



Building systems and operations

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The trainers



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Introductory roundtable

Introduce yourself !

Name, country, organisation

State one buildings policy or technology you think is the most promising for your region

State the most interesting thing you learned from the previous session or the site visit

Over the next 3 days:

Speak up and engage with others
Ask questions, give answers

Net Zero Building SD4 NUS



How the session will work

1. Introduction to the subtopics
2. Setting the level of ambition: what are we trying to achieve?
3. Identifying Technology Gaps
4. Identifying Policy Gaps
5. Identifying the “Enablers”
6. Identifying the Key Actions

Fill in templates for:

- technology timeline
- policy timeline
- key actions

Current 8 strategic priority areas:

1. **Urban planning:** use urban planning policies to enable reduced energy demand, increased renewable energy capacity and improved infrastructure resilience.
2. **New buildings:** Increase uptake of new buildings with net-zero operating emissions.
3. **Building retrofits:** Increase the rate of building energy renovation and increase the level of sustainability in existing buildings.
4. **Building operations:** Reduce the operating energy and emissions through improved energy management tools and operational capacity building.
5. **Systems:** Reduce the energy and emissions needed for equipment, appliances, lighting and cooking.
6. **Materials:** Reduce the environmental impact of materials and products in buildings and construction by taking a life-cycle and circular economy approach.
7. **Resilience:** Reduce building risks related to climate change through building design, selection of materials and improving resilience to structural, water and heat risks.
8. **Clean energy:** Increase secure, affordable and sustainable energy and reduce the carbon footprint of energy demand in buildings.

1. Introduction to the subtopics

Building systems and operations

“Buildings don’t use energy, people do” :

Building systems are **operated by people** to make people **comfortable**, and these systems use energy.

This module will cover measures to reduce the energy use of building systems during their operation.



Roadmap for Buildings and Construction

Set targets for:

- Urban planning
- New buildings
- Building retrofits
- Building operations
- **Systems**
- Materials
- Resilience
- Clean energy

Building systems improvement for:

- Efficient and low carbon heating systems
- Efficient cooling systems
- Efficient lighting systems
- Efficient large appliances and cooking
- Efficient small appliance and electronics

Achieve these through:

- Minimum energy performance standards
- Product labelling
- Testing and evaluation
- Incentives
- Technology and knowledge transfer

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Existing building operations improvement:

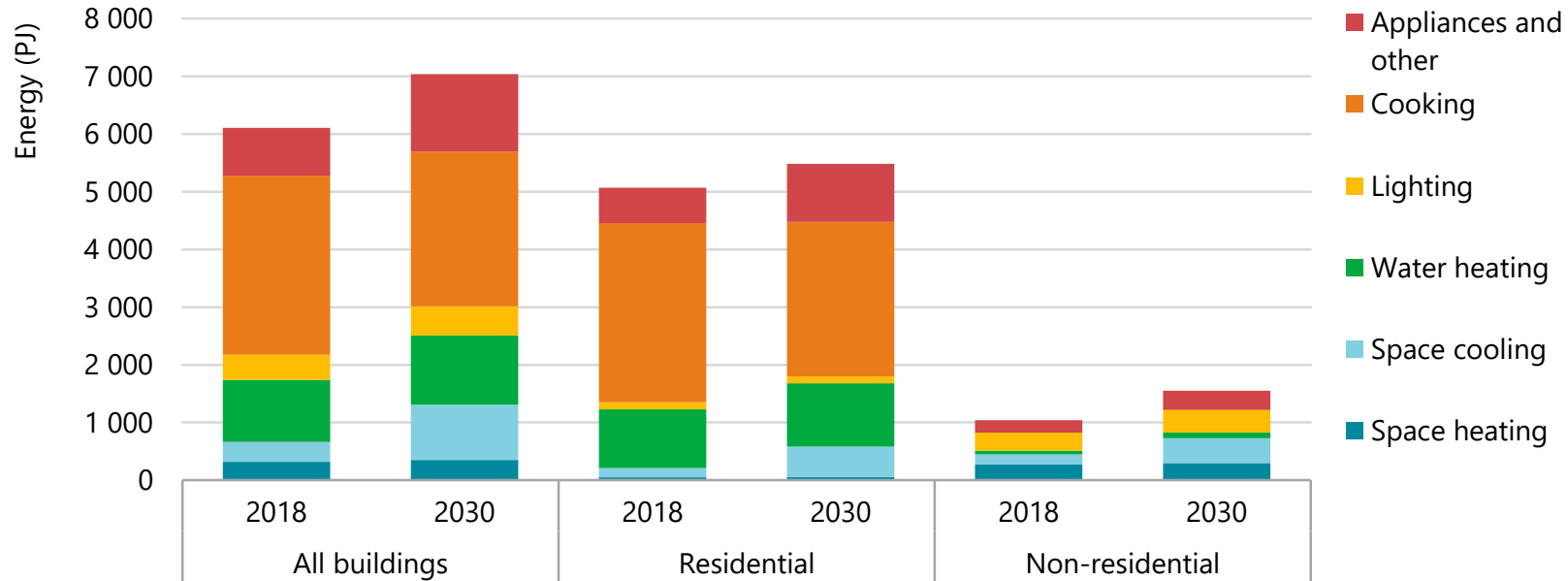
- Improved energy management
- (Nearly) net zero operating emissions

Achieve these through:

- Energy reduction targets
- Occupant behaviour
- Energy management tools (e.g. ISO)
- Energy data collection/disclosure
- Building energy labelling and certification
- Building and system commissioning
- Building passports
- Technology and knowledge transfer

What systems are we talking about ?

Energy consumption by end-use in ASEAN



For electricity consumption: prioritise water heating and appliances (residential) and lighting, cooling and appliances (non-residential). Note: AC ownership in households is growing.

What operations are we talking about?

- Building operations consists of the activities necessary to **operate, maintain, and manage** buildings. This includes maintaining the HVAC systems, plumbing, electrical, and building system configuration.
- Operation and management activities, methods, and approaches should **enable energy savings** while maintaining or enhancing **indoor environmental quality** and **equipment reliability**.
- Good operation and management practices will lead to the efficient operation of buildings rather than emphasising energy-efficient capital improvements or equipment-specific maintenance procedures. Can also lead to increased productivity of occupants, and a longer lifetime of the building and its components.
- Operation management Improvements focus on:
 - Management: goals, planning, accounting
 - Teamwork: staffing, training, outsourcing
 - Resources: documentation: tools, assessments
 - Energy-Efficient operation and maintenance: Tune-up, automated controls, scheduling, tracking, prevention

PECI, 2000

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Implementing smart management



Asys smart management, 2019

2. Setting the level of ambition: what are we trying to achieve?

Building systems and operations:

What are we trying to achieve

- **Low operational energy**
- **Low capital cost**
- **Comfortable**
- **Easy to maintain**
- Resilient
- Low emission

What are the factors

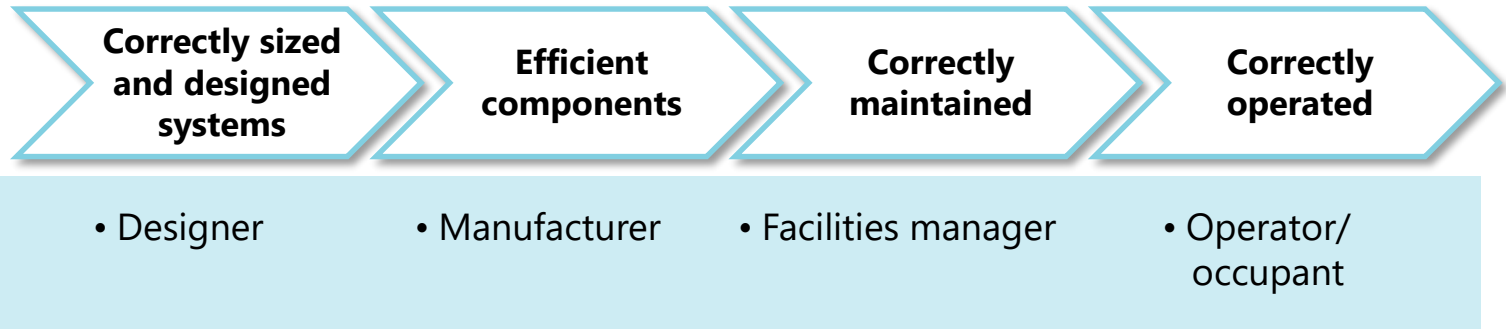
- Climate
- Typology
- Choice of systems
- Operation and maintenance

How might we measure that ?

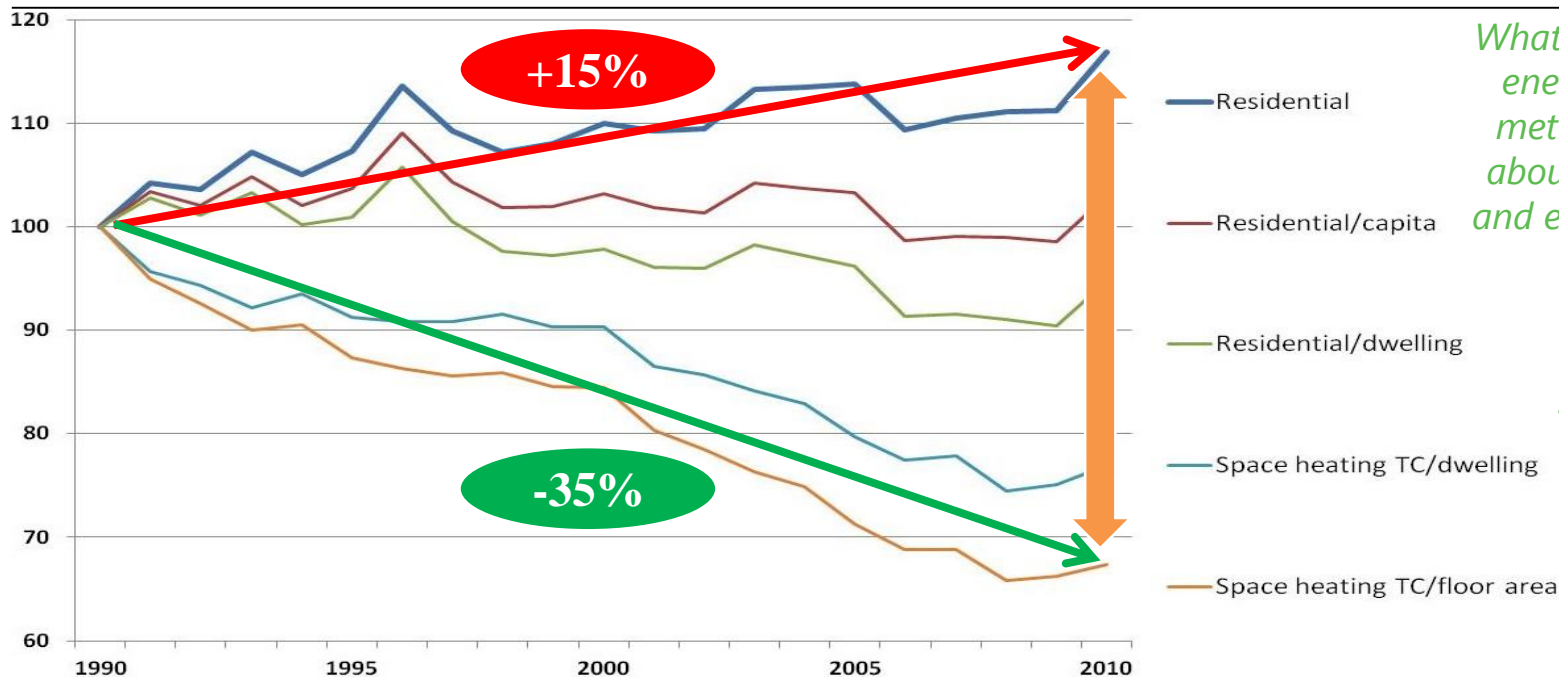
- Annual energy consumption, EPI (kWh/m²/year)
- Efficiency of systems
- Use of procedures

Drivers of building energy use: systems

Once energy needs have been reduced through passive measures, the principle factors become:



Evaluation: choosing the right metric



What are these types of energy performance metrics not telling us about energy demand and efficiency progress?

Behaviour?

Technology?

Efficiency?

Income?

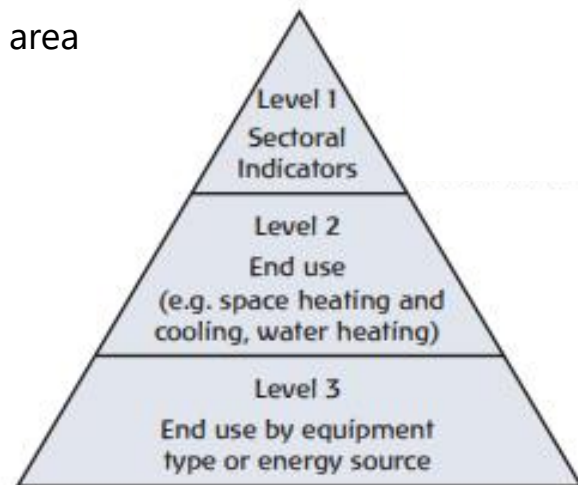
Index: 1990=1. Data for IEA18 (Australia, Austria, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Norway, Slovakia, Spain, Sweden, Switzerland, UK, USA).
TC: Temperature Corrected.

The right energy performance metric is crucial to understanding & tracking progress over time.

Source: IEA energy efficiency indicators database

Energy efficiency indicators pyramid

- Residential
 - **Energy per household**
 - Energy for end-use (eg. Water heating, appliances) per household
 - **Energy per floor area**
 - Energy for end-use (eg heating, cooling, lighting) per floor area
 - Equipment energy use per floor area and type
- Commercial
 - **Energy per floor area**
 - Energy by building type per floor area
 - Energy for end-use by building type per floor area



Source: [IEA energy efficiency indicators](#)

3. Technology gaps

- Let's try and think of all the **technologies** that are relevant to building systems and operations in your regions.

Residential	
Cooking & water heating	Space cooling
<ul style="list-style-type: none">- More efficient fuels eg. Electricity or gas- Heat pump- Solar thermal- District heating	<ul style="list-style-type: none">- Split systems- Inverters- Window units, portable ACs- VRF, VRV
Appliances & lighting	Ventilation
<ul style="list-style-type: none">- Efficient appliances with low standby power- "Smart" devices- LEDs- Smart meters	<ul style="list-style-type: none">- Properly sized and positioned kitchen extract- Fans

Non-residential	
HVAC	
<ul style="list-style-type: none">- Central HVAC, pumps and fans, commissioning- Air cooled vs water cooled chillers- Split systems, inverters, heat pumps- District systems- Evaporative cooling, heat recovery, free cooling, hybrid cooling- Temperature set point	
Lighting	Controls & Energy management
<ul style="list-style-type: none">- LED- Dimming, daylight harvesting	<ul style="list-style-type: none">- Variable speed drives- Smart and connected sensors- Building management systems- Daylight control of lighting- Audit tools, metering- Maintenance tools
Appliances and other loads	
<ul style="list-style-type: none">- Efficient data centres- Efficient and low standby losses- Elevators, escalators etc	

Think about: - which are available locally? Which are currently affordable? Expensive? Are specially skilled workers or tools required?

Setting targets

- For the roadmap, we will set targets for the key technologies in this format:



- List the key barriers and enablers for achieving this timeline.

Technology refresher – keeping buildings cool

- **Step 1: building envelope and design**

- ✓ Module 1

- **Step 2: lower heat gains through efficient appliances**

- More efficient lights and appliances reduce the heat transfer to the space

- **Step 3: assisted ventilation**

- Efficient ceiling fans with high performance brushless DC motors and improved blade designs
 - Can bring down the perceived temperature down by 2-4°C

- **Step 4: energy-efficient air conditioning**

- Raised set point
 - High EER, seasonal efficiency, label rating
 - Water based systems

Technology refresher – reducing HVAC demand

Decrease transport energy



- ✓ VFD for pump and fans for adaptation to the demand
- ✓ Chilled Water systems instead of air systems

Decrease the cooling demand



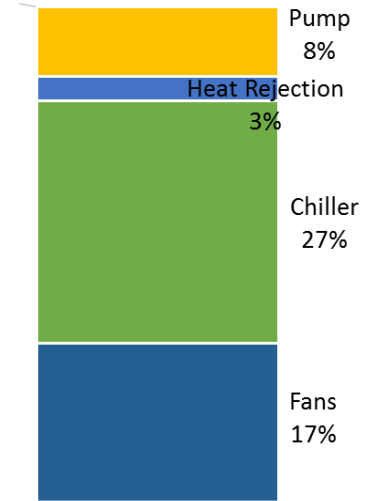
- ✓ Free cooling
- ✓ Evaporative cooling
- ✓ Enthalpy recovery

Increase the efficiency of the cooling production



- ✓ Gliding temperature for the chilled water production
- ✓ Select chillers on part load performance with VFDs on fans and pumps
- ✓ Run chillers on optimum point

Typical HVAC energy breakdown for CHW system:



Source: BEEP

Technology refresher – energy management

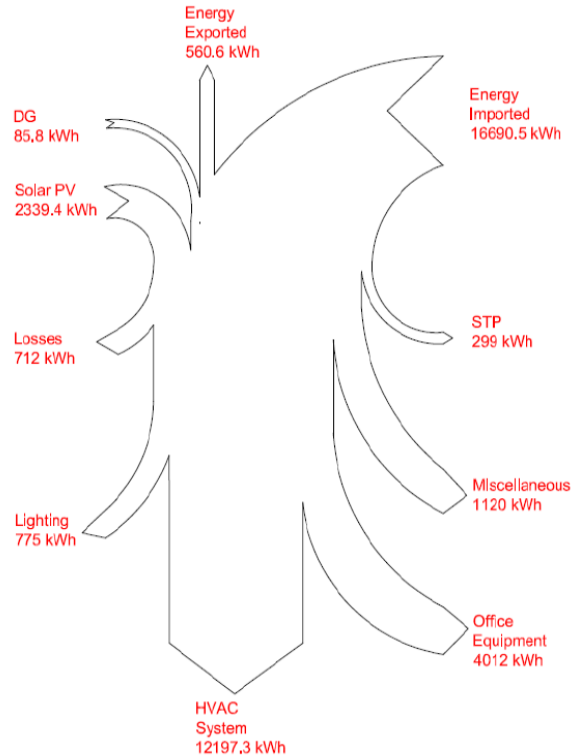
- Example: energy monitoring equipment at Aranya Bhawan Office Building, Jaipur, India



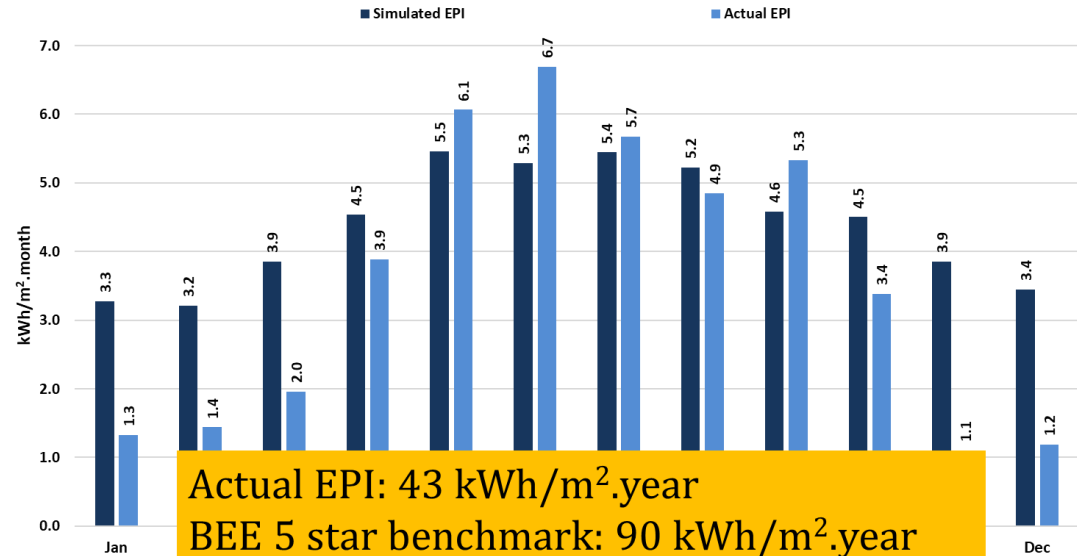
Source: BEEP

Energy monitoring results – Aranya Bhawan

Energy flow (Sankey Diagram) for the Summer Monitoring



Monthly EPI Comparison: Simulated vs. Actual



Source: BEEP

Roadmap for Buildings and Construction

Set targets for:

- Urban planning
- New buildings
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- Building operations
- **Systems**
- Materials
- Resilience
- Clean energy

		Baseline status (2019)	Short-term (2030)	Medium-term (2040)	Long-term (2050)
Heating, cooling and lighting	Space heating	Typical: X COP Exceptional: >X COP	<u>Achieve</u> : X COP <u>Aspire</u> : X COP	<u>Achieve</u> : X COP <u>Aspire</u> : X COP	<u>Achieve</u> : X COP <u>Aspire</u> : X COP
	Space cooling	Typical: X EER and X SEER Exceptional: ≥ X EER and X SEER	<u>Achieve</u> : X SEER <u>Aspire</u> : X SEER	<u>Achieve</u> : X SEER <u>Aspire</u> : X SEER	<u>Achieve</u> : X SEER <u>Aspire</u> : X SEER
	Ventilation	Typical: mechanical without energy recovery Exceptional: natural	<u>Achieve</u> : X% energy recovery <u>Aspire</u> : X% natural	<u>Achieve</u> : X% energy recovery <u>Aspire</u> : X% natural	<u>Achieve</u> : X% energy recovery <u>Aspire</u> : X% natural
	Water heating	Typical: X COP Exceptional: >X COP	<u>Achieve</u> : X COP <u>Aspire</u> : X COP	<u>Achieve</u> : X COP <u>Aspire</u> : X COP	<u>Achieve</u> : X COP <u>Aspire</u> : X COP
	Lighting	Typical: <100 lumens/watt Exceptional: >200 lumens/watt	<u>Achieve</u> : X lm/w <u>Aspire</u> : X lm/w	<u>Achieve</u> : X lm/w <u>Aspire</u> : X lm/w	<u>Achieve</u> : X lm/w <u>Aspire</u> : X lm/w

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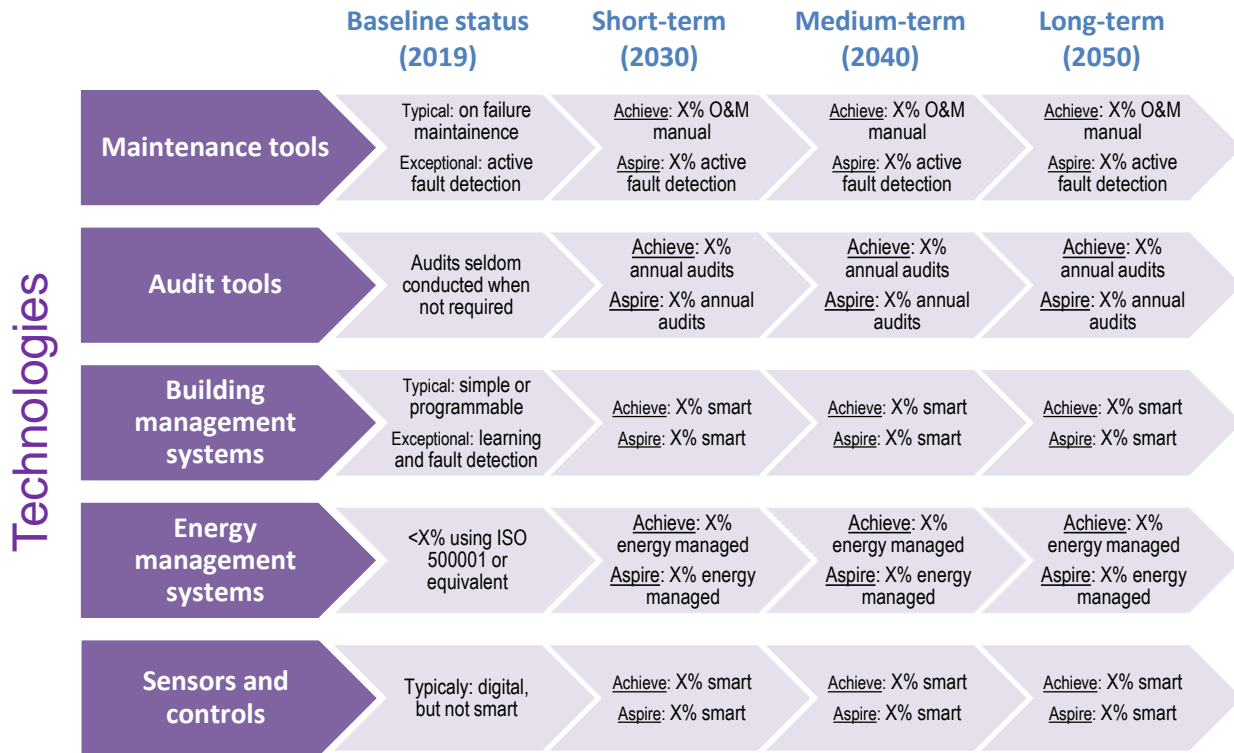
Appliances and controls

	Baseline status (2019)	Short-term (2030)	Medium-term (2040)	Long-term (2050)
Refrigerators	Typical: X kWh/year/litre Exceptional: X kWh/year/litre	Achieve: X kWh/year/litre Aspire: X kWh/year/litre	Achieve: X kWh/year/litre Aspire: X kWh/year/litre	Achieve: X kWh/year/litre Aspire: X kWh/year/litre
Cooking	X% clean cooking Typical: <X% efficient	Achieve: X% clean cooking Aspire: X% efficient	Achieve: X% clean cooking Aspire: X% efficient	Achieve: X% clean cooking Aspire: X% efficient
Sensors and controls	Typically: digital, but not smart	Achieve: X% smart Aspire: X% smart	Achieve: X% smart Aspire: X% smart	Achieve: X% smart Aspire: X% smart
Management systems	Typical: simple or programmable Exceptional: learning and fault detection	Achieve: X% smart Aspire: X% smart	Achieve: X% smart Aspire: X% smart	Achieve: X% smart Aspire: X% smart

Roadmap for Buildings and Construction

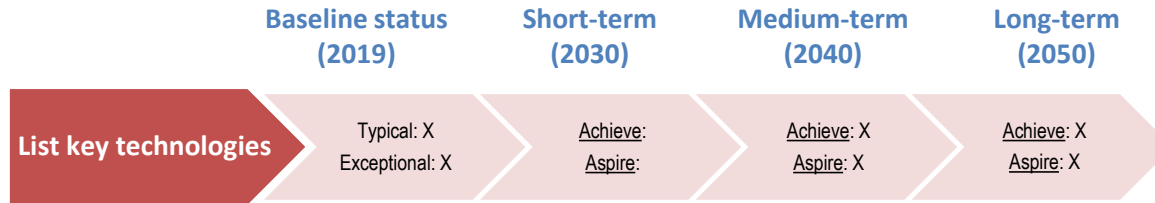
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Setting targets

- For the roadmap, we will set targets for the key technologies in this format:



- List the key barriers and enablers for achieving this timeline.

Coffee break

4. Policy gaps

- Let's try and think of all the **policies** that are relevant to building systems and operations in your regions.

To remove inefficient products off the market	To increase the demand for efficient products:
<ul style="list-style-type: none">- MEPS- Phase-out	<ul style="list-style-type: none">- Building certification- Information and awareness- Incentives- Bulk or EE procurement
To promote low energy consumption of buildings	To increase the efficiency of products
<ul style="list-style-type: none">- Mandatory disclosure- Benchmarking- Mandatory audits- Recommissioning	<ul style="list-style-type: none">- R&D- Incentives

- Some things to think about:
 - Mandatory or voluntary policies ? How stringent should they be? Does the resource and capacity for enforcement exist?

Setting targets

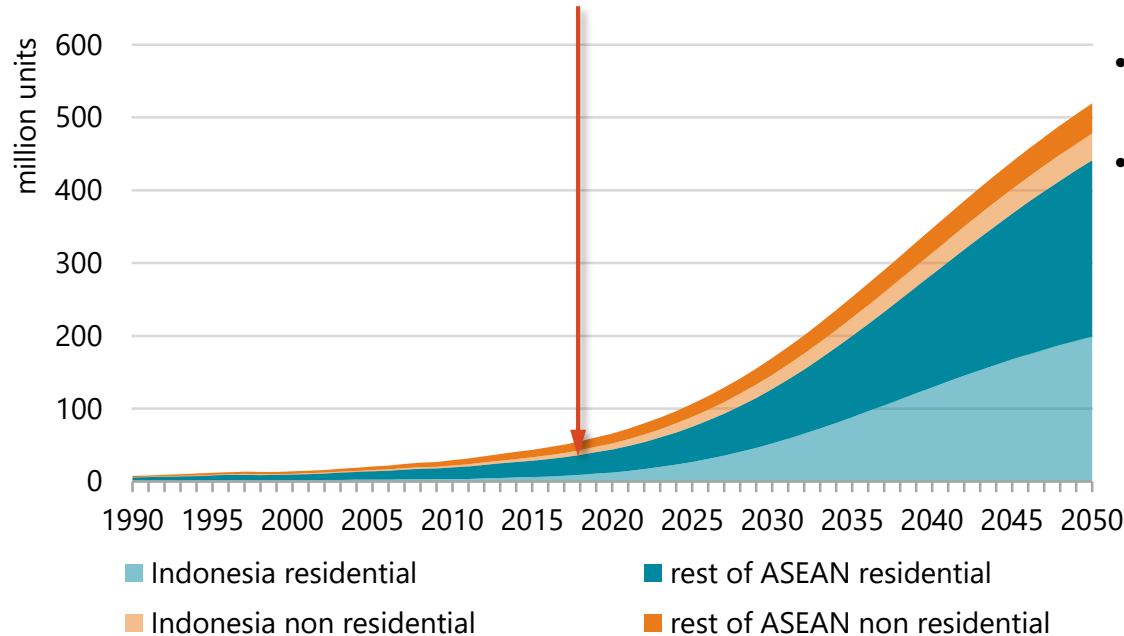
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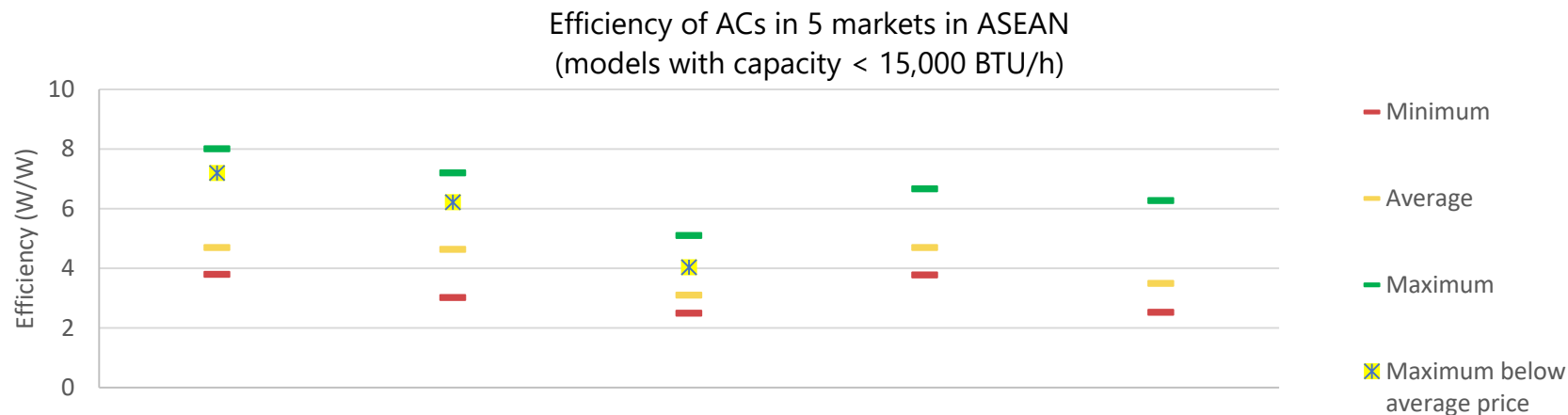
Policy refresher – MEPS for ACs

Stock of Air Conditioners in ASEAN



- Stock of ACs in ASEAN is growing, and could be 10 times as high as it is today in 2050.
- Almost all homes will have on average 2 ACs.
- Efficiency of small ACs needs to improve drastically to avoid catastrophic impacts on the grid capacity, security and air pollution.

Efficiency of ACs in ASEAN



- If ACs are already available that are much more efficient than the current MEPS, should the MEPS be revised?
- MEPS and labelling are important mechanisms to increase the average efficiency of ACs on the market.
- MEPS and labels should use appropriate metrics. EER, SEER or CSPF?

Policy refresher – mandatory disclosure

- **Example: mandatory disclosure for commercial buildings in Australia - NABERS**

Commercial Buildings using NABERS have reported energy efficiency improvements of almost 10%. In addition to that, surveys conducted in the program framework show that **lessors and sellers can obtain up to a 9% green premium on the building value**, depending on their score. Accordingly, buildings with BEEC have considerably increased their ratings in the first years of the program (2010 to 2014), but now have shown steady and even slightly decreasing scores due to: increased difficulty due to higher improvements marginal costs, and the reduction of the floor area threshold in 2017-2018, leading to more and smaller, poorer performing buildings participating in the program than the previous years.

- **Example: mandatory disclosure for large buildings in New York City – Energy Star**

By the beginning of 2020, the Department of Buildings will assign a grade to each building, which will have to be placed near each building entrance within 30 days after receiving the score. The benchmarking and disclosure program are part of the city's efforts to reach the goal of reducing greenhouse gas emissions by 80% in 2050.

Setting targets

- For the roadmaps, we will set targets for the key technologies in this format:



- List the key barriers and enablers for achieving this timeline.
- Some things to think about:
 - Mandatory or voluntary policies ? How stringent should they be? Does the resource and capacity exist?

5. The “enablers”

- Some “enabling” strategies

Capacity Building

- Government training
- Professional training
- Educational training
- Awareness and information
- Institutional coordination

Finance

- Urban development funds
- Infrastructure funds
- Dedicated credit lines
- Guarantees
- Green bonds
- Preferential tax, grants and rebates
- EPCs
- Procurement purchase or lease
- On-bill/ tax repayment

Multiple benefits

- Emissions savings, air quality
- Energy savings, energy security, energy prices
- Economic, productivity, employment, asset value
- Poverty alleviation, health and wellbeing, safety and security

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Policies

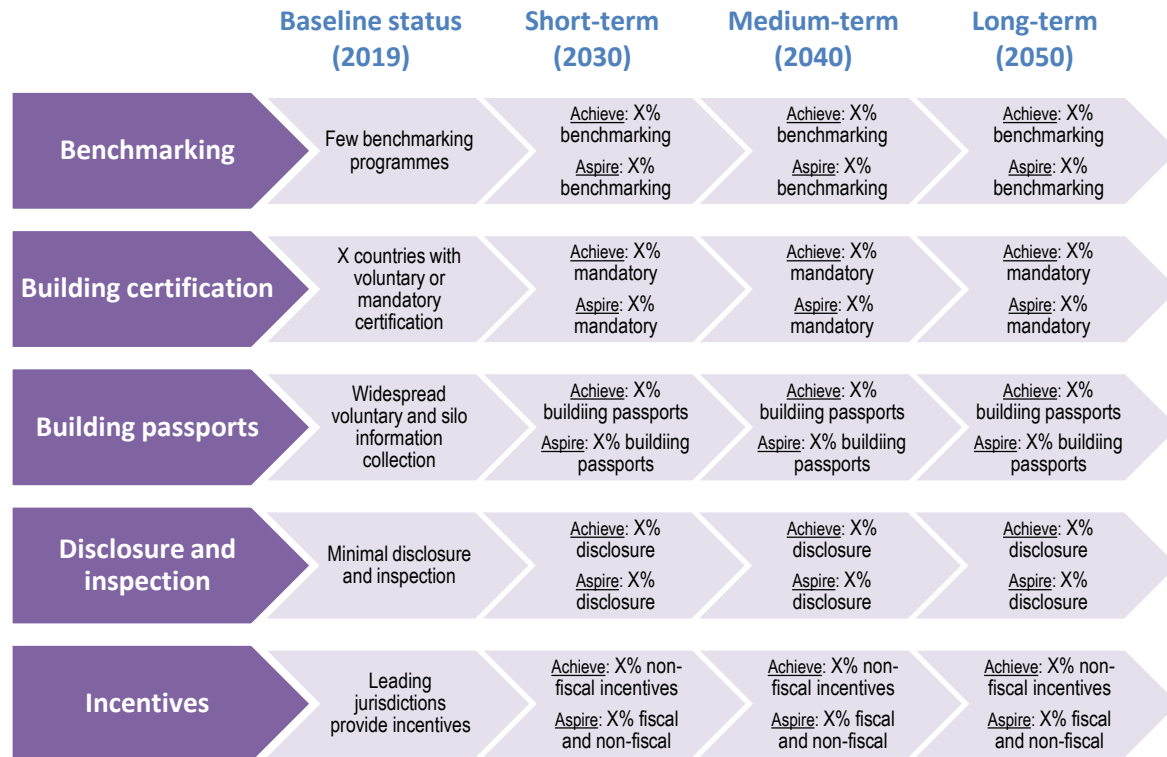
	Baseline status (2019)	Short-term (2030)	Medium-term (2040)	Long-term (2050)
Minimum performance standards	X countries have at least one minimum performance standard	<u>Achieve</u> : X% mandatory <u>Aspire</u> : X% mandatory	<u>Achieve</u> : X% mandatory <u>Aspire</u> : X% mandatory	<u>Achieve</u> : X% mandatory <u>Aspire</u> : X% mandatory
Information and awareness	Minimal consumer awareness	<u>Achieve</u> : X% labels & education <u>Aspire</u> : X% awareness	<u>Achieve</u> : X% labels & education <u>Aspire</u> : X% awareness	<u>Achieve</u> : X% labels & education <u>Aspire</u> : X% awareness
Research and development	Mission Innovation goal of doubling investment	<u>Achieve</u> : X% more investment <u>Aspire</u> : X% more investment	<u>Achieve</u> : X% more investment <u>Aspire</u> : X% more investment	<u>Achieve</u> : X% more investment <u>Aspire</u> : X% more investment
Circular economy	Minimal circular economy decisions	<u>Achieve</u> : X% plan circular economy <u>Aspire</u> : X% plan circular economy	<u>Achieve</u> : X% plan circular economy <u>Aspire</u> : X% plan circular economy	<u>Achieve</u> : X% plan circular economy <u>Aspire</u> : X% plan circular economy
Procurement and phase out	Leading jurisdictions procure sustainably	<u>Achieve</u> : X% green procurement <u>Aspire</u> : X% green procurement	<u>Achieve</u> : X% green procurement <u>Aspire</u> : X% green procurement	<u>Achieve</u> : X% green procurement <u>Aspire</u> : X% green procurement
Incentives	Leading jurisdictions provide incentives	<u>Achieve</u> : X% non-fiscal incentives <u>Aspire</u> : X% fiscal and non-fiscal	<u>Achieve</u> : X% non-fiscal incentives <u>Aspire</u> : X% fiscal and non-fiscal	<u>Achieve</u> : X% non-fiscal incentives <u>Aspire</u> : X% fiscal and non-fiscal

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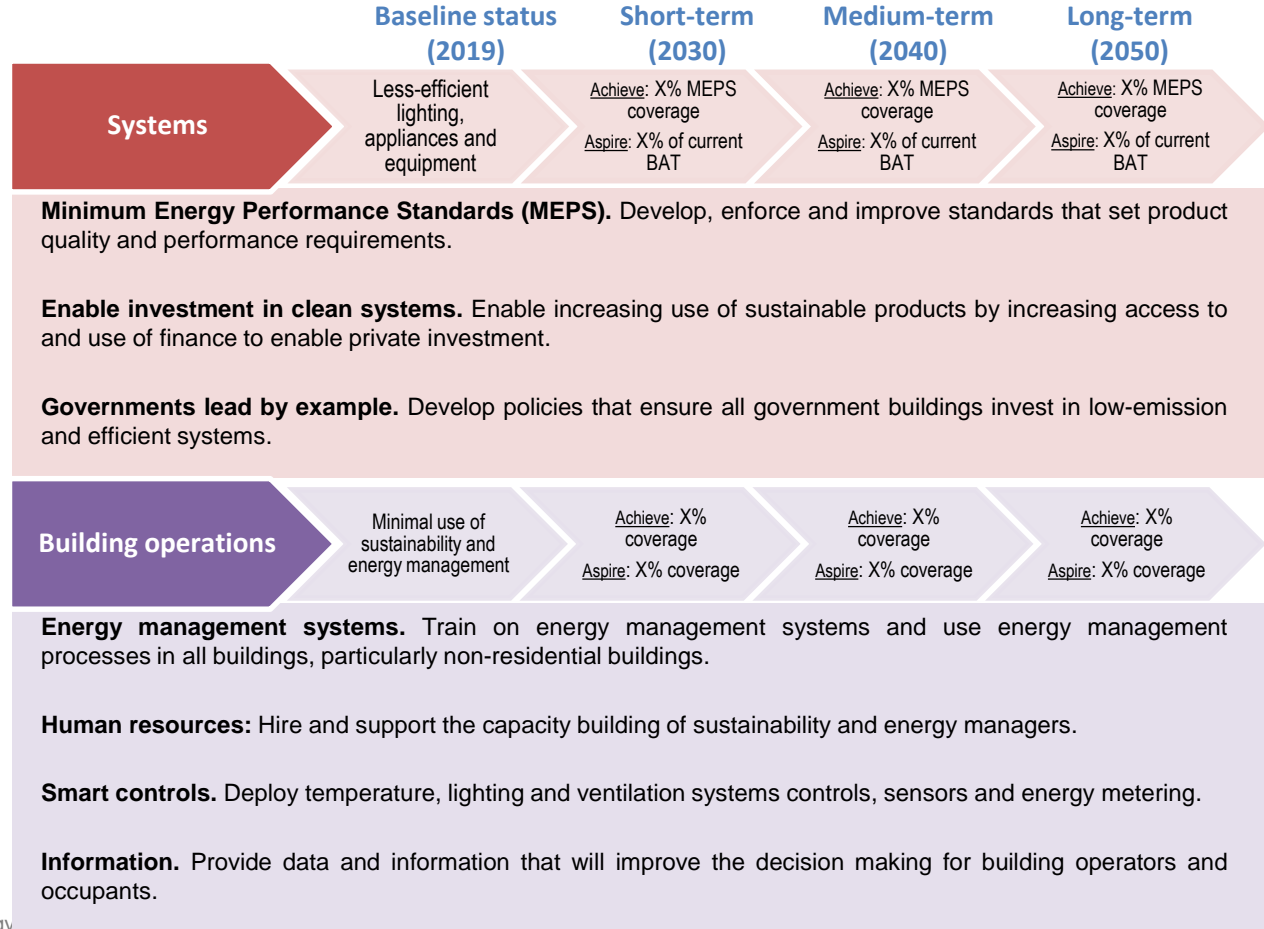
Policies



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Thank you!

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