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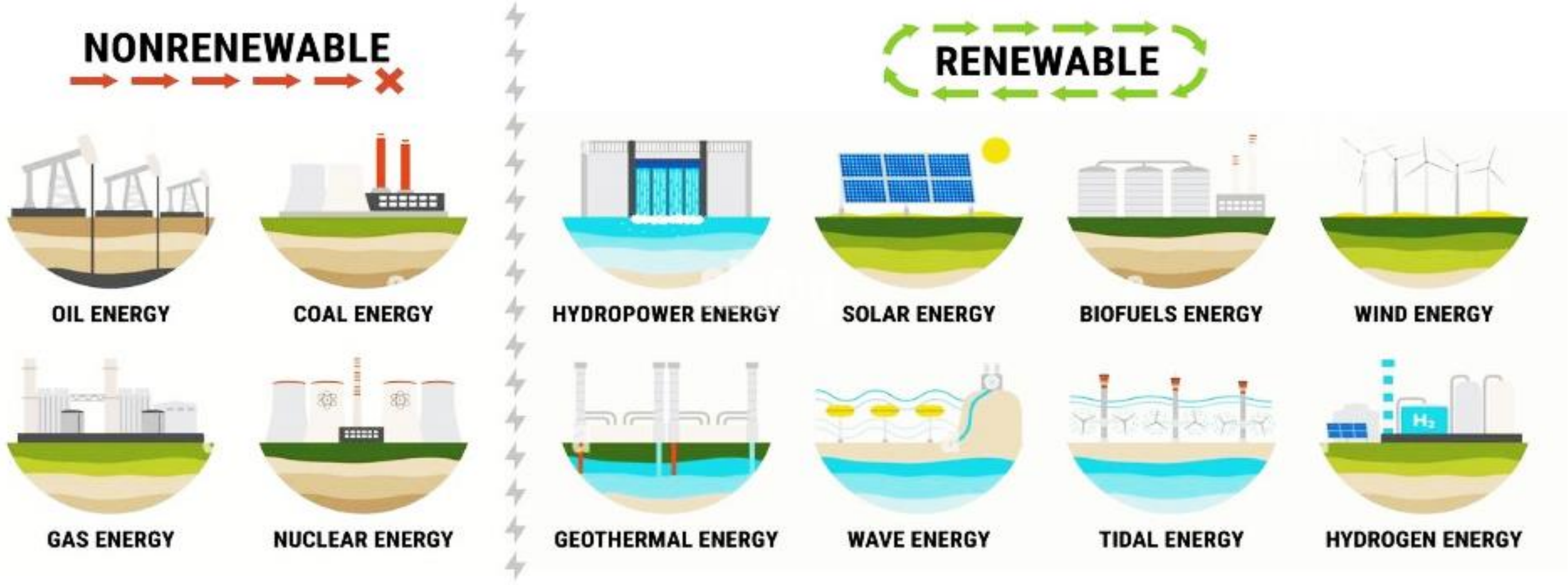
BIOMASS AND BIOENERGY



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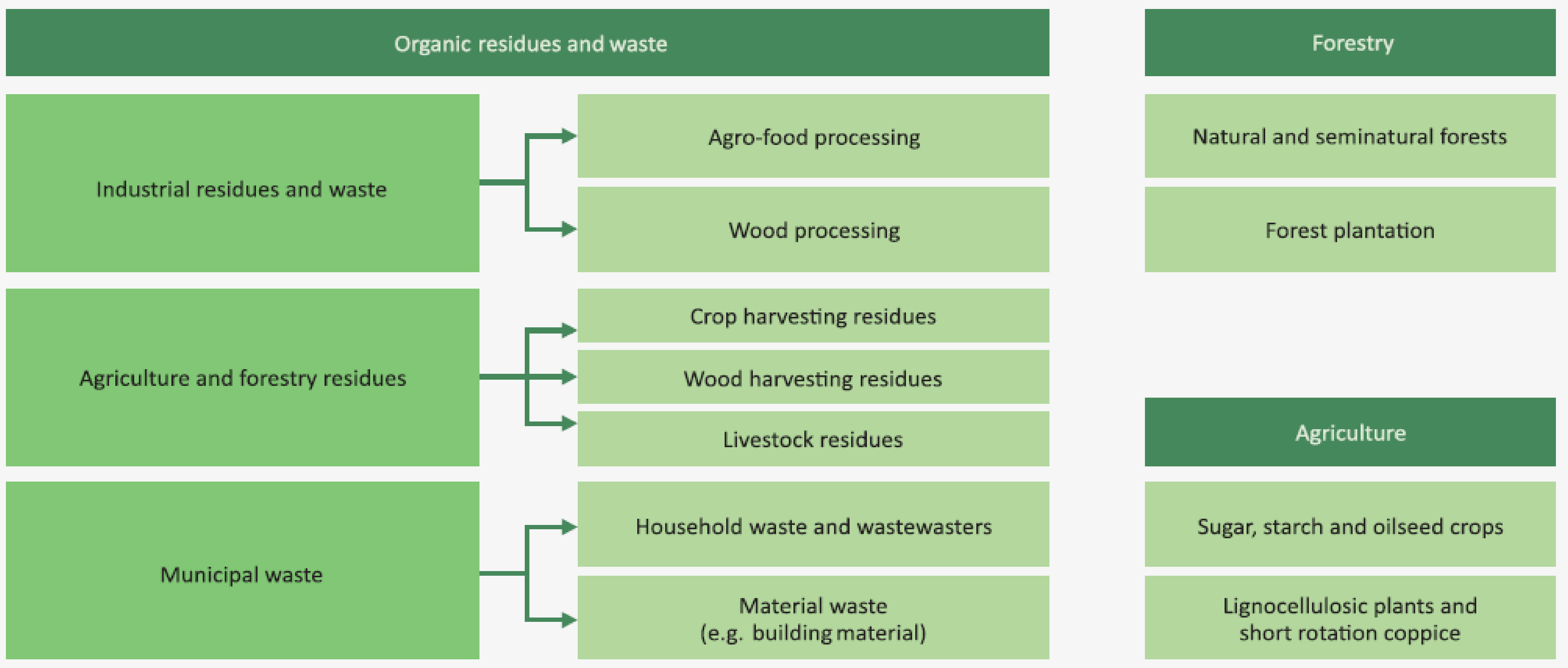
MULTIPLE SOURCES OF BIOMASS



HOW TO DEAL WITH SUSTAINABILITY RISKS

Precautions needed

- to avoid that nature conservation areas, rain forests, … (areas with high biodiversity and carbon storage) are used
- to avoid that biomass use leads to deforestation or a reduction of carbon stored (& carbon uptake capacity) in soils & forests
- to avoid competition with food and bio-material production
- to achieve high GHG reduction compared to fossil fuels (e.g. coal powered ethanol facilities in the US had negative GHG balance)
- to make sure that bio-energy / biofuels are creating opportunities for local communities (socio-economic conditions), not only multinationals (avoid land-grabbing)
- to consider indirect effects (e.g. displacements)

⇒ Worldwide agreements

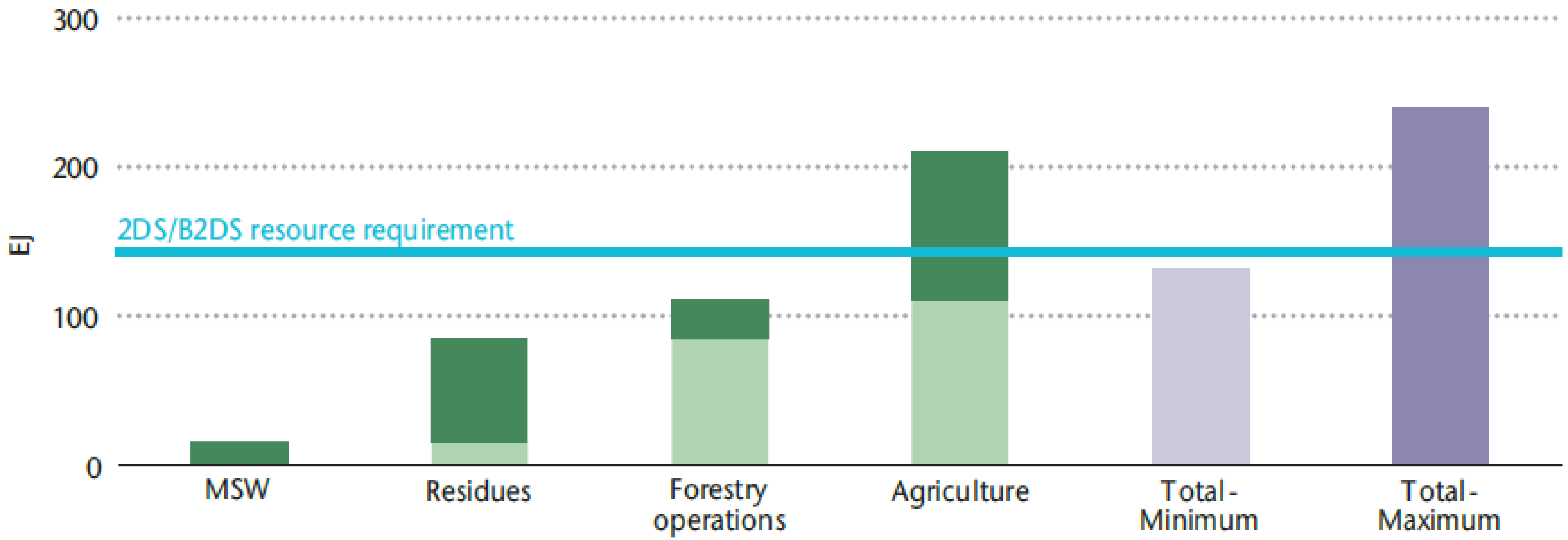
⇒ Sustainability requirements (e.g. EU Renewable Energy Directive)

⇒ Certification

SUSTAINABLE BIOMASS POTENTIALS

Bioenergy Resource	Conditions for Sustainability	Potential 2060 (EJ)
Municipal wastes	Taking account of the waste management hierarchy, which favours waste prevention and minimisation and recycling and evolution of waste management systems in economies as they develop.	10-15
Agricultural wastes and residues and processing residues from wood and agro- industry	Respecting the need to reserve some of the available resource for animal feed and to leave sufficient residues in the field for soil protection, and consistent with other uses	46-95
Wood harvesting residues and by-products	Used within the context of a sustainable forestry plan which takes carbon aspects fully into account, along with measures to maintain other forest characteristics including biodiversity	15-30
Agriculture	Produced on land in ways which do not threaten food availability and whose use leads to low land use change emissions, and subject to a positive assessment on other sustainability indicators such as biodiversity and water availability and quality. Crop or forestry production on degraded and derelict land linked to attempts to afforest, reforest or otherwise improve the quality of these areas.	60-100

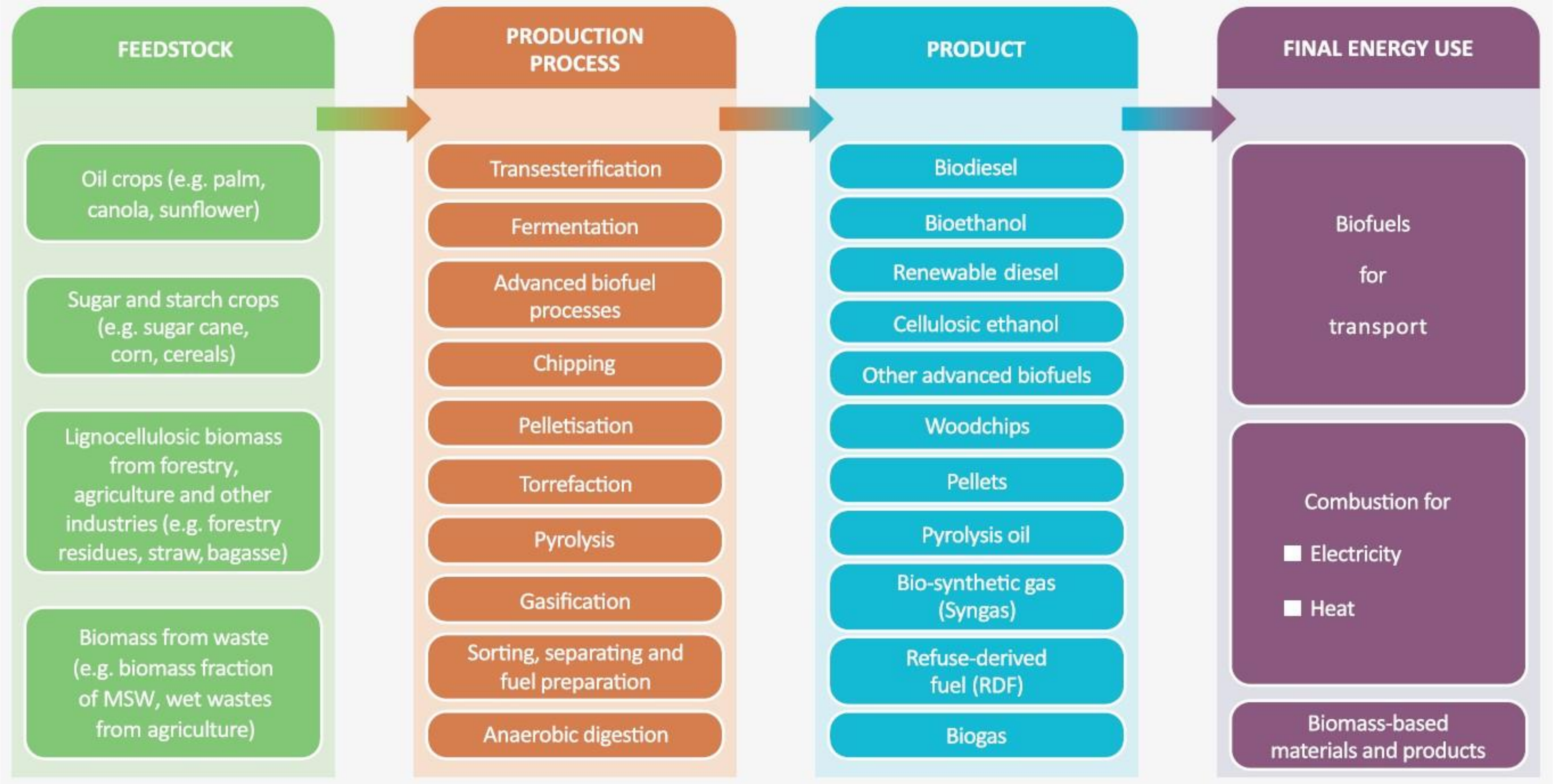
SUSTAINABLE BIOMASS POTENTIALS



Deployment will need wastes, residues, forestry and energy crops

- Produced in line with sustainable resource management, forestry and agricultural practice
- Produced with minimized impacts on land use change emissions by co-production with food, use of under-productive land, improved production
- Supported by general effort to improve agricultural productivity and efficiency

BIOENERGY PATHWAYS

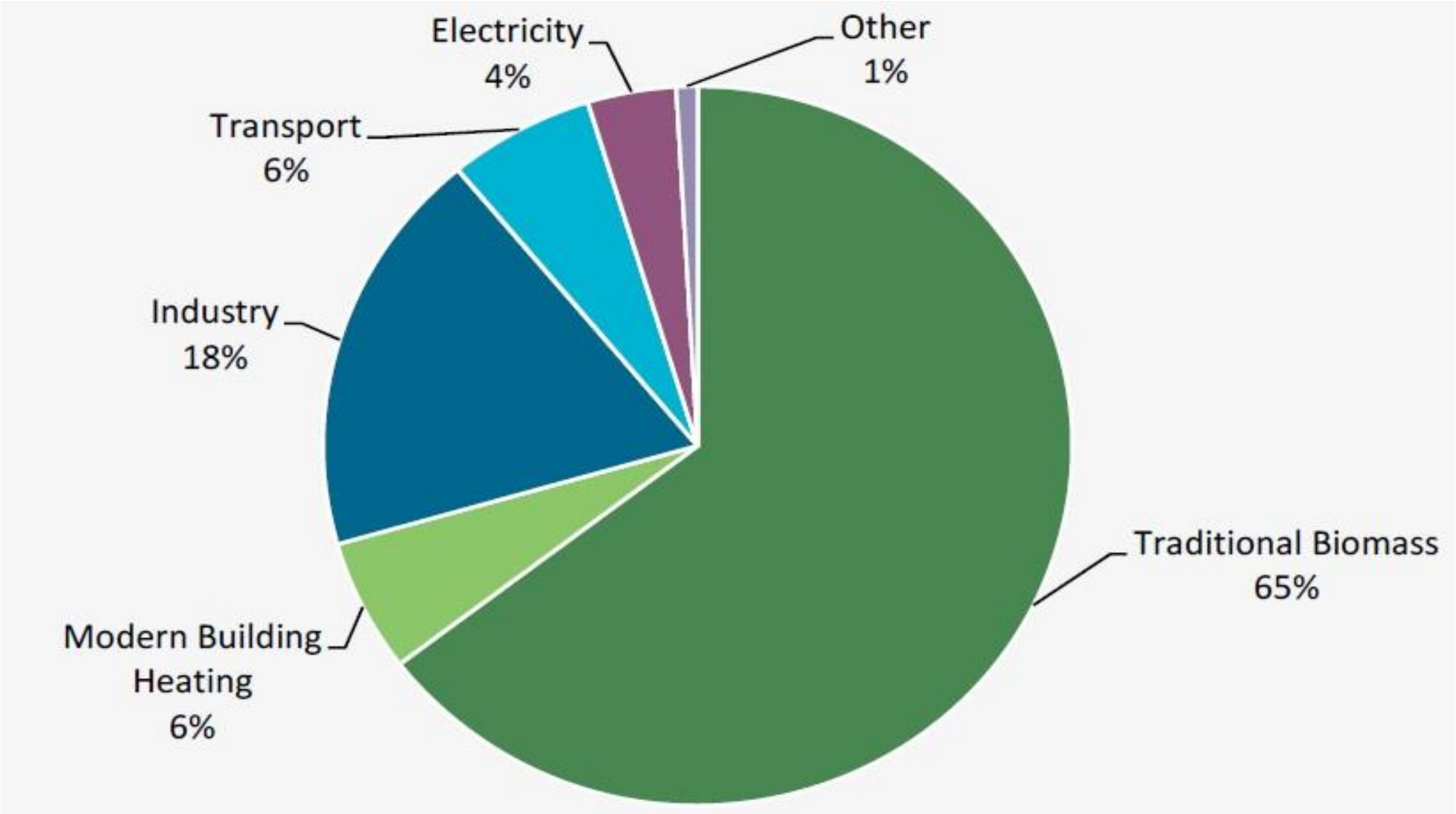


TRADITIONAL BIOENERGY

- Considered as unsustainable application of biomass
- Biomass used in open fires or basic stoves at very low efficiency
  e.g. 5-15%, for cooking, hot water and residential heating
- High particulate matter (PM) emissions and other air pollutants
  => severe health issues
- Local biomass sourcing can exceed sustainable supply
- Current estimates indicate that over 2.5 billion people still rely on the traditional use of biomass as their principal source of energy

⇒ International efforts to transition away from traditional use of solid biomass

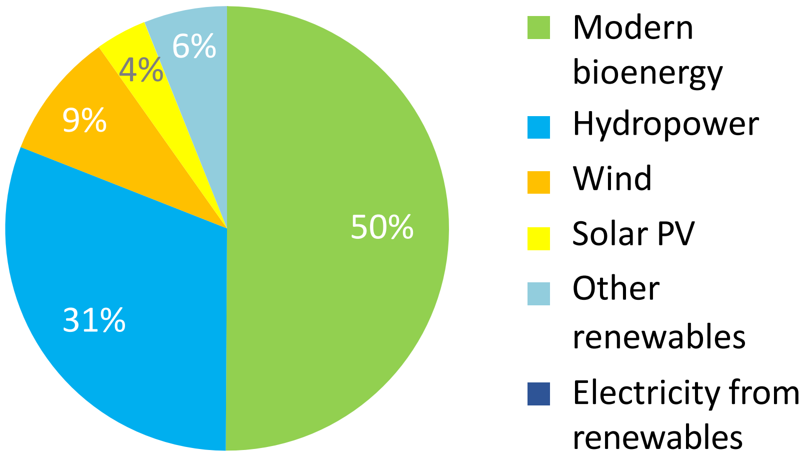
BIOENERGY IN FINAL ENERGY CONSUMPTION (BY END USE)

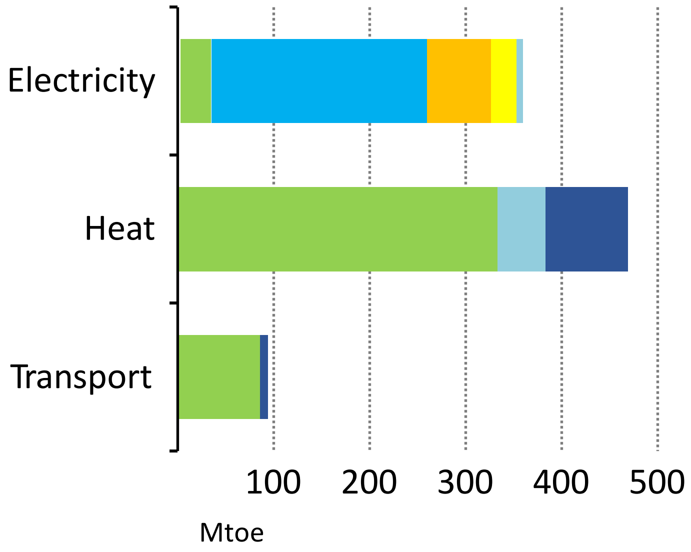


- Bioenergy is today dominated by the traditional use of biomass and by uses for heat in industry and buildings.
- Bioenergy accounted for ~ 11% (46 EJ) of world final energy demand in 2015
- ~1/3 modern bioenergy (18 EJ) => focus in the roadmap

MODERN BIOENERGY: THE OVERLOOKED GIANT OF RENEWABLES

Total final energy consumption from renewables by sector, 2017

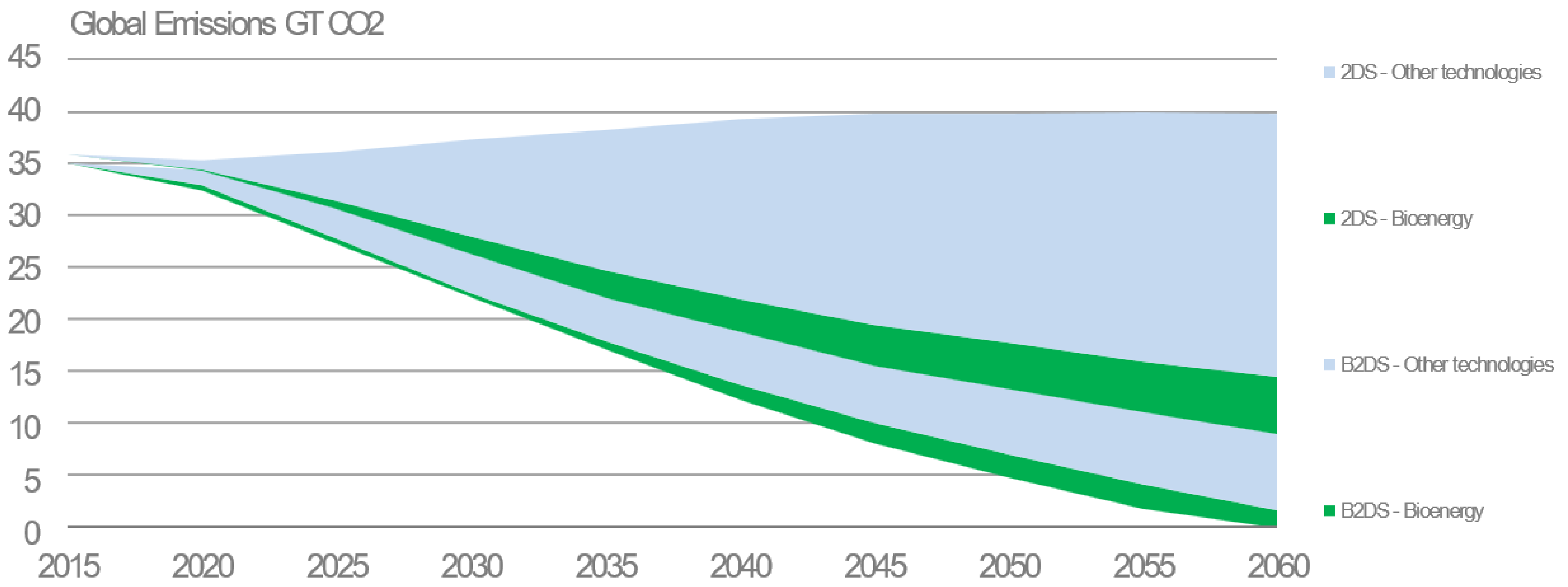




- Modern bioenergy accounts for 50% of all renewables in total final energy consumption.
- Modern bioenergy is the only renewable source that can provide electricity, direct heat and transport fuels
- Two thirds of modern bioenergy heat is used in industry
- A large proportion of bioenergy is already from low sustainability risk residue and waste feedstocks.

Source: IEA Renewables 2018 Market Report

BIOENERGY IS ESSENTIAL COMPONENT OF IEA LOW CARBON SCENARIOS



Source: IEA Bioenergy Roadmap, 2017

Bioenergy to provide some 17% of cumulative carbon savings to 2060 in the 2DS and around 22% of additional cumulative reductions in the B2DS, including an important contribution from BECCS

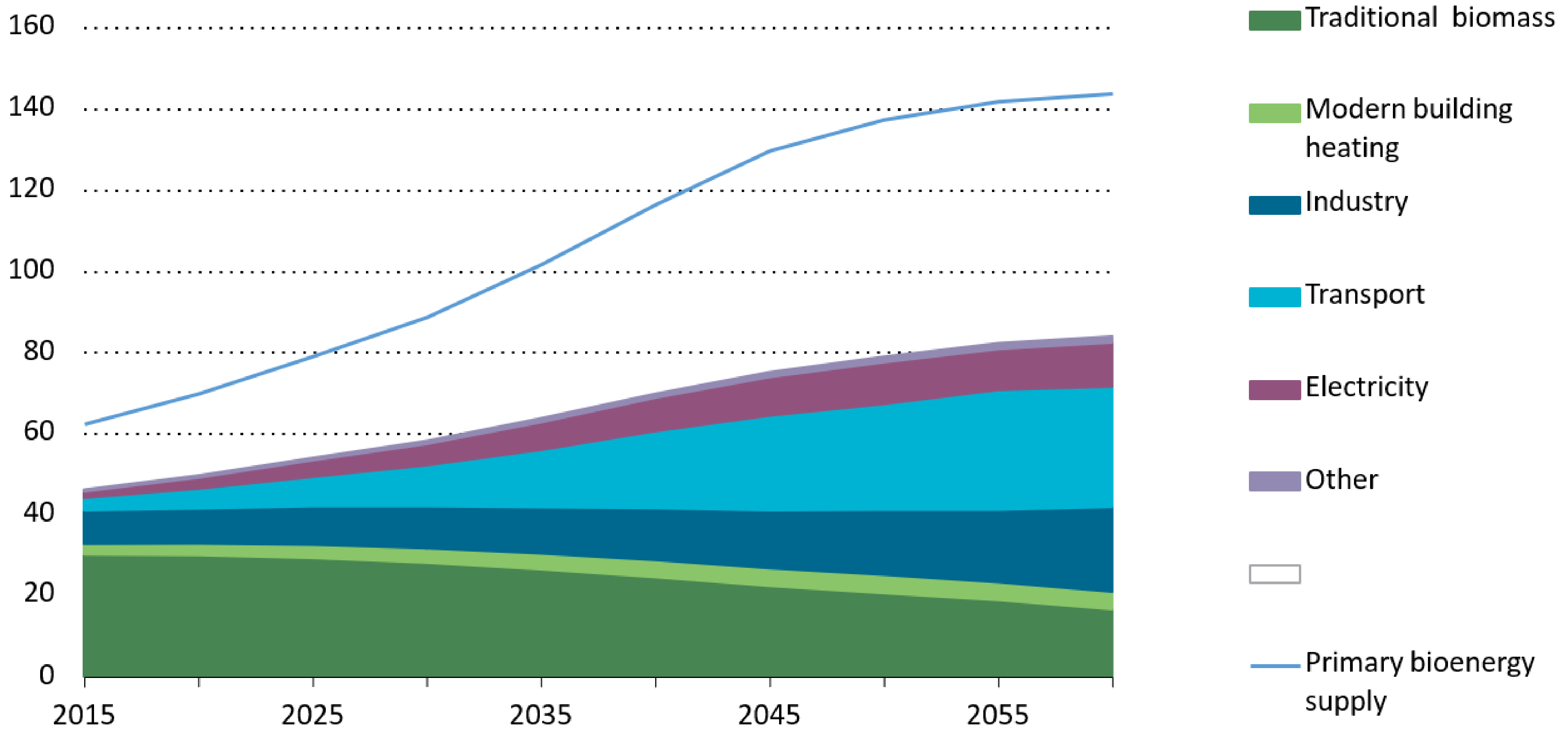
RTS: Reference technology scenario

2DS: scenario with 50% change to stay below 2˚C temperature rise by 2100

B2DS: beyond 2˚C scenario (<1.75˚C)

BECCS = bioenergy combined with carbon capture & storage

EVOLUTION OF BIOENERGY IN 2DS SCENARIO



Source: IEA ETP 2017

Bioenergy for transport grows strongly in the 2DS, and total biomass supply exceeds 140 EJ.

In the B2DS, there is a shift in bioenergy use patterns (more electricity) to facilitate the use of BECCS.

POLICIES TO SUPPORT BIOFUELS

- Biofuel blending mandates
- Excise duty reductions/exemptions
- Low carbon fuel standards (LCFS)
- Research and development, demonstration funding and financial de-risking measures
- Sustainability policy

Source: IEA Bioenergy Task 39

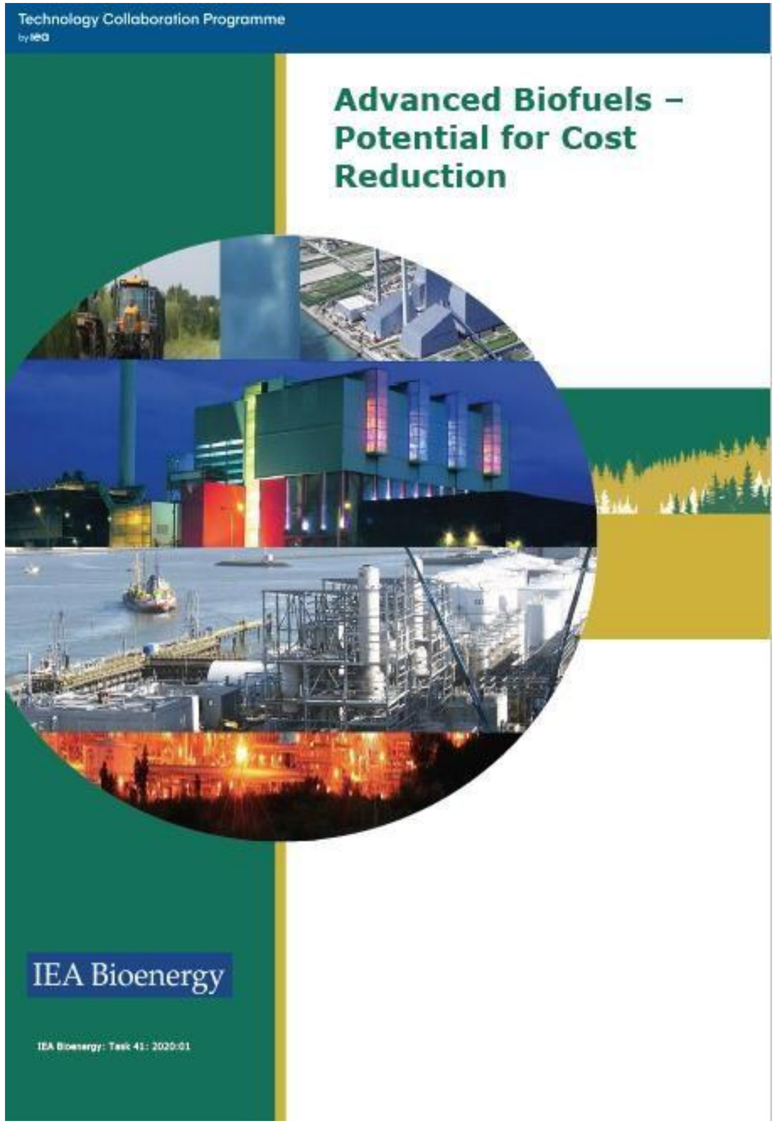
http://task39.sites.olt.ubc.ca/files/2020/02/IEA-Bioenergy-Task-39-Implementation-Agendas-Final-Draft-Executive-Summary-Feb-4-2020.pdf

ADVANCED BIOFUELS?

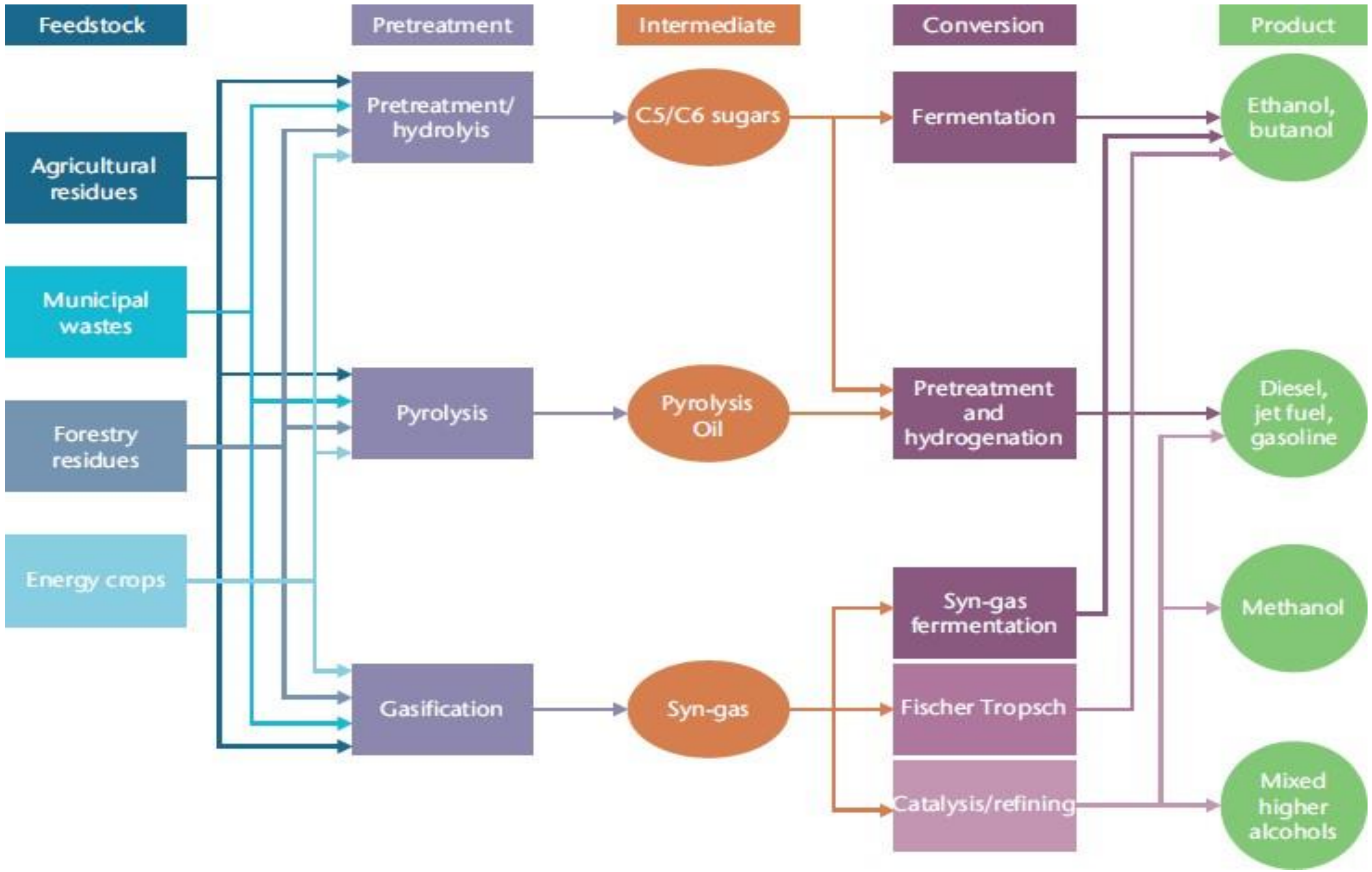
IEA definition:

- produced from non-food crop feedstocks or residues/waste (focus on lignocellulose)
- capable of delivering significant lifecycle GHG emissions reductions compared with fossil fuel alternatives
- no directly competition with food and feed crops for agricultural land
- no adverse sustainability impacts

In general production costs are higher than conventional biofuels => importance of policy framework



SOME ADVANCED BIOFUEL PATHWAYS



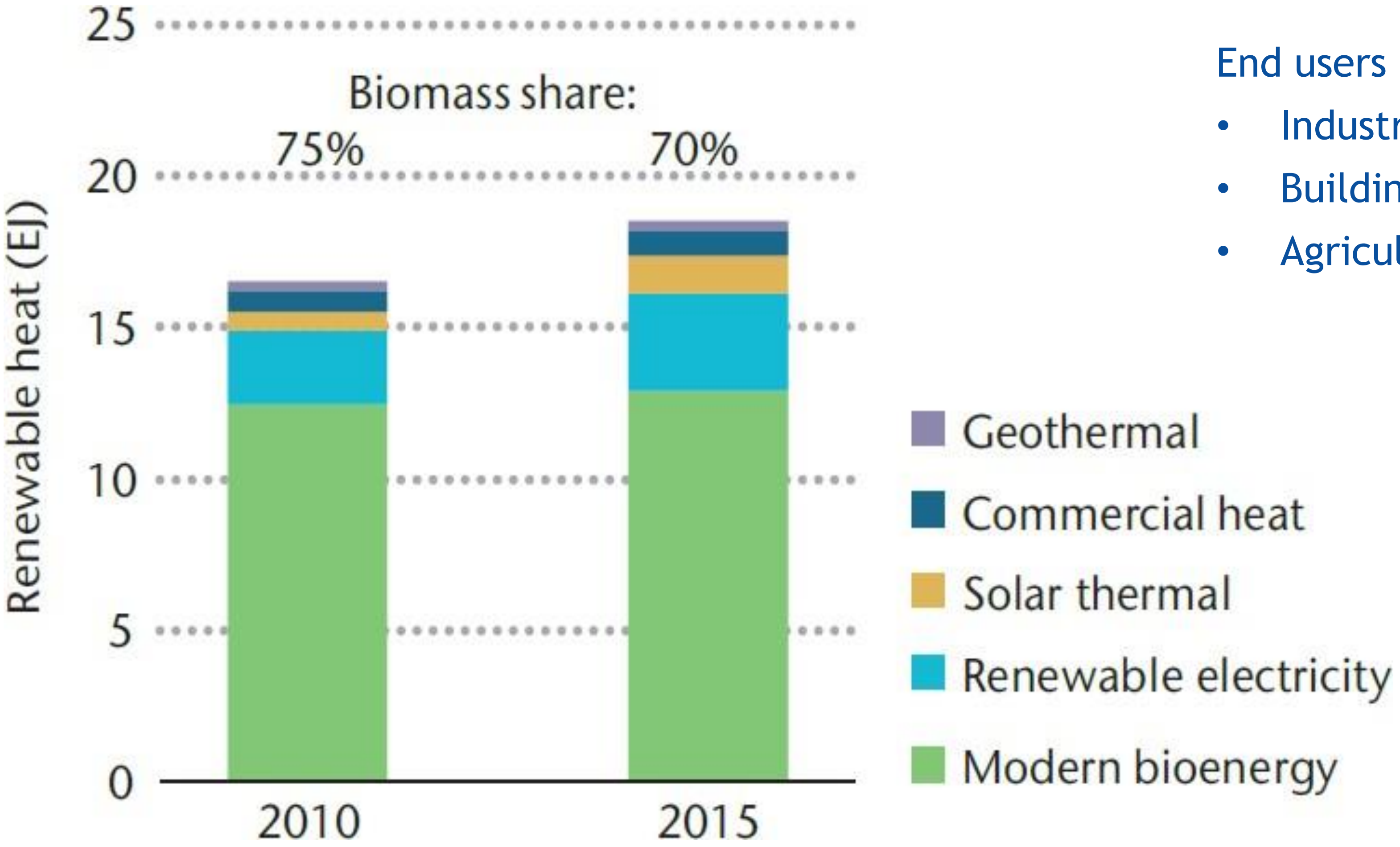
HEAT: IMPORTANT, BUT LESS VISIBLE

- Heat accounts for > 50% of final energy consumption – remains largely fossil fuel-based.
- Less attention in policy

2 main pillars:

- Buildings: heating, hot water, cooking
- Industry: contribute to industrial processes, incl. high temperature heat, feedstock for chemicals

RENEWABLE HEAT BY TECHNOLOGY

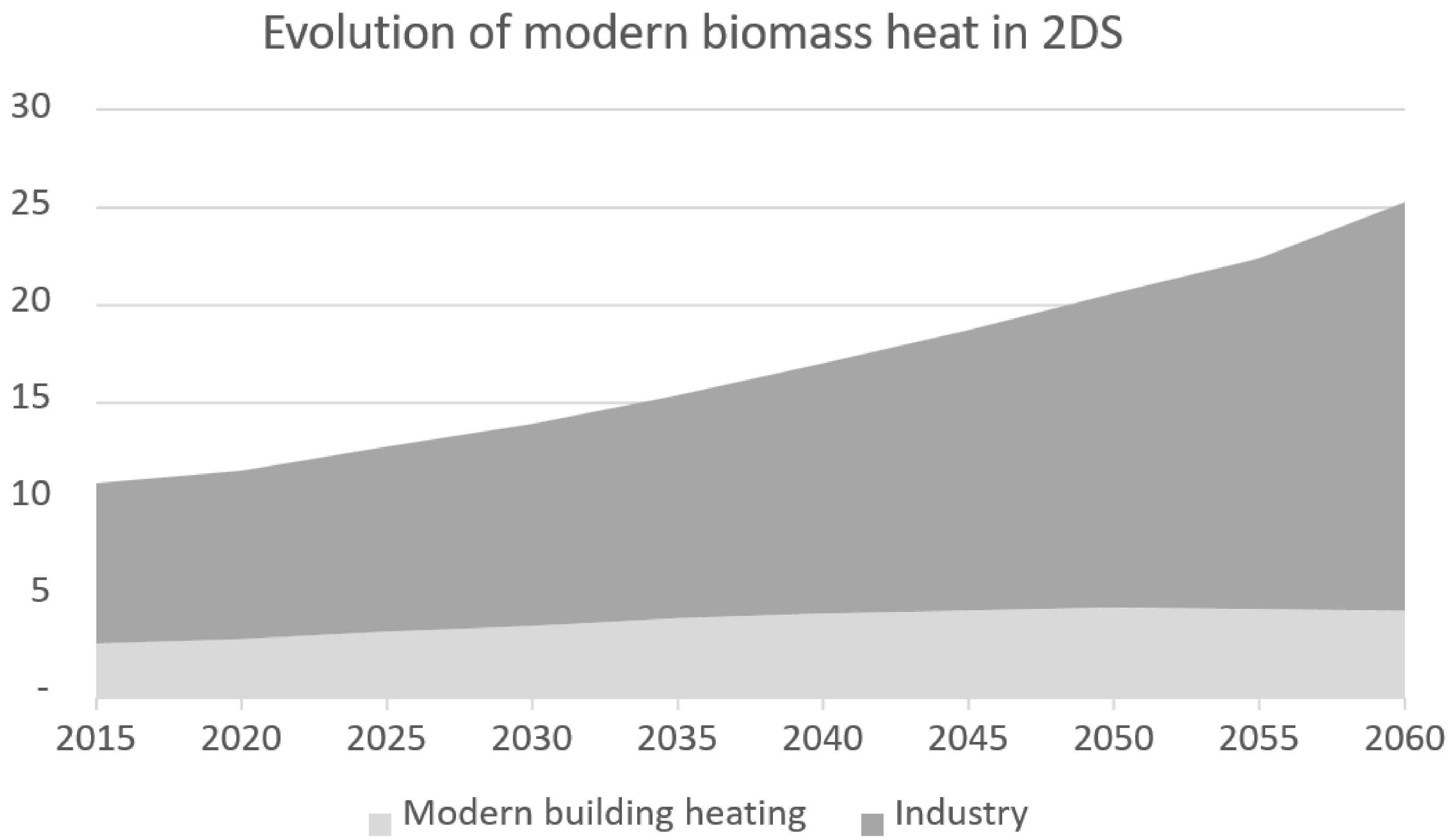


Source: IEA Bioenergy Roadmap, 2017

End users modern biomass heat:

- Industrial processes: 63%
- Buildings: 34%
- Agriculture: 3%

BIOMASS HEAT IN DECARBONISATION SCENARIOS



Source: IEA ETP 2017

- Important growth in biomass for industry
- Biomass for buildings stagnates

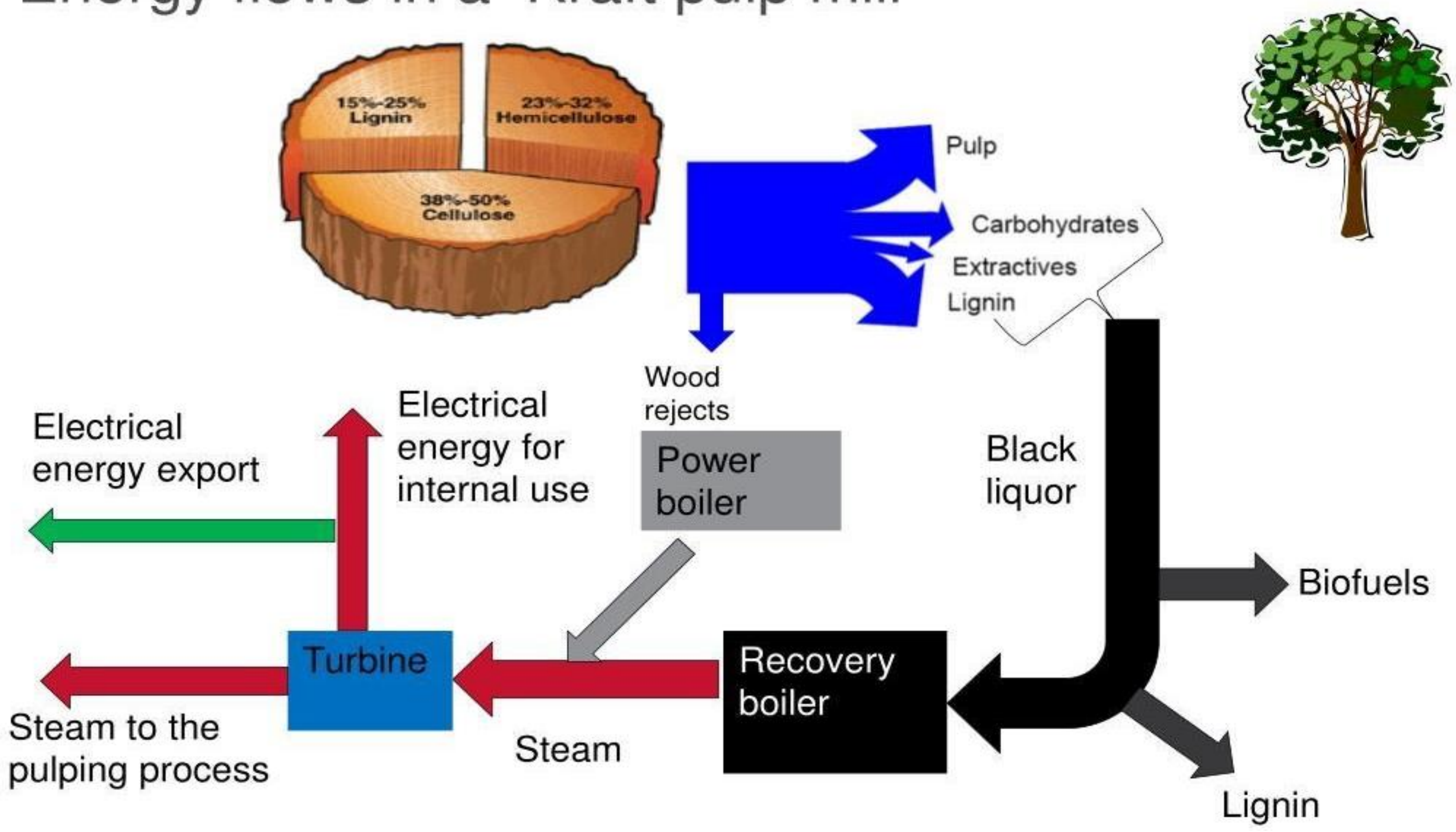
INDUSTRY

Biomass use industry grows ~ 3 times in 2DS

⇒ up to 14% of industrial energy needs

- Heat & steam in non-energy intensive industries
  - Food & beverage -> represents ~80% of industrial bioenergy use in 2060
  - Energy demand in the pulp and paper sector
  - Drying in wood processing industries
- High-temperature applications,
  - Cement industry (10% of energy from biomass; 15% from waste)
  - Blast furnaces & coke ovens (iron & steel industry)
- Biobased routes to produce chemicals

Energy flows in a Kraft pulp mill

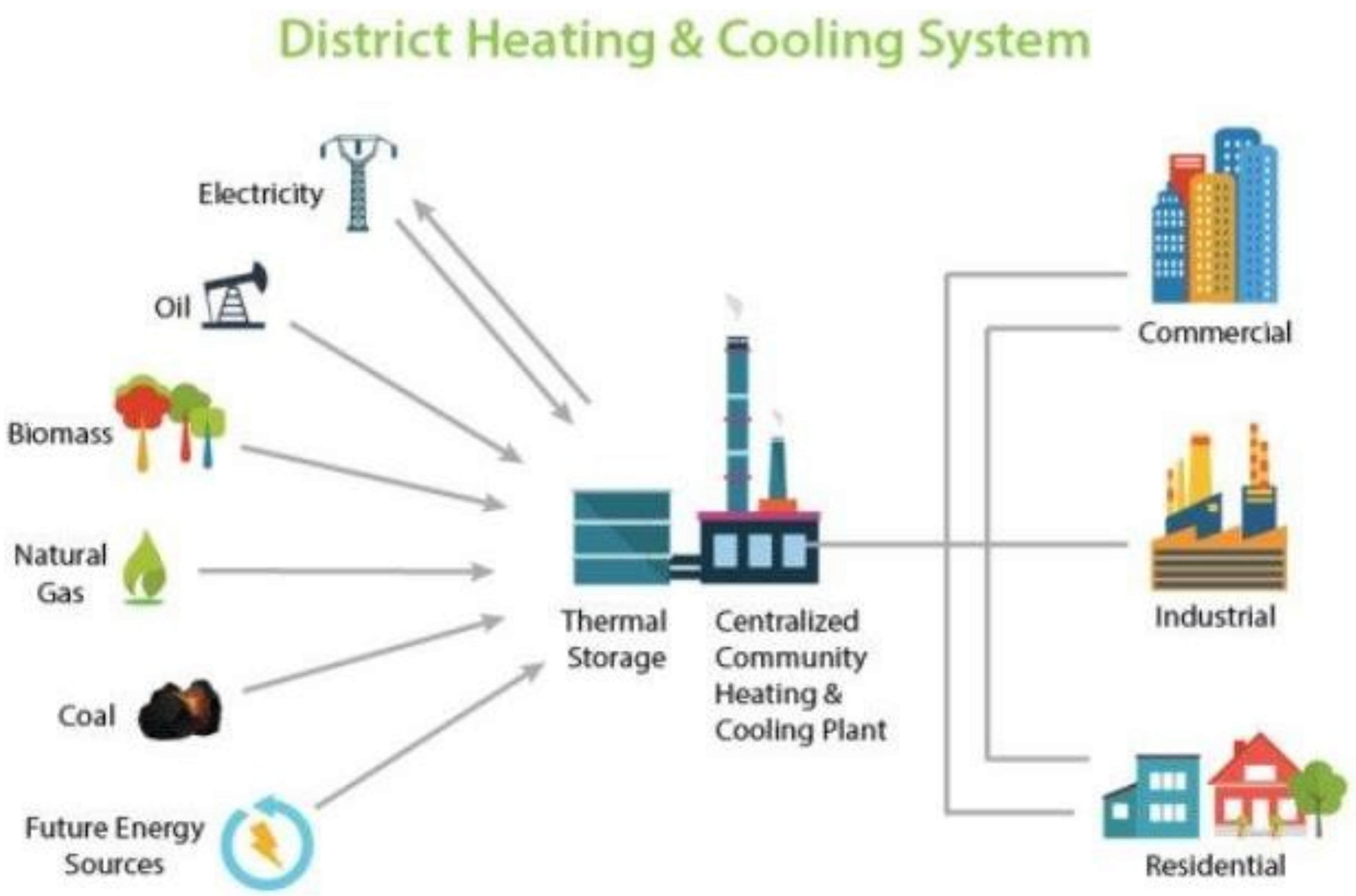


BUILDINGS

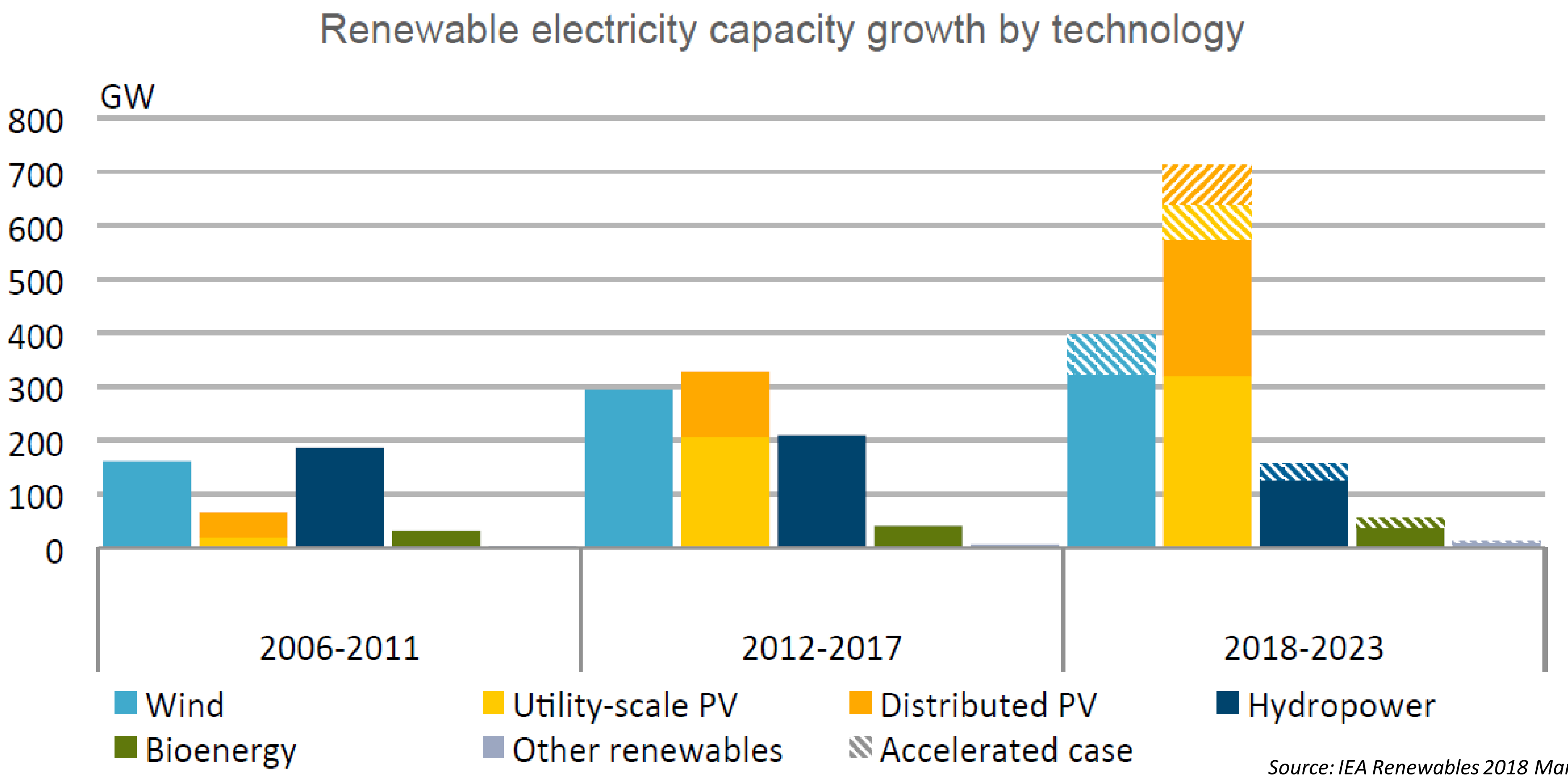
- Traditional use of biomass declines by ~40% between 2015 and 2060, however remains significant (particularly in Africa & Asia)

- Modern bioenergy in buildings: some initial growth & stable afterwards
  - Short to medium term: replace fossil fuels in district heating systems (from 7% in 2015 to 70% in 2060)
  - Longer term: growth constrained by
    - Reduced heat demands (better energy efficiency)
    - Other low-carbon technologies (solar thermal, direct electric heating, heat pumps);
    - Extended use of other sources of low-carbon heat (heat from industrial processes or from heat recovery systems).

BUILDINGS


District Heating & Cooling System
Electricity
Oil
Biomass
Natural Gas
Coal
Future Energy Sources
Thermal Storage
Centralized Community Heating & Cooling Plant
Commercial
Industrial
Residential

RENEWABLE ELECTRICITY CAPACITY GROWTH



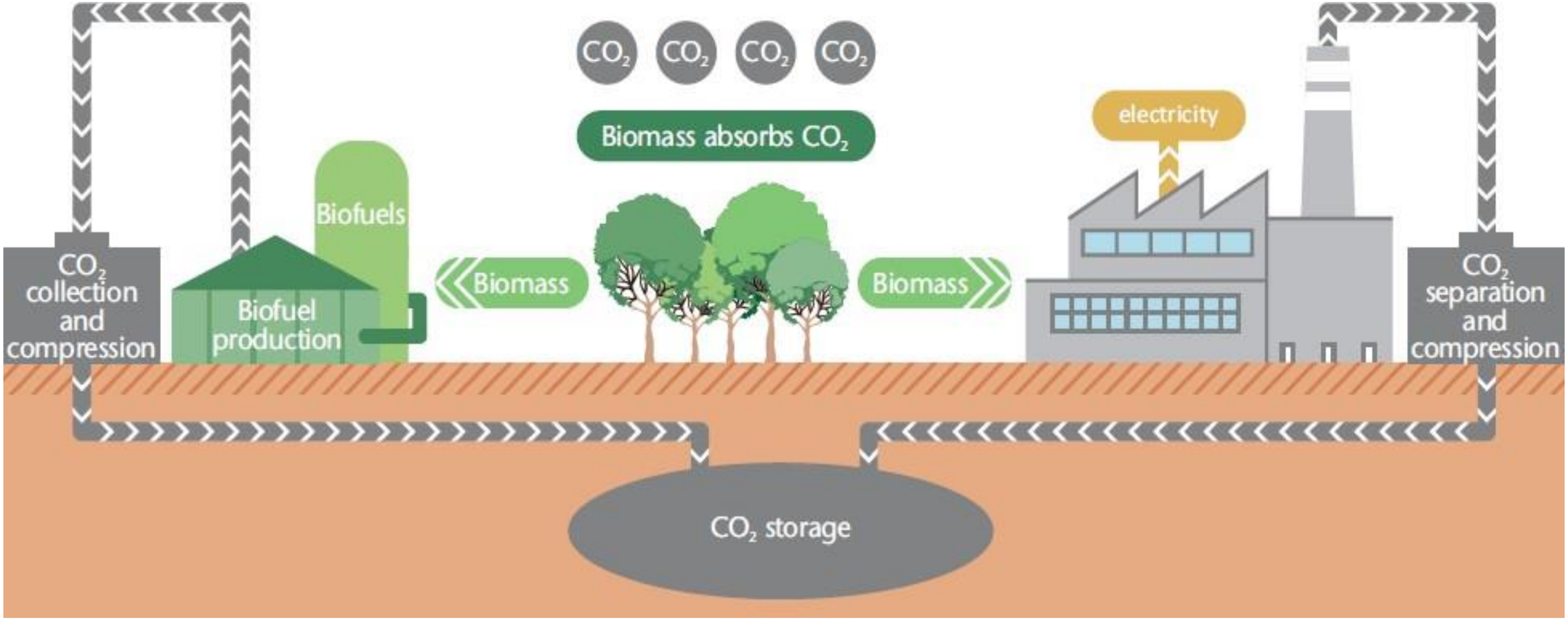
Source: IEA Renewables 2018 Market Report

- Capacity growth (in GW installed) biggest for PV & wind
- BUT mind difference in capacity factors (full load hrs/yr)
- Modest role for bioenergy

PARTICULAR ROLE OF BIOMASS IN ELECTRICITY PRODUCTION:

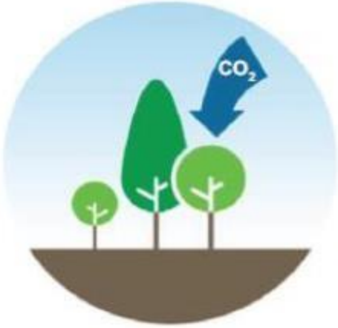
- Short–to-medium term: replace fossil fuels in existing power
  - plants (biomass co-firing or conversion to 100% biomass)
- Biogas / renewable gas to replace natural gas
- Combined heat & power (CHP) – driven by heat demand (industry or district heating)
- Energy-from-waste installations
- Provide flexible renewable electricity generation => complement variable renewables (wind and solar)
- Link to carbon capture and storage (BECCS) or use (BECCU)

BIOENERGY HAS GOOD CARBON CAPTURE OPPORTUNITIES



Capturing CO_2 byproducts in biofuel production (left), and CO_2 emissions in bio- electricity production (right)

BECCS IS ONE OF THE MAIN NEGATIVE EMISSION OPTIONS



Afforestation and reforestation

Additional trees are planted, capturing CO_2 from the atmosphere as they grow. The CO_2 is then stored in living biomass.

Bioenergy with carbon capture and sequestration (BECCS)

Plants turn CO_2 into biomass, which is then combusted in power plants, a process that is ideally CO_2 neutral. If CCS is applied in addition, CO_2 is removed from the atmosphere.

Biochar and soil carbon sequestration (SCS)

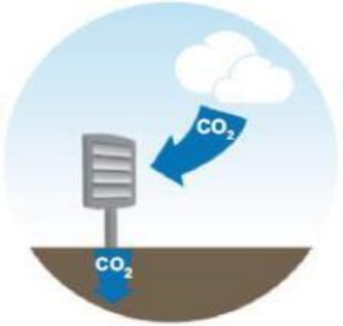
Biochar is created via the pyrolysis of biomass, making it resistant to decomposition; it is then added to soil to store the embedded CO_2. SCS enhances soil carbon by increasing inputs or reducing losses.

Enhanced weathering

Minerals that naturally absorb CO_2 are crushed and spread on fields or the ocean; this increases their surface area so that CO_2 is absorbed more rapidly.

Ocean fertilization

Iron or other nutrients are applied to the ocean, stimulating phytoplanton growth and increasing CO_2 absorbtion. When the plankton die, they sink to the deep ocean and permanently sequester carbon.



Direct air capture (DAC)

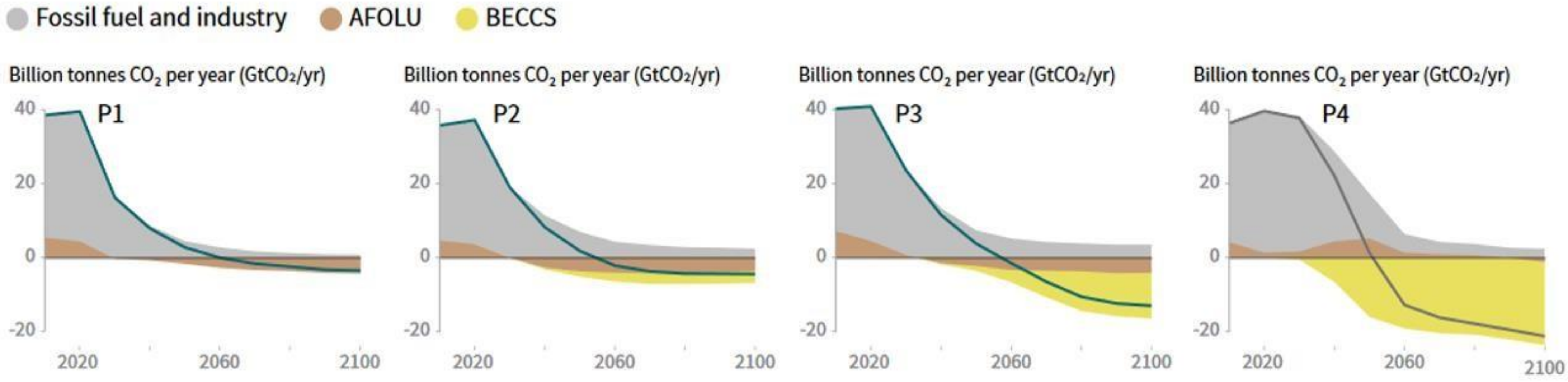
Chemicals are used to absorb CO_2 directly from the atmosphere, which is then stored in geological reservoirs.

Combinations also possible, e.g. afforestation & bioenergy, or bioenergy & biochar

Source: Minx, Jan et al. (2017) Fast growing research on negative emissions. Environ. Res. Lett. 12: 035007

IPCC SCENARIOS TO STAY WITHIN 1.5°C

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



P1: A scenario in which social, business and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A downsized energy system enables rapid decarbonization of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

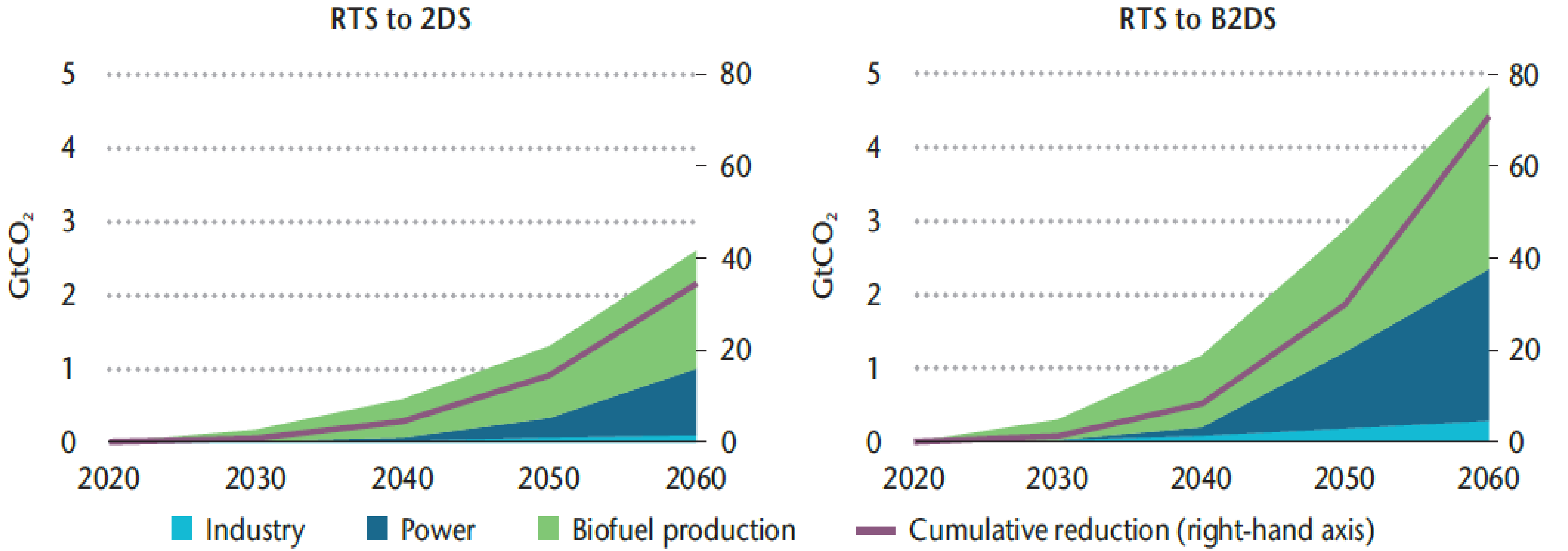
P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

P4: A resource- and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas-intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

Source: IPCC SR1.5 report

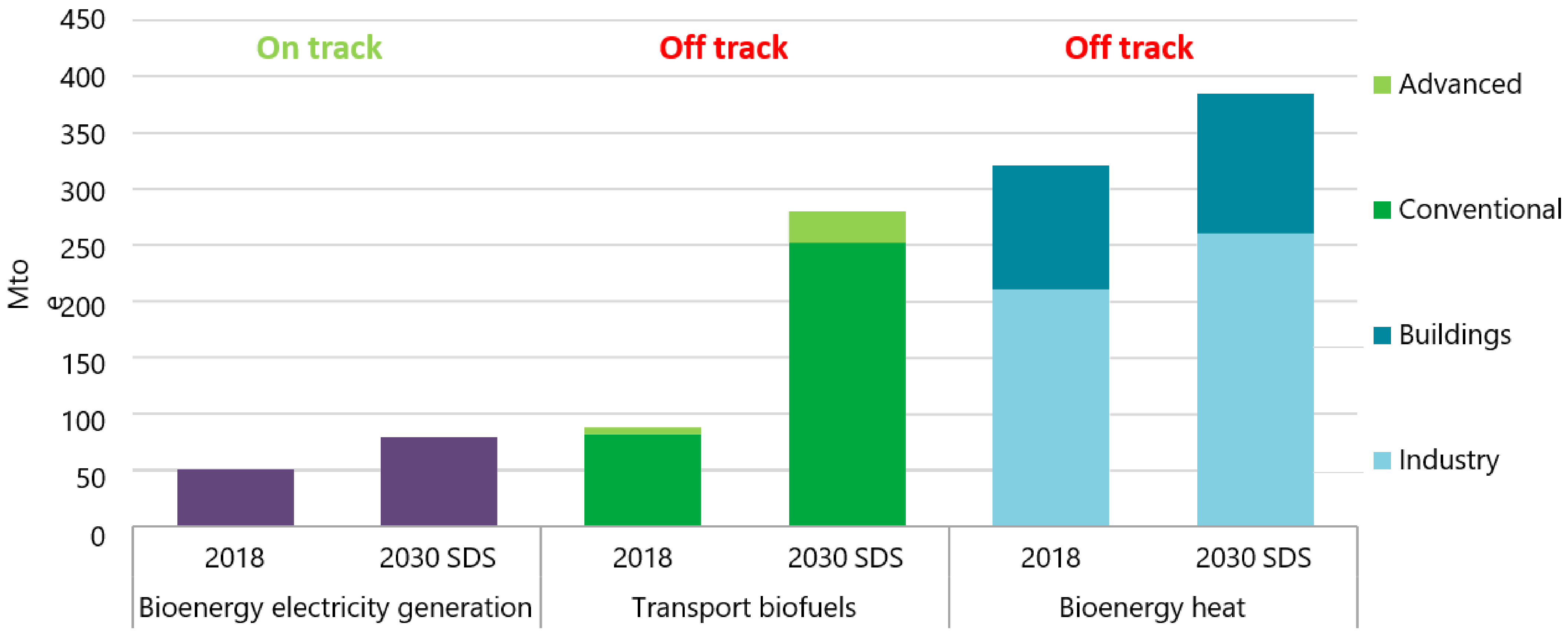
The later CO_2 emissions are reduced, the higher the need for Negative Emissions

ROLE OF BECCS IN THE 2DS AND B2DS



- BECCS is an indispensable component of the further CO_2 emission reductions in decarbonisation scenarios, particularly for staying below 2°C.
- CO_2 by-product in biofuel production (ethanol, biomethane) are lowest cost to capture
- Further => capture CO_2 from flue gases of biomass combustion

TRACKING PROGRESS



SDS = Sustainable Development Scenario *(equivalent to BSDS)*

Source: IEA Renewables 2018 Market Report

ROADMAP: FOUR KEY ACTIONS

1. Promote short term deployment of **mature options**
2. Stimulate the development and deployment of **new technologies**
3. Deliver the necessary feedstock sustainably, backed by a supportive **sustainability** governance system
4. Develop capacity and catalyse investment via a coordinated **international collaboration** effort

A RANGE OF MATURE BIOENERGY SOLUTIONS CAN SCALE UP IMMEDIATELY

Bioenergy solutions suitable for immediate scale-up

- Biomethane from waste and residues for use as a transport fuel.
- HVO / HEFA from waste and residues for use in heavy-duty road freight and aviation.
- Higher ethanol blends and unblended ethanol in road transport.
- Bioenergy-based district heating networks in urban areas.
- The conversion of existing fossil fuel infrastructure for bioenergy use.
- Energy recovery from municipal waste solutions.
- Maximising the efficiency of sugar cane residue co-generation in the sugar and ethanol industry.
- Medium-scale biomass heating systems in commercial and public buildings.

Source: IEA Bioenergy Roadmap, 2017

Accelerating bioenergy deployment up to 2025 will depend on greater utilisation of technically mature solutions which can roll out quickly under supportive policies and market conditions

KEY POLICIES TO ENABLE A SCALE-UP IN SHORT TERM OPPORTUNITIES

- For transport solutions life-cycle carbon intensity based policy frameworks
- Where high levels of investment is required financial de-risking measures
- Active municipal government support, e.g. planning, waste management, public procurement, heat mapping
- Robust sustainability governance arrangements to provide confidence to policy makers and the general public

In addition, other enabling factors such as the availability of infrastructure, technical specification development and enhancing workforce skills play a key role

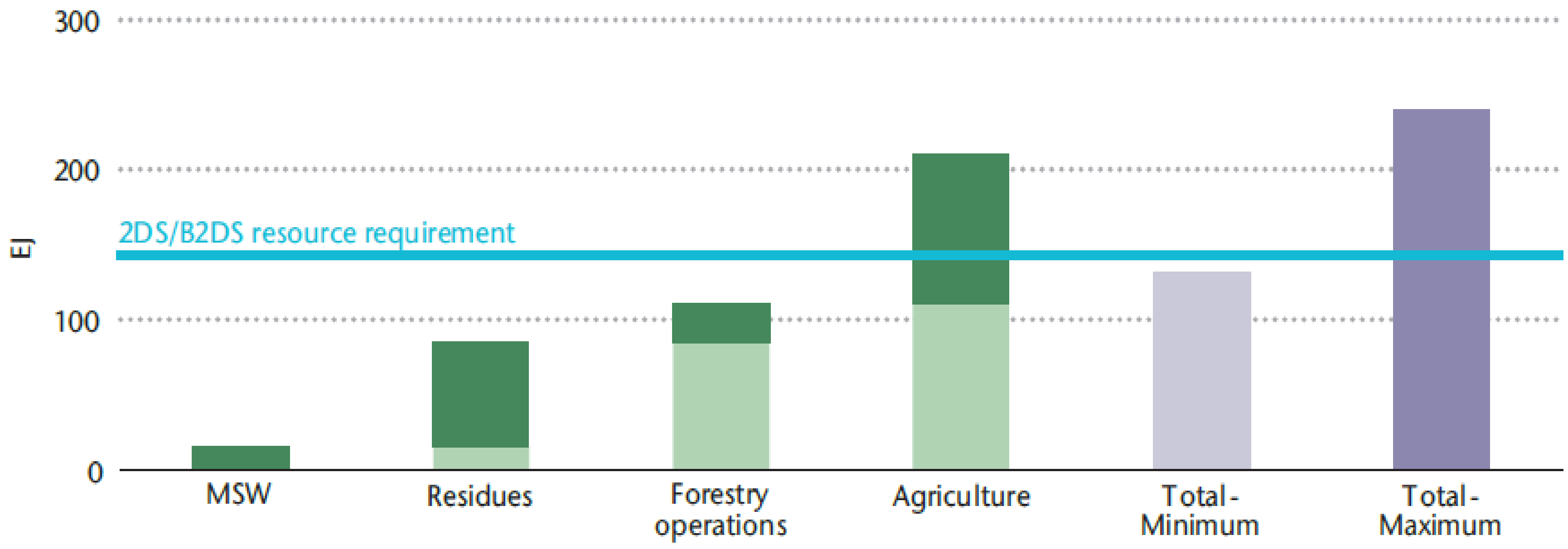
IMPORTANT TO STIMULATE DEVELOPMENT AND DEPLOYMENT OF NEW TECHNOLOGIES !

- New technologies needed with good carbon performance and adapted to market roles in 2DS/B2DS
- Continued RD&D to reduce costs and improve GHG performance of existing biofuel technologies
- Demonstrate reliable performance from existing “novel biofuels” plants
- Develop and demonstrate routes to diesel and biojet with improved costs, better C balances and GHG performance (link to renewable H2 production)
- Identify potential and development paths for cost reduction

DELIVER THE FEEDSTOCK SUSTAINABLY

Deployment will need wastes, residues, forestry and energy crops

- Produced in line with sustainable resource management, forestry and agricultural practice
- Produced with minimized impacts on land use change emissions by co-production with food, use of under-productive land, improved production
- Supported by general effort to improve agricultural productivity and efficiency



BIOFUELS

HOW DOES IT WORK?

MAIN CONCLUSIONS

- Sustainable bioenergy is an **essential** element in the portfolio of measures needed for a low carbon scenario.
- Biofuels can play a particularly important role in the transport sector (complementing energy efficiency measures and electrification, and with a special role in aviation, shipping and other long haul transport), but also grows in industry, electricity and buildings.
- **Progress** in bioenergy is much slower than necessary, need to
  - Expand deployment of existing technologies
  - Commercialise new technologies
  - Develop sustainable supply chains and appropriate sustainability governance systems
  - Build technical and regulatory capacity in a much wider range of countries and regions
- Putting in place suitable **policy frameworks** is a vital step in accelerating deployment

Thank you very much for your attention!

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