



2026 EDITION

Sustainable Materials and Energy

A new paradigm for one blue planet

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2022 then, 2026 now

When this talk was first given in Jakarta, the world was coming out of an energy price shock. Here is what has moved since.

	2022 then	2026 now	Source
People on the planet	8.0 billion	8.2 billion	<i>UN, 2022 and 2024</i>
New solar each year	about 240 GW	664 GW	<i>SolarPower Europe, 2022 and 2025</i>
Battery pack price	US\$151/kWh	US\$108/kWh	<i>BloombergNEF, 2022 and 2025</i>
Fossil CO ₂ emissions	rising	38.1 Gt, a record	<i>Global Carbon Budget 2025</i>
Share of the economy that is circular	8.6%	6.9%	<i>Circularity Gap Report 2022 and 2025</i>

Solar and batteries moved faster than anyone forecast. Emissions and material use did not turn.



PART 1

Sustainability

Precepts, definitions and concepts

Sustainability is a promise about time

- Do we know how long the universe will last, and whether it is sustainable?
- Do we know how long time itself will last?
- So we need a working definition, one that fits a human time scale.

Brundtland also set two kinds of fairness at the centre: between generations, and between people alive today.

“

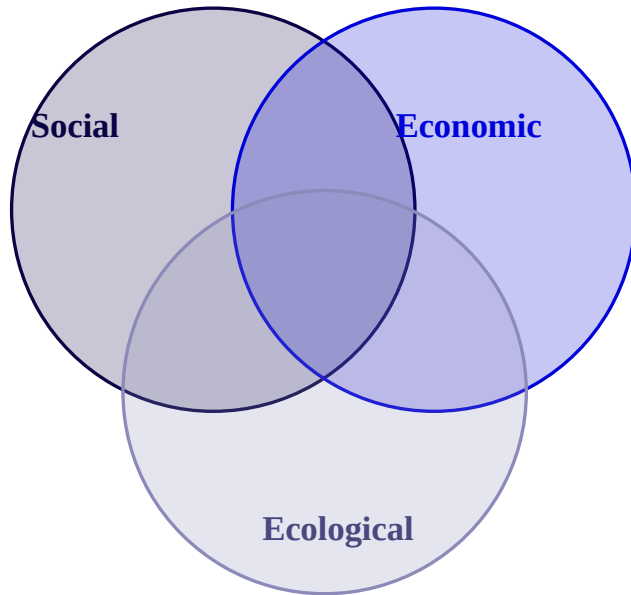
Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

United Nations Brundtland Commission, Our Common Future, 1987

Source: World Commission on Environment and Development, Our Common Future (1987).

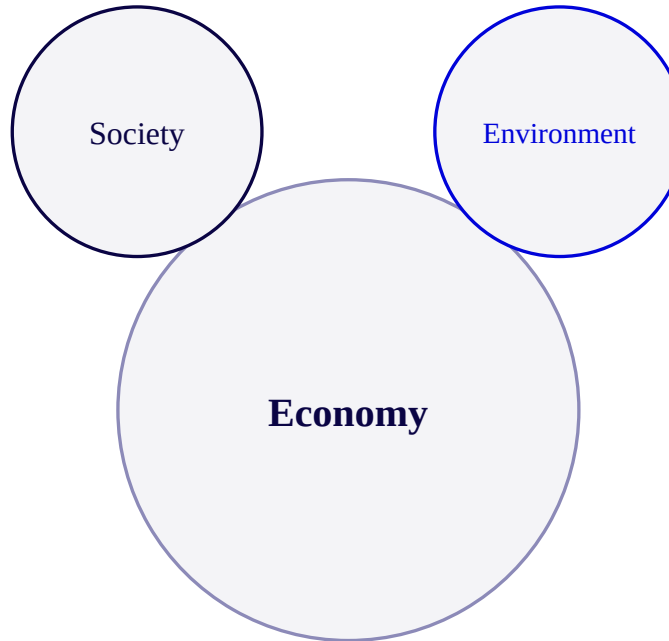


Society lives inside the environment



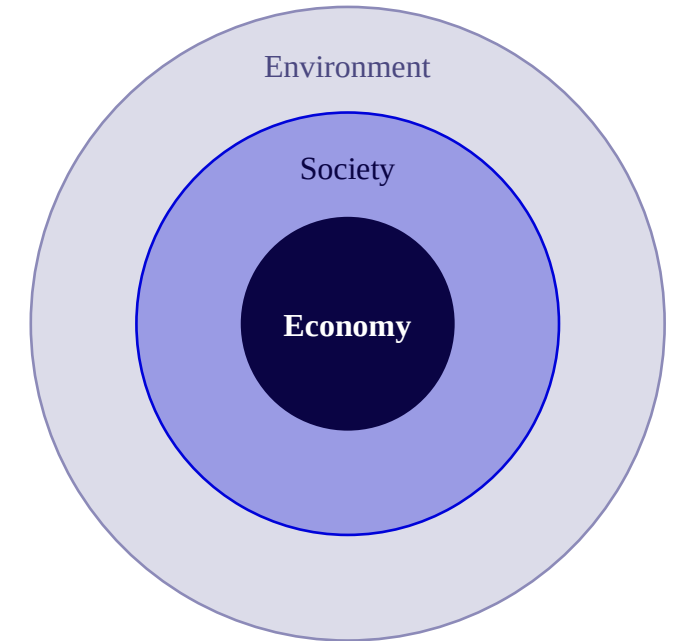
Three circles

Equal and overlapping. Easy to draw, but it suggests nature is one interest among three.



Mickey Mouse

The economy is the face, the rest are ears. This is how most decisions are still made.



Bullseye

The economy sits inside society, and both sit inside the environment. This is the physical truth.

Two laws set the limits

1 First law: nothing is created or destroyed

Energy only changes form. Matter works the same way: atoms used in a product come back in some form at its end of life, as waste, emissions or a resource. Nothing goes away.

2 Second law: every conversion loses quality

Each time energy changes form, some becomes low-grade heat that can do less work. Materials degrade the same way when they are mixed, diluted or downcycled. Recovery always costs energy.

Design consequence: keep energy at high quality for as long as possible, and keep materials pure and separable.

Three worldviews behind every decision

1

Anthropocentric

People are the centre. Nature matters for what it does for us. Most economics and planning still works from here.

2

Biocentric

Every living thing has value in itself, whether or not it is useful to people.

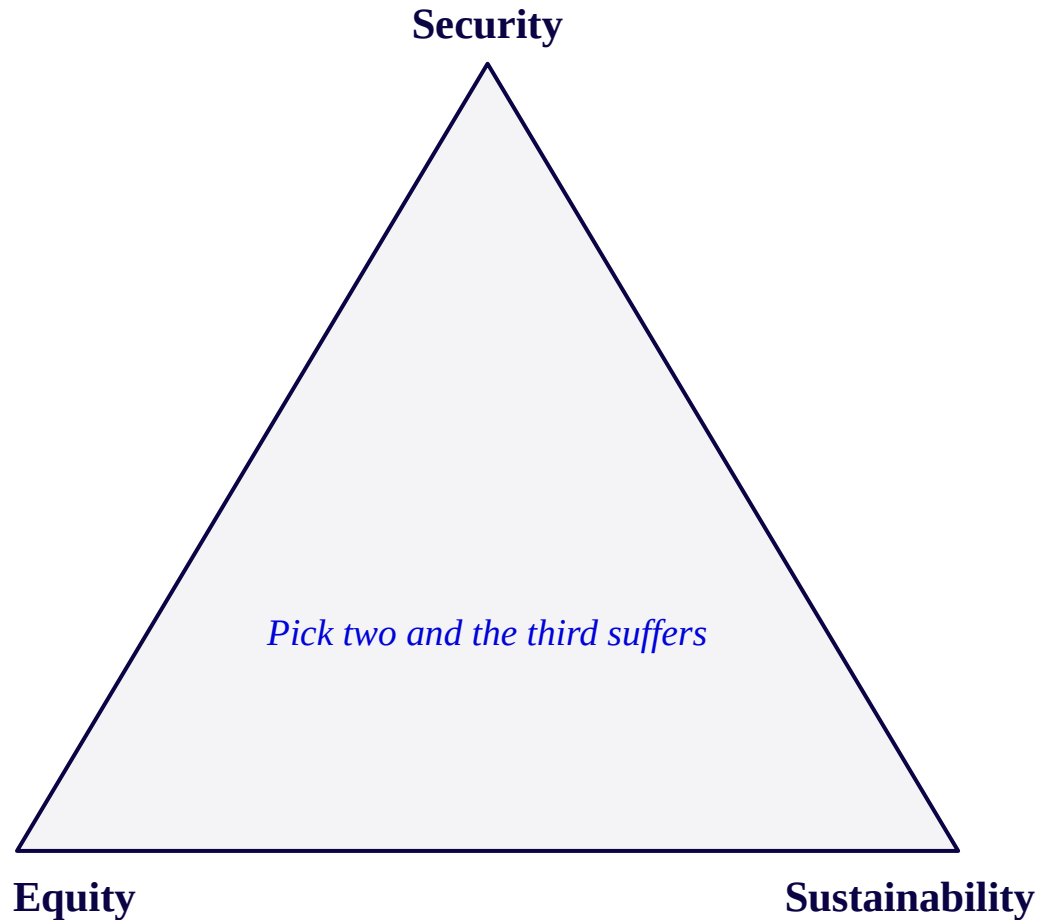
3

Ecocentric

The whole system matters: species, soils, rivers and climate together. The bullseye model follows from this view.

Engineers rarely say which view they hold. The choice still shows up in what gets counted and what is left out.

The energy trilemma



Equity

Energy people can afford, wherever they live. Asia's mandates for biodiesel and ethanol are partly about price and jobs at home.

Security

Supply that does not stop. Since 2022 most countries have counted local solar, storage and biofuels as security, not only as climate policy.

Sustainability

Supply the planet can carry. Fossil CO₂ reached a record 38.1 Gt in 2025.

Source: Global Carbon Budget 2025 (fossil CO₂); World Energy Council energy trilemma framework.

PART 2

The scale of the issue

Energy, emissions, materials and people, as of 2026

Electricity is growing more than twice as fast as energy

1.3%

growth in world energy
demand in 2025

about 3%

growth in world electricity
demand

33.8%

of world electricity came from
renewables, the first year
above one third

636 TWh

more solar power than in
2024, a record rise of about
30%

- Solar supplied more than a quarter of the growth in all energy supply. Renewables and nuclear met nearly 60% of it.
- Fossil power generation stopped growing in 2025, the first year without an increase since 2020.
- More than 20 million electric cars were sold, about one new car in four.

Source: IEA Global Energy Review 2026 (2025 data); Ember Global Electricity Review 2026.



The 1.5 °C budget is about four years of today's emissions

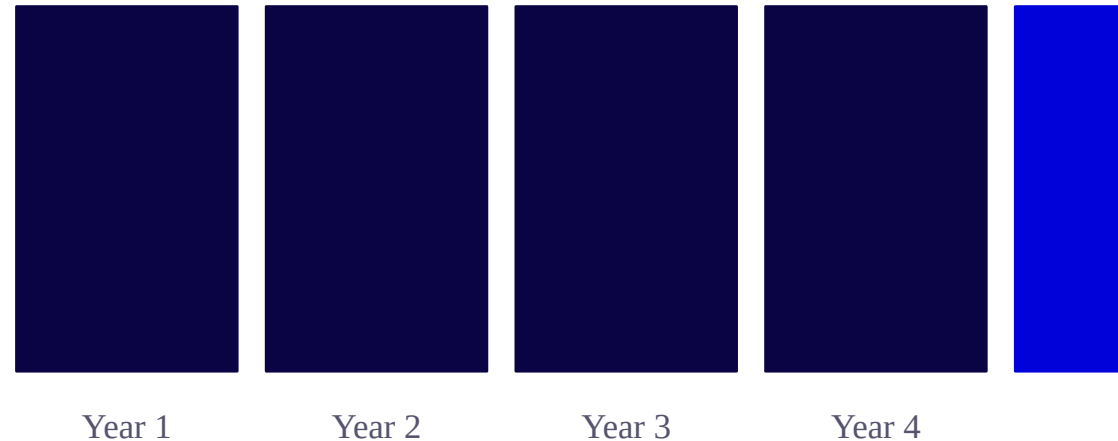
38.1 Gt

fossil CO₂ in 2025, a record, 1.1% above 2024

170 Gt

CO₂ left in the budget for a 50% chance of holding warming to 1.5 °C

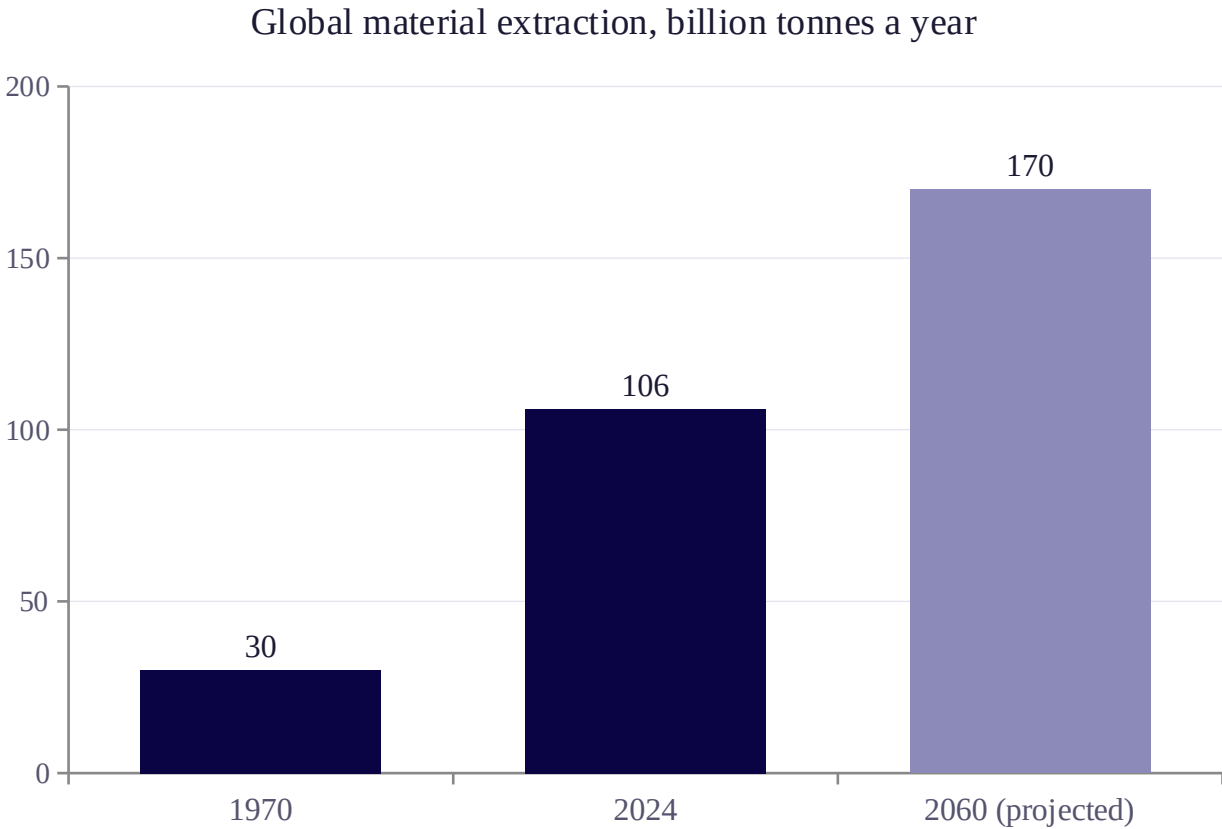
The remaining budget, in years of 2025 emissions



Land-use change adds about 4 Gt a year more. The budget is shrinking faster than new clean supply is growing.

Source: Global Carbon Project, Global Carbon Budget 2025 (November 2025).

We now dig up 106 billion tonnes a year



Over 60%

of warming emissions come from extracting and processing resources

90%

of land-related biodiversity loss and water stress comes from biomass extraction and processing

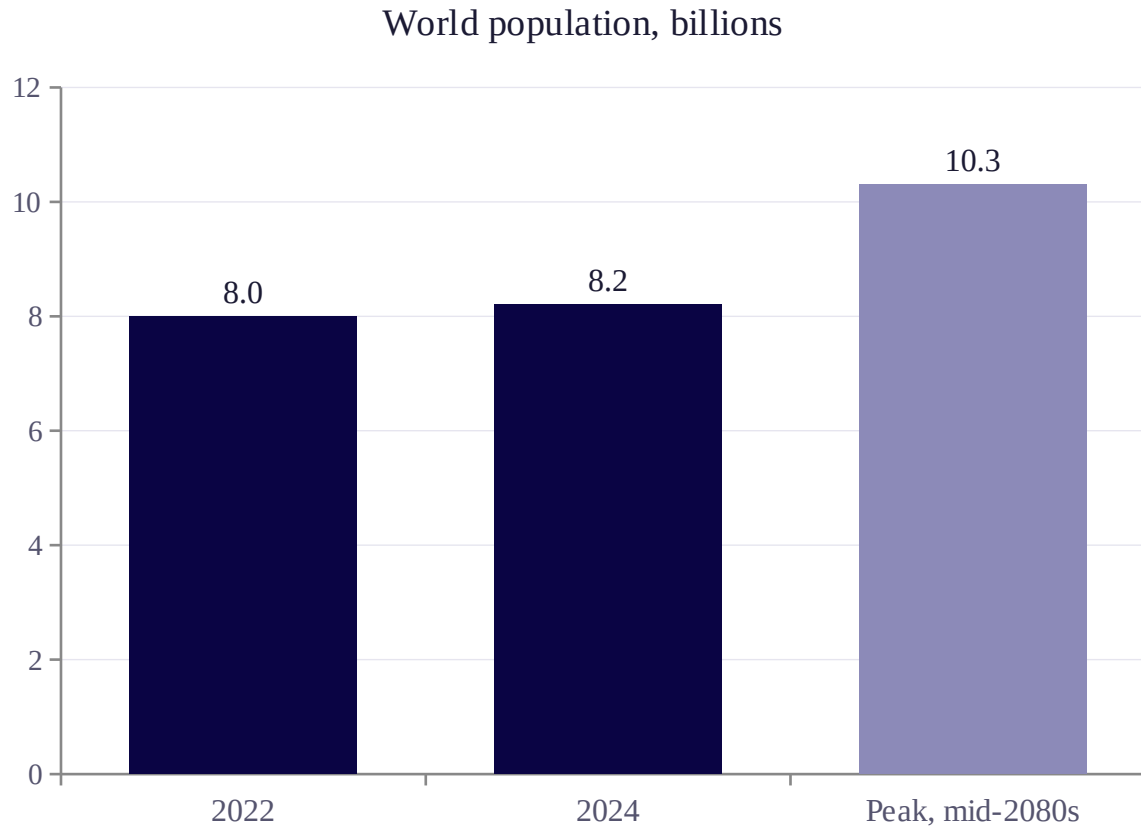
6.9%

of the materials the world uses come back round. It was 8.6% in 2022

Source: UNEP International Resource Panel, Global Resources Outlook 2024 (2060 value: 60% above 2024); Circularity Gap Report 2022 and 2025.



8.2 billion people, peaking near 10.3 billion



- The UN now expects the world's population to peak in the mid-2080s, earlier and lower than it expected ten years ago.
- Material use is growing faster than population. Each person uses more each year, mostly in the richest countries.
- Rich countries use about six times more materials per person than low-income ones.
- So the question is less how many of us there are, and more how we build, move and eat.

Source: UN World Population Prospects 2024; UNEP Global Resources Outlook 2024.



PART 3

Energy, the electric way

Hydrogen, solar, storage and biofuels

Every conversion step costs energy

Direct electricity



Fewest steps. Most of the power reaches the wheels or the process.

Hydrogen



Several steps, each with losses. Worth it where electricity cannot go directly.

E-fuels



Longest chain. Best kept for aircraft, ships and chemicals that need molecules.

The second law again: use electricity directly where you can, and save molecules for the jobs only molecules can do.

Almost 100 Mt used, under 1% of it low-emission

≈100 Mt

of hydrogen used worldwide in 2024, mostly made from natural gas and coal

<1%

of that demand was met by low-emission hydrogen

Where it is used today

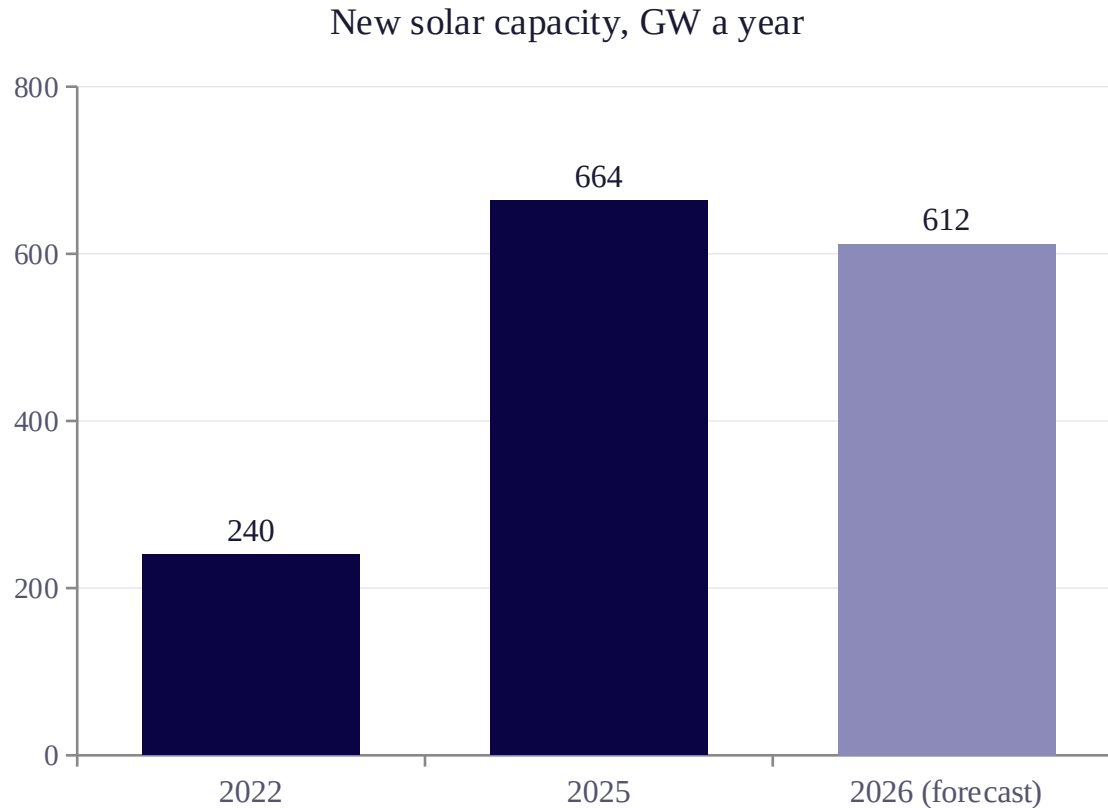
- Oil refining
- Ammonia for fertiliser
- Methanol
- Direct reduced iron for steel
- New uses, such as biofuel upgrading and synthetic fuels, are under 1%

NAMINDO MOONSHOT

Hydrogen storage

Green hydrogen has to be stored between when it is made and when it is used. Storage cost and safety decide whether it pays. We are working on a new way to store it at scale. An Australian patent application is filed.

The world added 664 GW of solar in 2025



- The world's solar fleet passed 3 TW in early 2026. It tripled in about four years.
- China installed 382 GW in 2025, about 57% of the world total.
- 2026 is forecast to be the first year in over 20 years with fewer installations than the year before.

NAMINDO FIELD PROGRAMME

More energy from bifacial solar farms. The rear face of a bifacial panel depends on how much light the ground reflects. We are developing ways to raise that reflectance across a farm, with an Australian patent application filed and a field trial planned.

Source: SolarPower Europe, Global Market Outlook 2026–2030 (2022 value about 240 GW, from its 2023 outlook).

Not only panels: the sun also makes heat and cold

1

Concentrated solar power

Mirrors focus sunlight to heat a fluid, often molten salt. The heat can be stored for hours and turned into power after sunset.

2

Solar heat for industry

Food, dairy, textiles and chemicals need large amounts of low and medium temperature heat. Sun can supply much of it directly.

3

Solar cooling

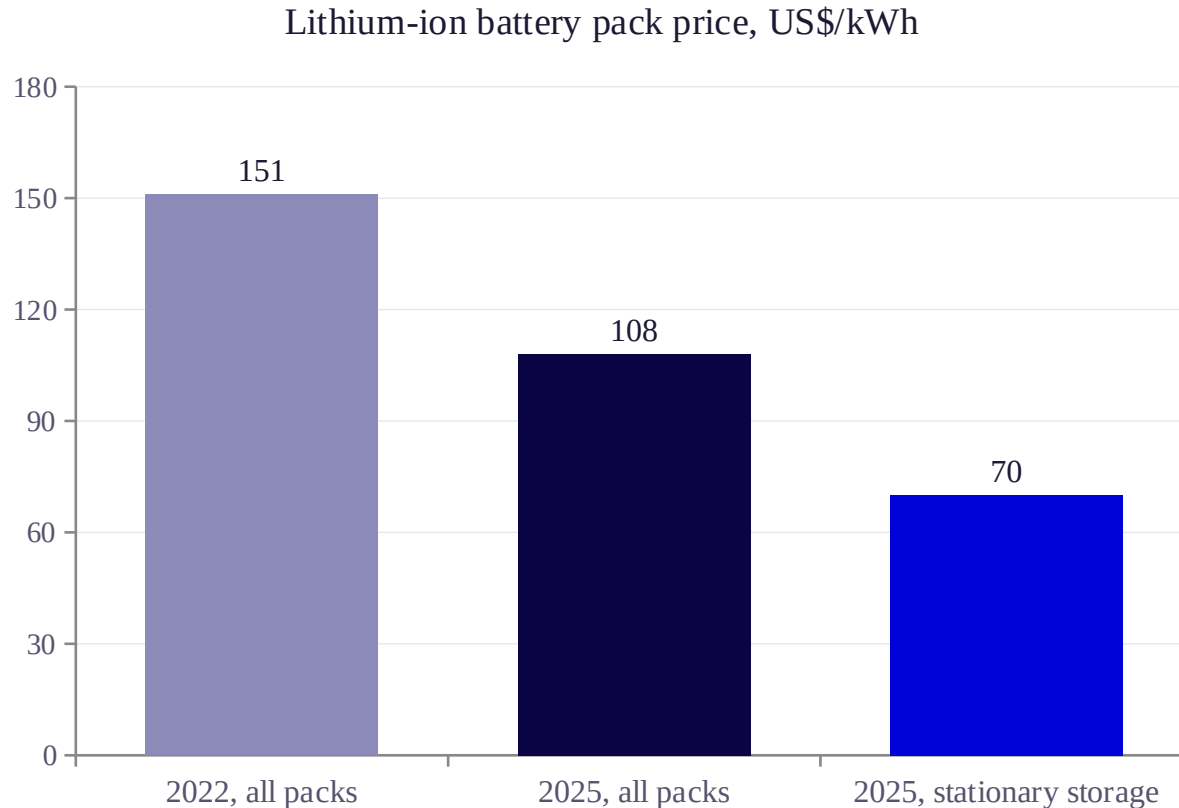
In hot countries cooling demand peaks when the sun is strongest. Heat-driven chillers can run on solar heat.

Heat is about half of the energy the world uses. It is the next big job for renewables after power.

Source: IEA, Renewables 2024 (heat share of final energy).



Batteries got cheap enough to firm solar



110 GW

of battery storage added worldwide in 2025, the fastest-growing power technology

-45%

fall in stationary storage pack prices in one year, to US\$70/kWh

Batteries cover hours. Thermal stores, pumped hydro and hydrogen are still needed for days and seasons.

Source: BloombergNEF battery price surveys 2022 and 2025; IEA Global Energy Review 2026.

Asia's mandates are now law, not plans

INDONESIA

B50

Mandatory 50% biodiesel blend from 1 July 2026, at all fuel stations by October 2026. Up from B40.

INDIA

E20

20% ethanol in petrol reached in 2025, five years ahead of the 2030 target.

SINGAPORE

SAF levy

The world's first SAF levy, collected on tickets sold from 1 October 2026 for flights from 1 January 2027.

Palm oil gives about 10% oil and 90% biomass. Using the whole fruit, including mill effluent and empty fruit bunches for biogas, is where the next gains are.

Namindo works as owner's engineer on biodiesel, ethanol, biogas and SAF projects in Indonesia, Malaysia, India and Australia.

Source: Antara (Indonesia B50, 2026); Government of India (E20, 2025); CAAS Singapore (SAF levy).

PART 4

Balance in design

From economics alone to cradle to cradle

From cost, to life cycle, to cradle to cradle

PAST

Only economics

Lowest first cost wins. Waste, emissions and end of life are someone else's problem.



PRESENT

Cradle to grave

Life-cycle assessment counts energy, water and emissions from extraction to disposal.



FUTURE

Cradle to cradle

Every material has a planned next life. Footprints are counted through reuse and regeneration.

With only 6.9% of materials coming back round today, most of the world is still designing for the grave.



Twelve principles of sustainable energy and material design

1 Inherent rather than circumstantial

Make inputs as benign as possible from the start.

2 Prevention rather than treatment

Avoid waste rather than treat it later.

3 Design for separation

Make parts and materials easy to take apart.

4 Maximise efficiency

Use mass, energy, space and time well.

5 Output-pulled, not input-pushed

Let demand drive what is made.

6 Conserve complexity

Treat built-in complexity as an investment.

7 Durability, not immortality

Design a useful life, then a safe end.

8 Meet need, not excess

Do not over-design for capacity you will not use.

9 Minimise material diversity

Fewer materials make reuse easier.

10 Integrate material and energy flows

Use what the site already has.

11 Design for commercial afterlife

Plan for parts to be reused.

12 Renewable rather than depleting

Prefer inputs that grow back.

Source: Adapted from Anastas and Zimmerman, *Design through the twelve principles of green engineering* (2003).



Start benign, prevent waste

1 Inherent rather than circumstantial

Make inputs as benign as possible from the start.

CASE STUDY

Design for the place

A house in Melbourne with full double-glazed windows facing north to take the winter sun, insulation on the south side and cross ventilation from east to west. It heats and cools itself before any machine is switched on.

2 Prevention rather than treatment

Avoid waste rather than treat it later.

CASE STUDY

Colour that is part of the material

Glazed roof tiles, natural brick and oiled timber carry their own colour. Nothing needs repainting, so no solvent paint enters the waste stream.



Make it separable, make it efficient

3 Design for separation

Make parts and materials easy to take apart.

CASE STUDY

Joins you can undo

Hardwood dowels in place of metal nails and glue. The timber stays 100% recyclable because nothing has to be separated out.

4 Maximise efficiency

Use mass, energy, space and time well.

CASE STUDY

Heat integration first

Match hot streams that need cooling with cold streams that need heating before buying steam or chilled water. In process plants this often cuts outside utility demand by a large share. Process intensification, such as the sonic reactors Namindo is developing, aims to do the same job in smaller equipment.

Build to demand, keep complexity useful

5 Output-pulled, not input-pushed

Let demand drive what is made.

CASE STUDY

Build to demand

Homes and plants sized and phased to what users actually need, so the cost of building stays low and the operating energy stays low.

6 Conserve complexity

Treat built-in complexity as an investment.

CASE STUDY

Fewer kinds of parts

A prefabricated timber house redesigned from 15 types of fastener down to 5. It is quicker to build, and easier to take apart and recycle.

Plan the end of life, size to the need

7

Durability, not immortality

Design a useful life, then a safe end.

CASE STUDY

The CFC lesson

CFCs were stable, safe and cheap. That stability let them reach the upper atmosphere and destroy ozone. A material that outlives its purpose becomes a problem.

8

Meet need, not excess

Do not over-design for capacity you will not use.

CASE STUDY

The modular house

Start with four bedrooms for a growing family. Take two away when the nest is empty. Space follows the need.

Fewer materials, joined-up flows

9 Minimise material diversity

Fewer materials make reuse easier.

CASE STUDY

Timber and recyclable composites

Wood and recyclable plastic composites can serve as floor, frame and wall. Fewer materials mean simpler recycling at end of life.

10 Integrate material and energy flows

Use what the site already has.

CASE STUDY

Waste to resource on site

Brown coal ash from Victoria's Latrobe Valley made into bricks near where it is produced. In the same spirit, dairy and food waste can become biomethane at the factory gate, which Namindo is studying for a dairy site in Victoria.

Give it a second life, use what grows back

11 Design for commercial afterlife

Plan for parts to be reused.

CASE STUDY

Plastic lumber

Used plastic packaging remade into boards and posts, and wood chaff made into MDF board. The molecules get a second life.

12 Renewable rather than depleting

Prefer inputs that grow back.

CASE STUDY

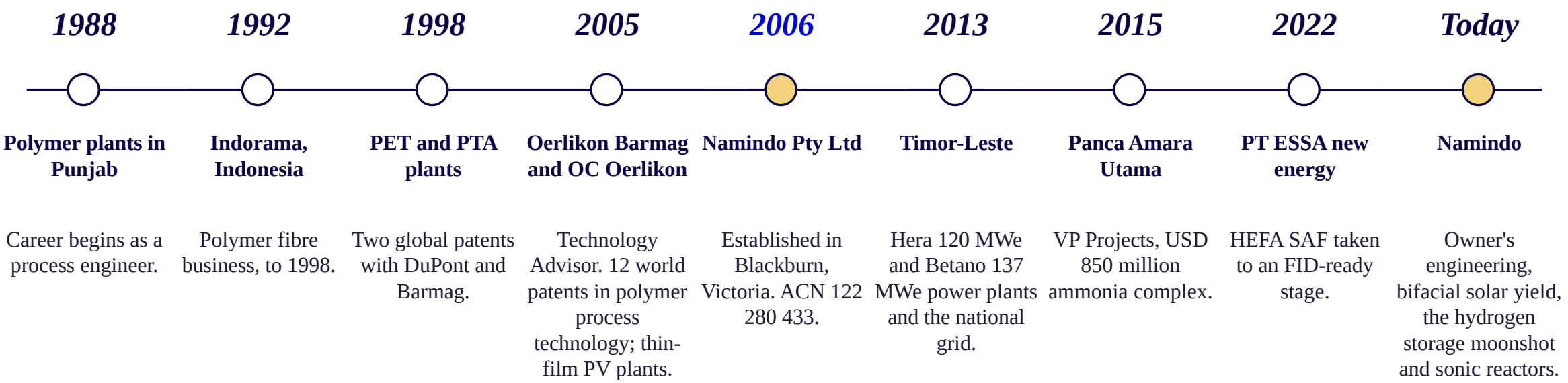
Plantation timber and reuse

Houses built from plantation timber, and old factories converted to homes. The inputs grow back, and the buildings get a second use.



Namindo since 2006

Thirty-eight years from polymer lines to power, ammonia and sustainable fuels. Each stage feeds the next.



THE TAKEAWAY

Design it right at the start

Most of a product's footprint is fixed on the drawing board. Electrify where you can, keep materials pure and separable, and plan every material's next life before you build.

Sources for the 2026 figures

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Thank you

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