can be significantly improved and more work is needed to ensure that new sales meet more stringent performance criteria.

Reflective Roof Opportunity

Table 3: Performance characteristics and energy-savings potential for reflective roofs

	SR of a dark roof	SR of a white roof	SR of a cool-coloured roof	Roof energy-savings potential (with high level of insulation)	Roof energy-saving potential (with low level of insulation)
Roof performance characteristics	SR 5 (black) to SR 20 (grey)	SR 60 (soiled) to SR 80 (clean)	SR 25 (darker colour) to SR 50 (lighter colour)	13%	25%

Note: High insulation refers to a U value of 0.29 W/m²K, and low level of insulation has a U value of 0.51 W/m²K or higher.



Source: LBNL, Heat Island Group

Assessment of Advanced Envelope Components

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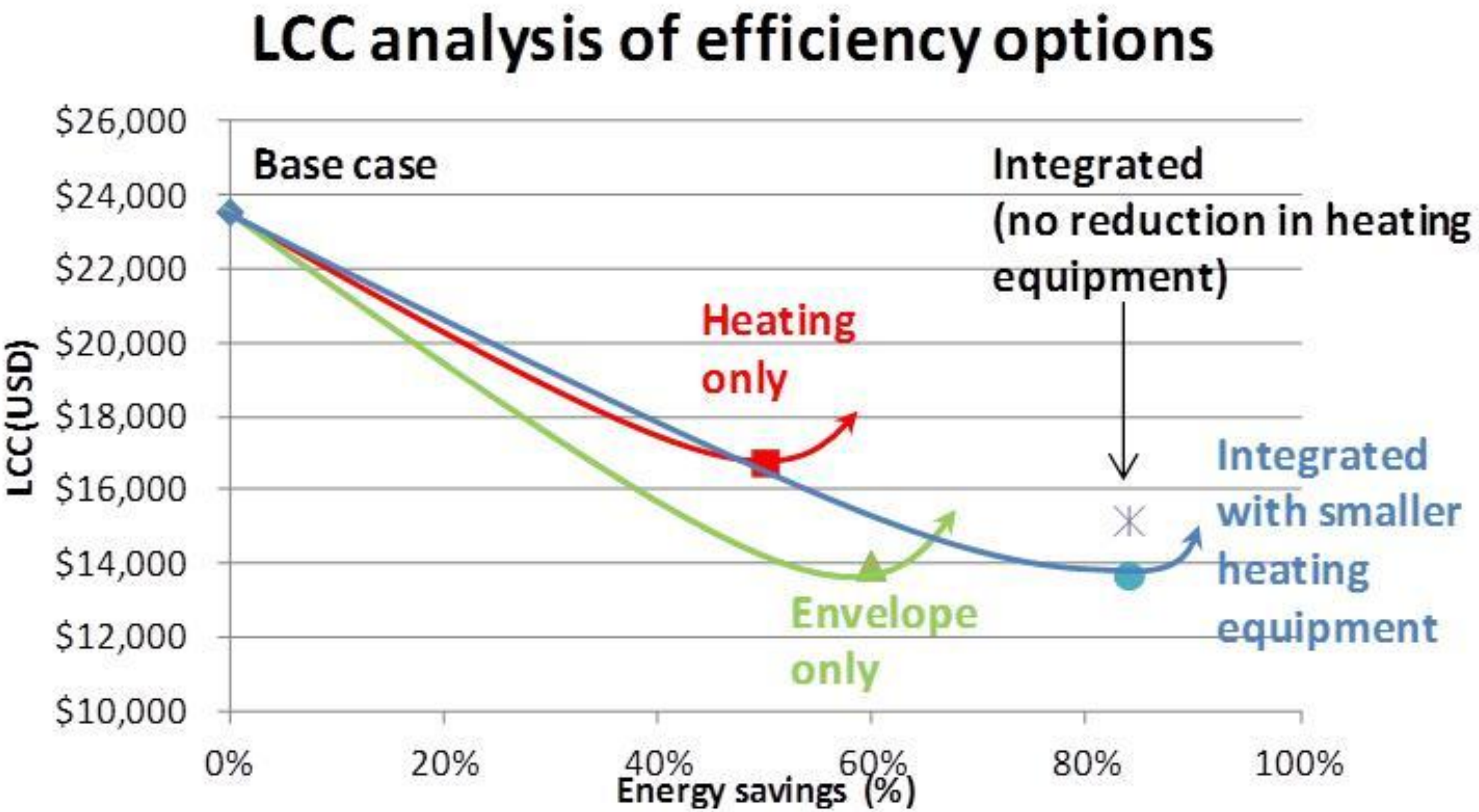
Market maturity/ saturation	ASEAN	Brazil	China	European Union	India	Japan/ Korea	Mexico	Middle East	Australia/ New Zealand	Russia	South Africa	United States/ Canada
Double-glazed low-e glass	●	▲	▲	★	▲	●	●	▲	●	●	●	★
Window films	▲	▲	▲	●	▲	●	▲	▲	●	▲	▲	●
Window attachments (e.g. shutters, shades, storm panel)	●	▲	●	★	▲	●	▲	●	●	▲	●	●
Highly insulating windows (e.g. triple-glazed)		▲	▲	●		▲		▲	▲	▲	▲	▲
Typical insulation	★	●	★	★	●	★	●	★	★	★	●	★
Exterior insulation	●	▲	●	★	●	●	▲	●		▲	▲	★
Advanced insulation (e.g. aerogel, VIPs)				▲		▲				▲	▲	▲
Air sealing	●	▲	▲	★	▲	●		▲	▲	▲		●
Cool roofs	▲	▲	▲	●	▲	▲	▲	▲	▲			★
BIPV/ advanced roofs	▲	▲		▲	▲	▲			▲	▲	▲	▲

★ Mature market ● Established market ▲ Initial market

Integrated Approach with Life-Cycle Cost



R&D Areas

- Highly insulated windows (U value ≤ 0.6 W/m^2K for ZEB) and dynamic solar control - integrated solution increase daylight and passive heating harvesting
- Lower air sealing approaches with validation testing
- Lower cost high performance “thin” insulation
- More durable and lower cost reflective surfaces

Source: Sage Electrochromics (St Gobain)

Source: Aspen Aerogel

Source: ORNL

Criteria for Policy Assessments, IEA Perspective

Policies	ASEAN	Brazil	China	European Union	India	Japan/ Korea	Mexico	Middle East	Australia/ New Zealand	Russia	South Africa	United States/ Canada
Governance	L	M	H	H	M	M	M	L	M	L	M	M
Energy prices	L	M	M	H	M	H	L	L	M	L	M	M
Infrastructure and human capacity	M	L	M	H	M	H	M	L	M	M	M	H
Commodity of efficient materials	L	M	H	H	M	H	M	L	M	M	L	H
Voluntary programmes	L	L	L	M	L	L	L	L	L	L	L	L
Mandatory building codes	L	L	M	H	L	M	M	L	M	M	M	H

Note: H: high, M: medium, L: low

Tracking Progress – Next Steps

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- Much more data is needed
  (e.g. new technology adoption rates, market share of zero-energy buildings, etc)
- More specific performance criteria needed even for most advanced regions
  (e.g. EU specifications for renovation in public buildings)
- IEA is considering a new building's partnership
  (for policy assessment, to improve data and modeling, and to enable deployment)

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DOWNLOAD THE ROADMAP AND ANNEXES AT:

http://www.iea.org/publications/freepublications/publication/name,45205,en.html

FOR ADDITIONAL INFORMATION CONTACT:

buildingsinfo@iea.org

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Role of storage in the energy system

- **Improving energy system resource use efficiency**
- **Integration of higher levels of variable renewables and end-use sector electrification**
- **Supports greater production of energy where it is consumed**
- **Increasing energy access**
- **Improving grid stability, flexibility, reliability and resilience**

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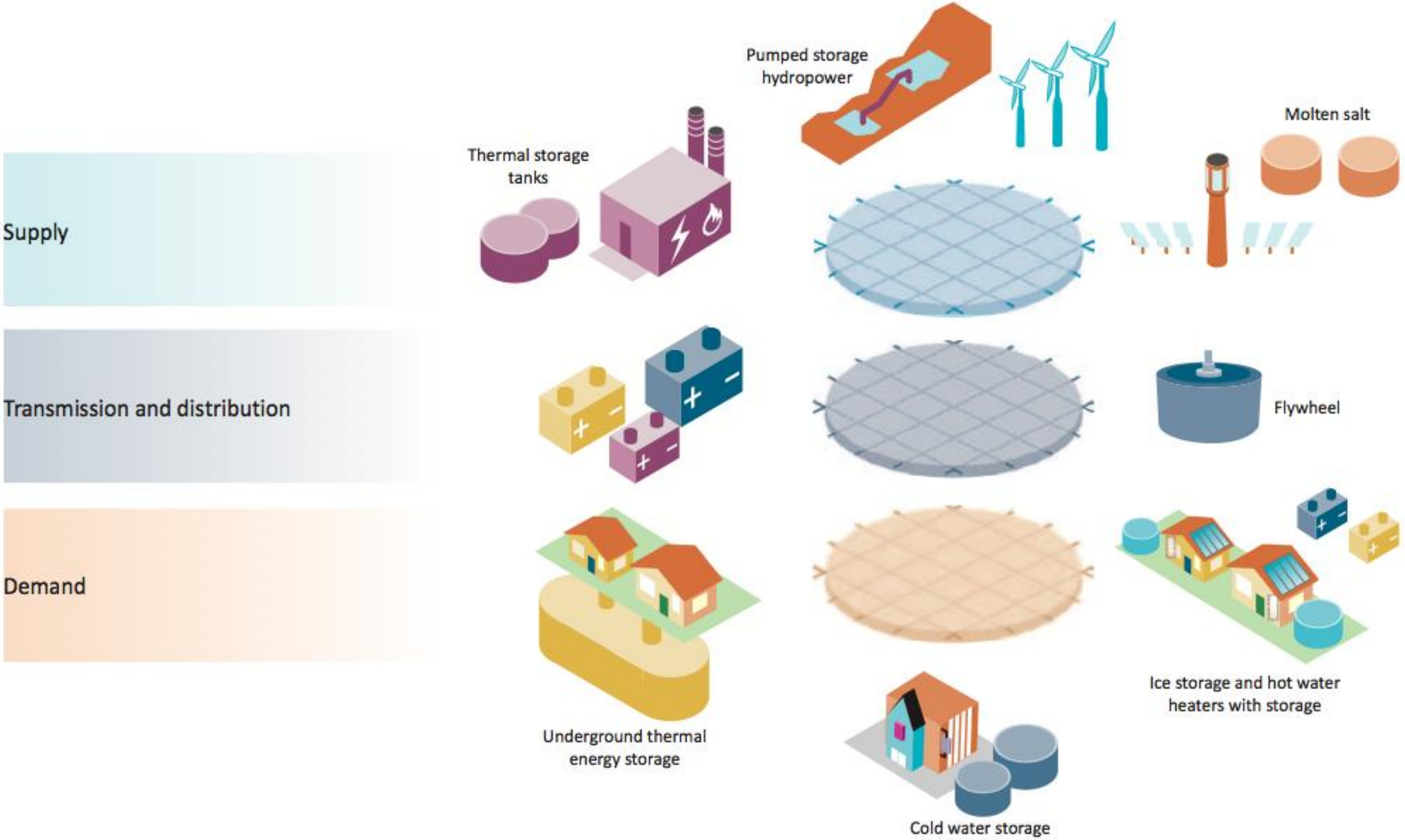
Storage can help to better integrate our electricity and heat systems



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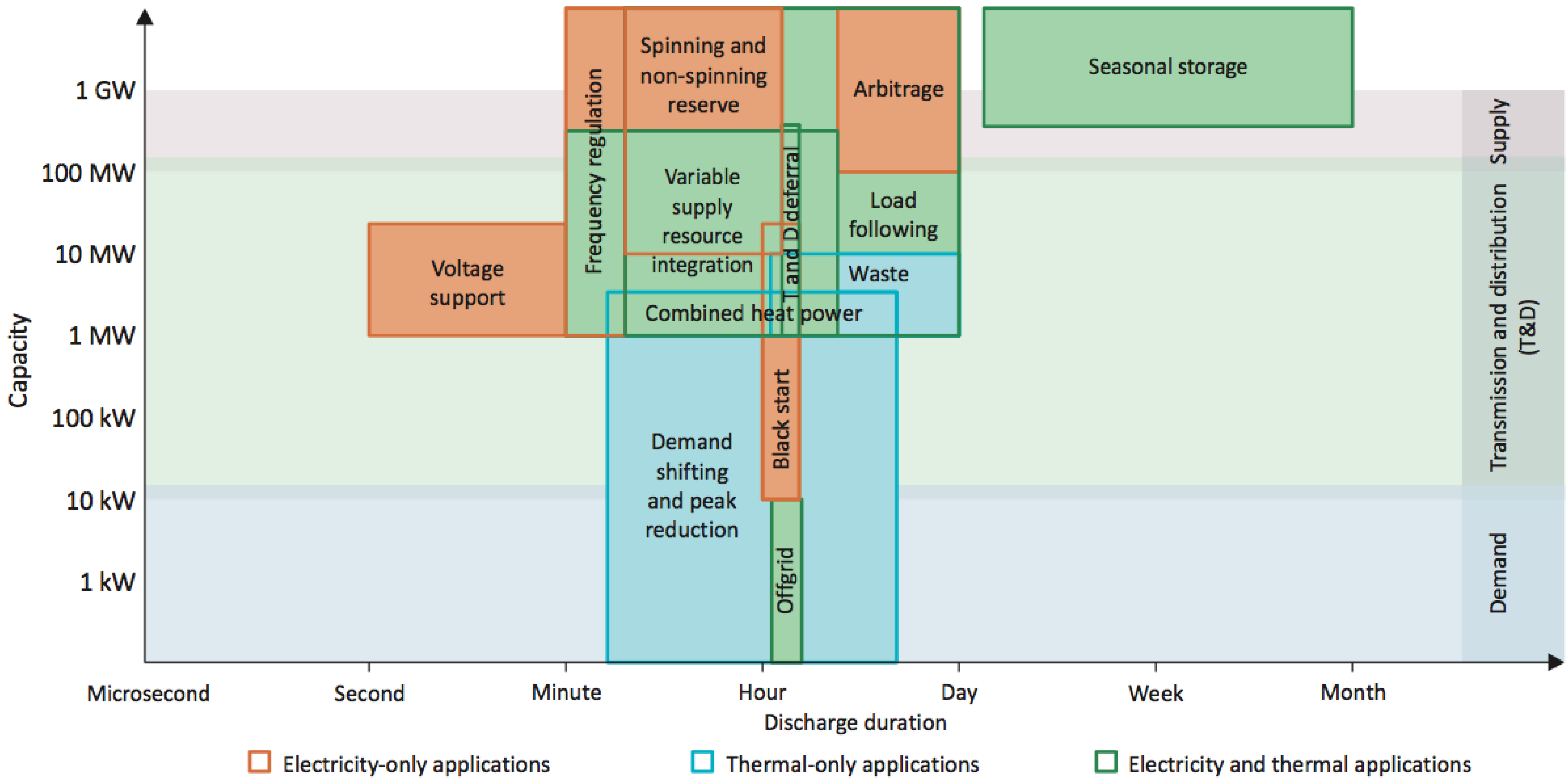
Electricity and thermal storage can provide a wide range of applications



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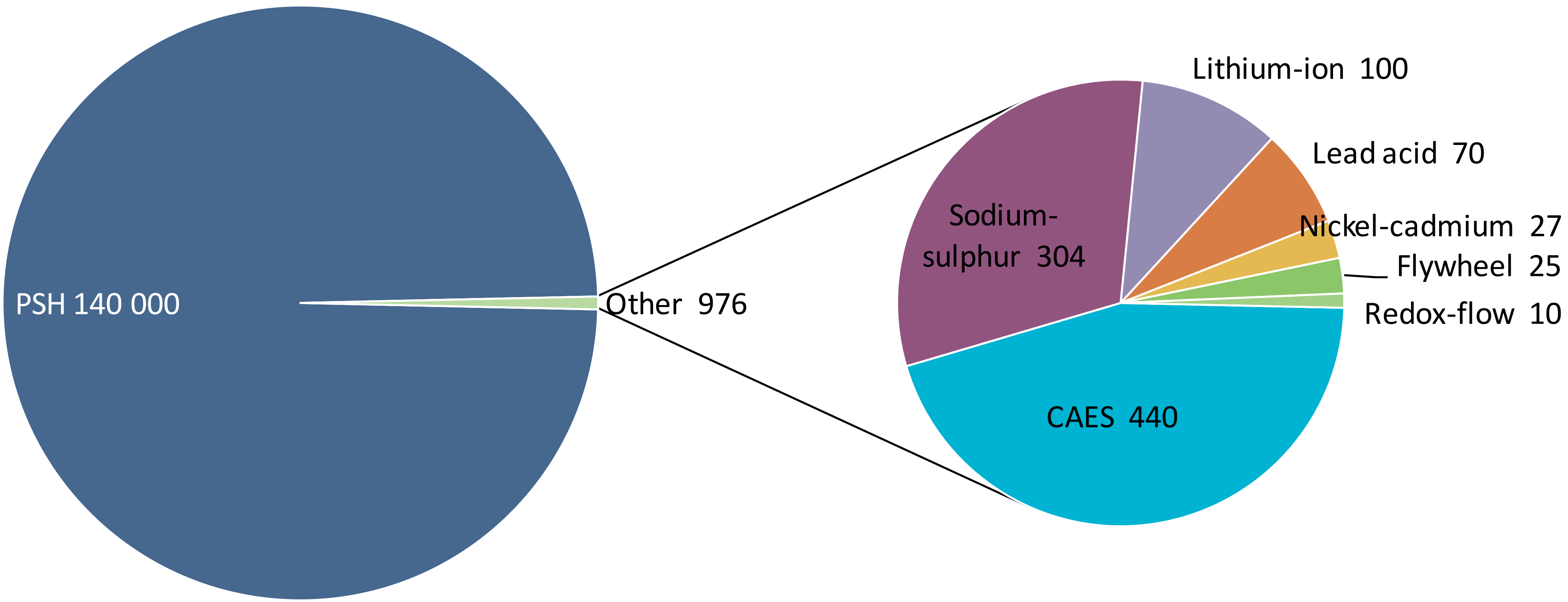
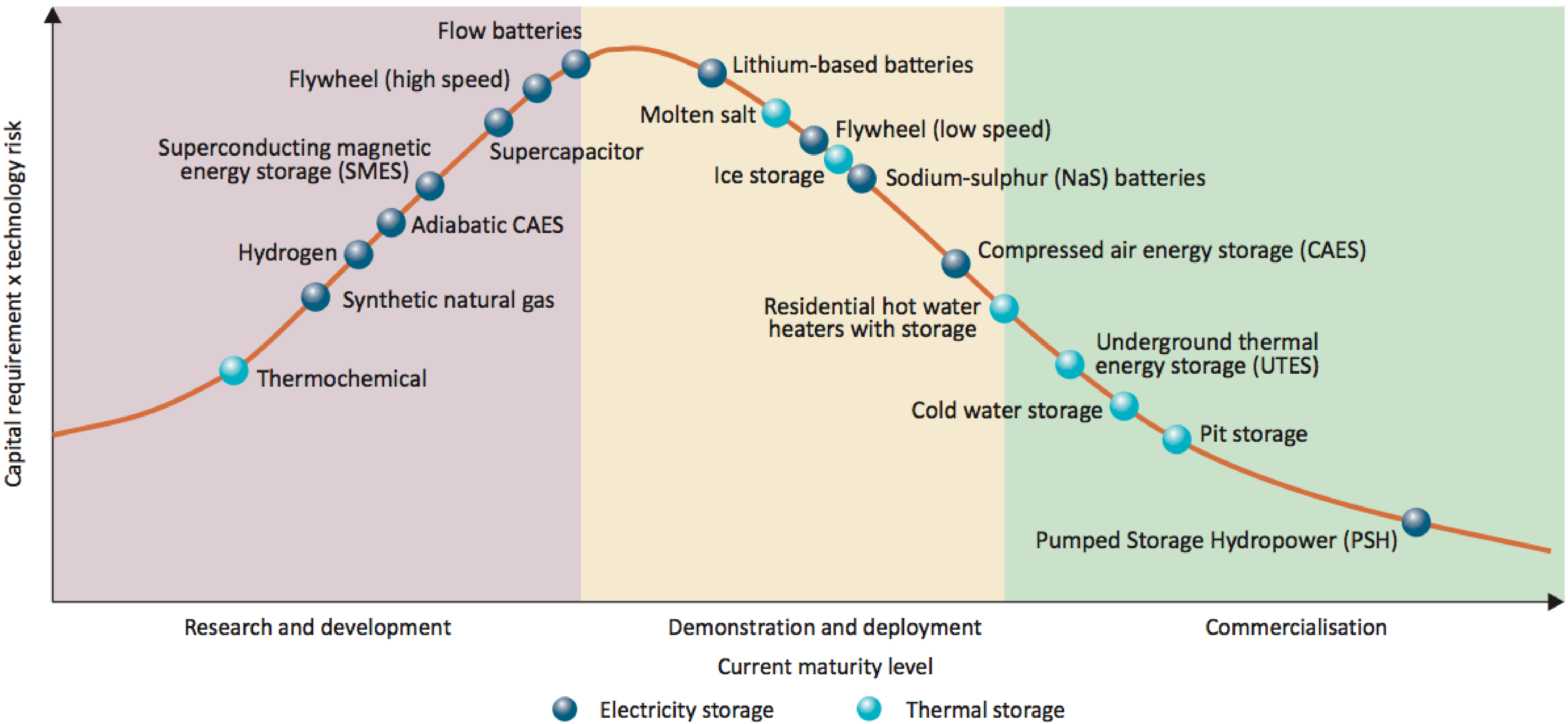
Current grid-connected electricity storage dominated by Pumped Storage Hydropower

Installed capacity in MW



A wide range of storage technologies exists at different stages of maturity



Storage technologies current status

Technology	Location	Output	Efficiency (%)	Initial investment cost (USD/kW)	Primary application	Example projects
Pumped storage hydropower	Supply	electricity	50-85	500 - 4 600	long-term storage	Goldisthal Project (Germany), Okinawa Yanbaru Seawater PSH Facility (Japan), Pedreira PSH Station (Brazil)
Underground thermal energy storage	Supply	thermal	50-90	3 400 - 4 500	long-term storage	Drake Landing Solar Community (Canada), Akershus University Hospital and Nydalen Industrial Park (Norway)
Compressed air energy storage	Supply	electricity	27-75	500 - 1 500	long-term storage, arbitrage	McIntosh (Alabama, USA), Huntorf (Germany)
Pit storage	Supply	thermal	50-90	100 - 300	medium temperature applications	Marstal district heating system (Denmark)
Molten salts	Supply	thermal	40-93	400-700	high-temperature applications	Gemasolar CSP Plant (Spain)
Batteries	Supply, demand	electricity	75-95	300 - 3 500	distributed/ off-grid storage, short-term storage	NaS batteries (Presidio, USA and Rokkasho Futamata Project, Japan), Vanadium redox flow (Sumimtomo Office, Japan), Lead-acid (Notrees Wind Storage, USA), Li-ion (AES Laurel Mountain, USA and Community Energy Storage, Canada), Lithium Polymer (Autolib, France)

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Storage technologies current status

Technology	Location	Output	Efficiency (%)	Initial investment cost (USD/kW)	Primary application	Example projects
Chemical – hydrogen storage	Supply, demand	electrical	22-50	500-750	long-term storage	Utsira Hydrogen Project (Norway), Complementary Systems H2Herten (Germany)
Flywheels	T&D	electricity	90-95	130 - 500	short-term storage	PJM Project (USA)
Supercapacitors	T&D	electricity	90-95	130 - 515	short-term storage	Hybrid electric vehicles (R&D phase)
Superconducting magnetic energy storage	T&D	electricity	90-95	130 - 515	short-term storage	D-SMES (United States)
Solid media storage	Demand	thermal	50-90	500 - 3000	medium temperature	Residential electric thermal storage (USA)
Ice storage	Demand	thermal	75-90	6 000 - 15 000	low-temperature	Denki University (Tokyo, Japan) , China Pavilion project (China)
Hot water storage	Demand	thermal	50-90	-----	medium temperature	Peak demand reduction in France, TCES (United States)
Cold-water storage	Demand	thermal	50-90	300-600	low-temperature	Shanghai Pudong International Airport (China)

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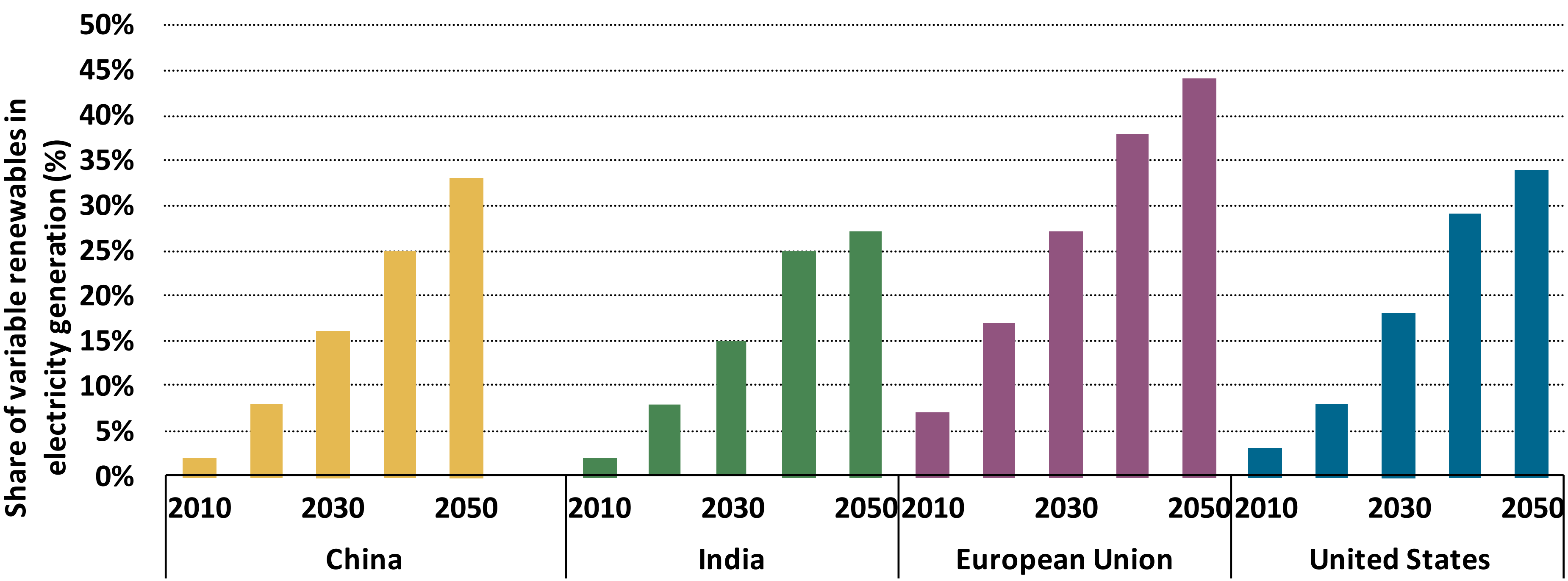
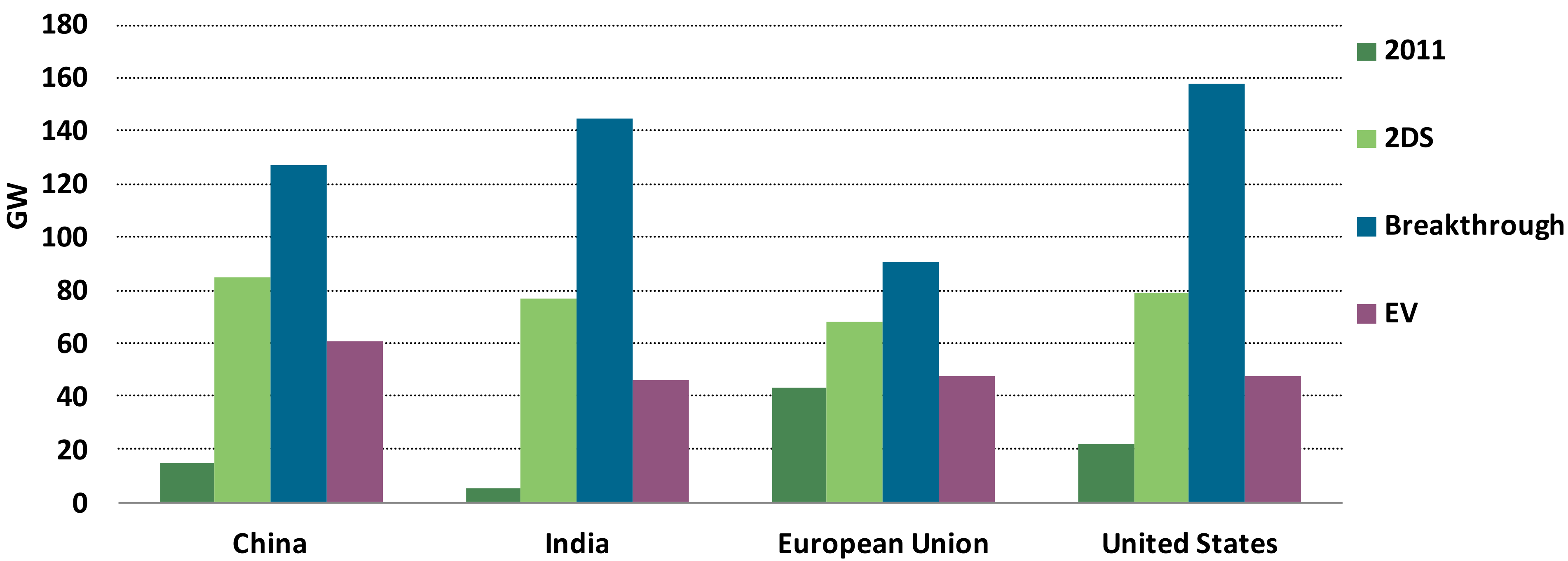
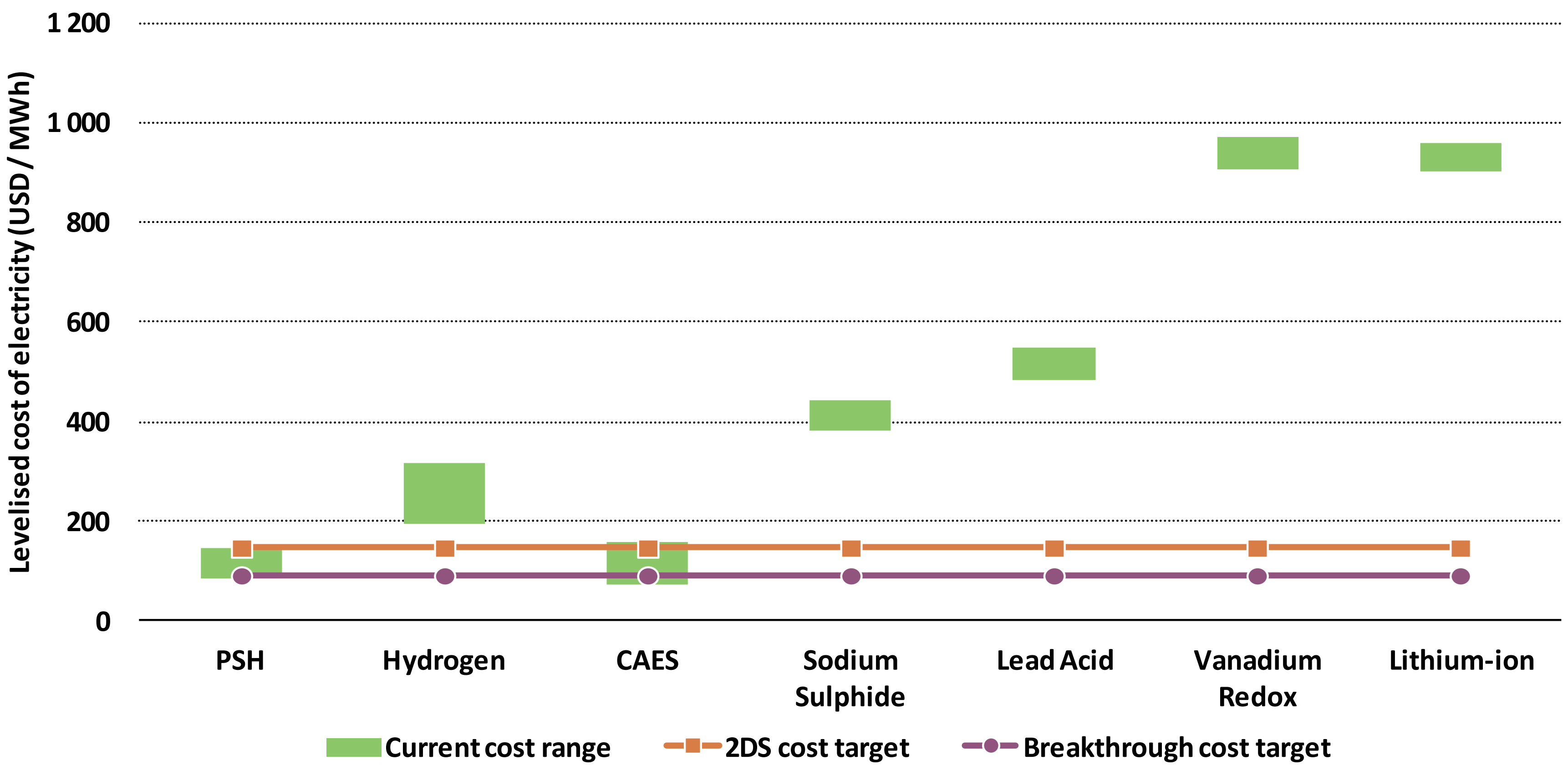
Storage can help to integrate higher levels of variable renewables



2DS vision for storage in the electricity systems



Sharp Declines in Costs Needed



Actions spanning across technologies and applications

This roadmap recommends the following actions:		***Proposed timeline***
Address data challenges for existing storage projects.	Create an accessible global dataset of energy storage technology project overviews, including information on system specifications, cost and performance with contextual details.	Concentrated effort in the short term (2014-17).
	Quantify waste heat availability and opportunities, including details on waste heat quantity, quality, and location for both resources and potential demand.	Concentrated effort in the short term (2014-17).
Address data challenges for use in assessing future energy storage potential.	Build a comprehensive dataset of renewable generation production with high levels of granularity to allow for assessment across a wide range of energy storage technology applications throughout the year.	Concentrated effort in the short term (2014-20).
	Assess global potential for energy storage deployment in the context of the ETP 2DS vision (technology-independent evaluation).	Longer-term effort (2020-30) after compilation of necessary datasets.
	Quantify distributed energy storage potential in buildings, e.g. domestic hot water heaters, commercial refrigeration centres.	Concentrated effort in the short term (2014-20).
Establish international and national data co-operation to foster energy storage research, monitor progress and assess the R&D bottlenecks.		2018
Support research, development and demonstration (RD&D) projects that incorporate the use of both electricity and thermal energy storage (i.e. hybrid systems) to maximise resource use efficiency, with emphasis on optimising the location/application factor.		Medium-term effort (2020-50).

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Policy and regulatory frameworks

This roadmap recommends that the following actions be taken:	*Milestone*
Eliminate price distortions and increase price transparency for power generation and heat production, e.g. time-of-use pricing schemes, pay-for-services (heating, cooling, quick response, etc.) models.	2020
Enable benefits-stacking for energy storage systems.	2020
Government support of energy storage use in off-grid and remote communities.	2025
Support of the rapid retrofit of existing energy storage facilities to increase efficiency and flexibility, where these retrofits appear warranted.	2030
Inclusion of energy storage technologies as options for supplying energy and power services, and support for their continued development through government-funded R&D programmes.	2030

Roadmap Key Findings

- Storage can support energy system decarbonisation
- Some technologies already competitive, others (particularly electricity storage) still too expensive
- Additional R&D still needed to reduce costs
- Optimal role for storage varies widely across regions
- Power markets are ill-equipped to compensate storage for suite of services they can provide
- Thermal energy storage systems could make better use of wasted heat

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Key actions over the next 10 years

- Retrofit existing storage facilities
- Develop markets and regulatory environments that enable accelerated deployment i.e benefits-stacking
- Support targeted demonstration projects and R&D
- Establish a comprehensive set of international standards
- Establish international and national data co-operation
- Complete regional assessments to quantify the value of storage in specific regions and energy markets

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http://www.iea.org/publications/freepublications/publication/name,36573,en.html

FOR ADDITIONAL INFORMATION CONTACT:

TechnologyRoadmapsContact@iea.org

Contact : report@tky.ieej.or.jp