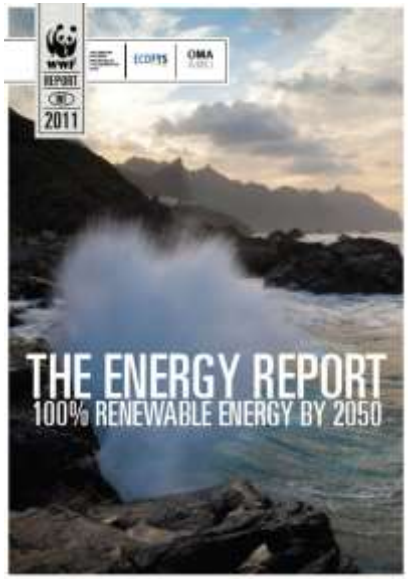
ECOFYS

sustainable energy for everyone



Pathway to a fully sustainable global energy system by 2050 "The Energy Report"

Prof. dr. Kornelis Blok
with Yvonne Deng, Stijn Cornelissen and Sebastian Klaus

"Every hour, we receive as much energy from the sun as we use in a year"

"Most Americans and Europeans believe that renewable energy will have replaced most fossil energy by 2050. As the hard truths make clear, this simply isn't going to happen"
Jeroen van der Veer, CEO of Shell, June 2007

"Every year, we don't even manage to improve our energy efficiency to keep up with wealth increases, let alone to cut emissions"
John Barrett, author of the SEI reports to both Defra and WWF

Key question:

Is a fully sustainable global energy system possible by 2050 ?

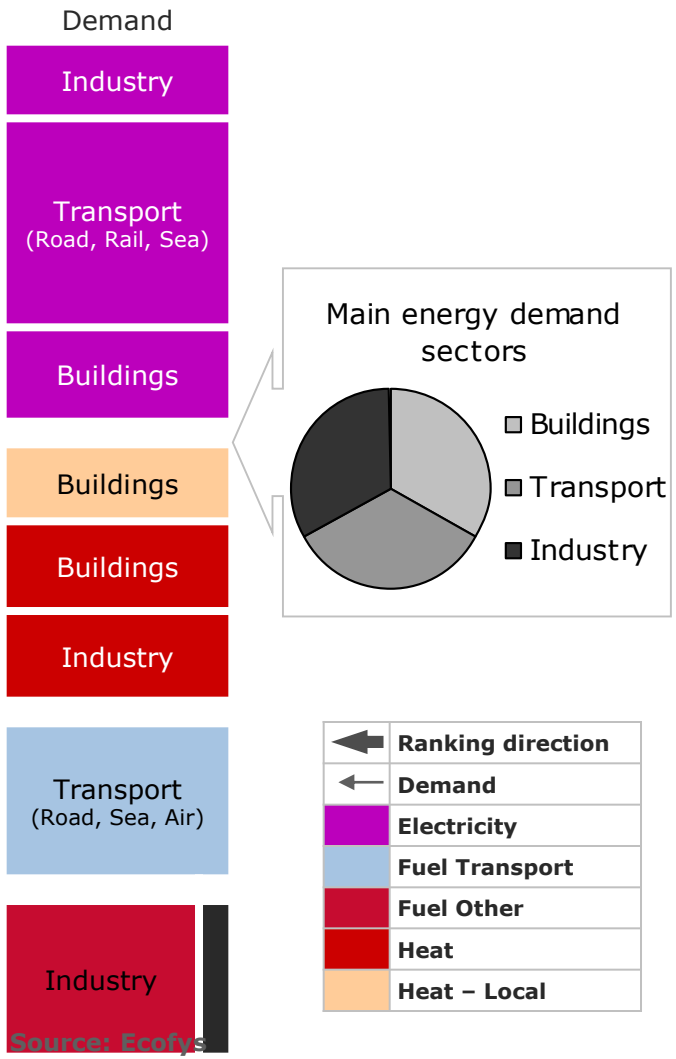
How we work

Traditionally: supply oriented approach

Energy generation → Energy conversion → Energy use

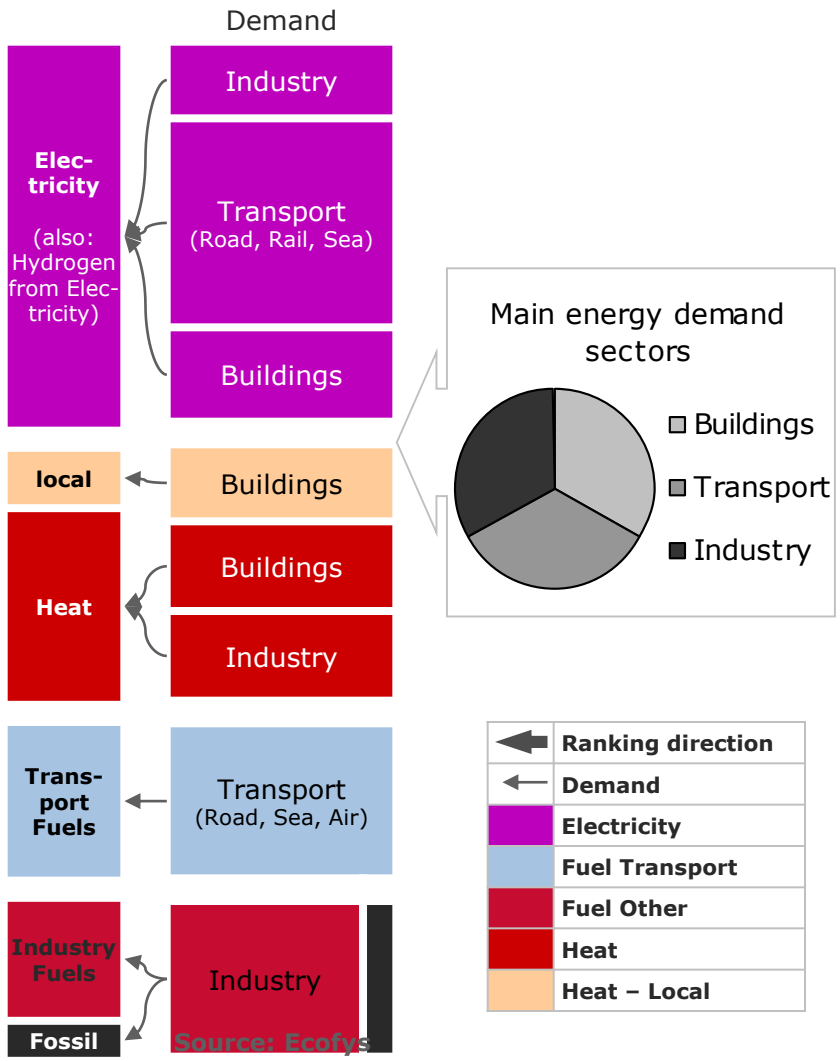
Ecofys thinking: start with (people) needs

1 a,b. Energy demand is forecast with strong efficiency assumptions



NB: The size of shapes here is NOT indicative of energy use per sector.

1 c. Energy demand is aggregated by carrier type



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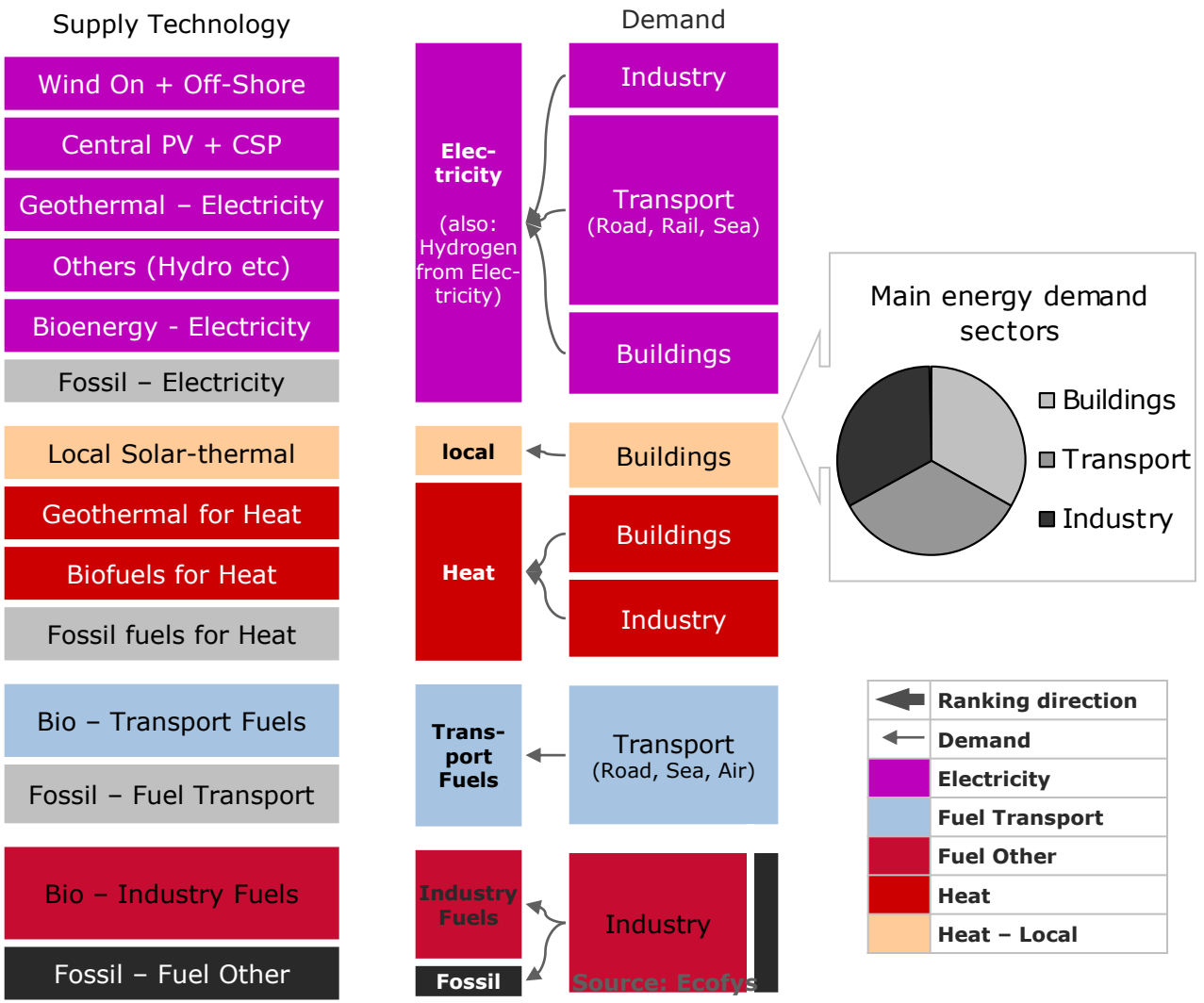
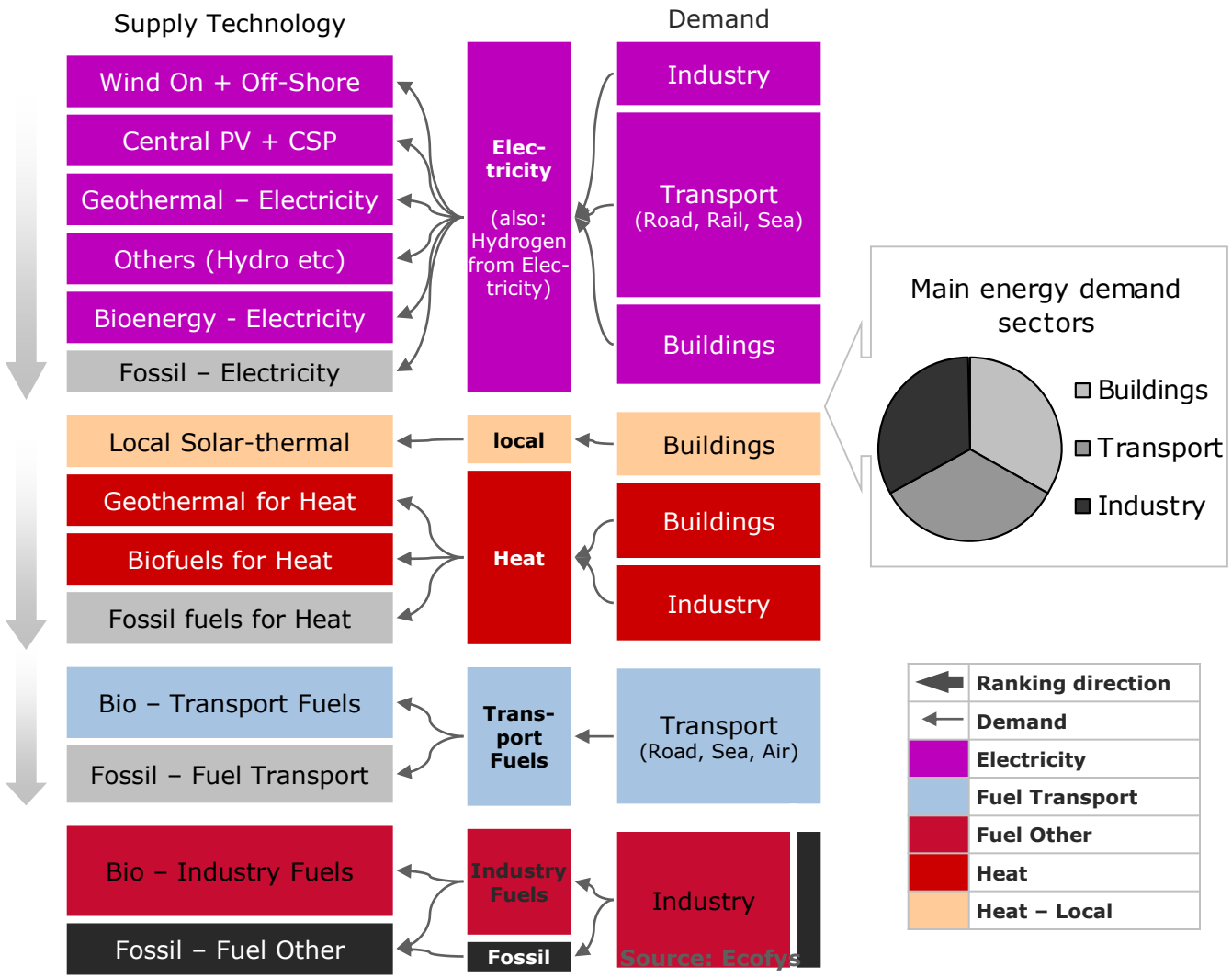
2 a. The potential of renewable energy options is assessed



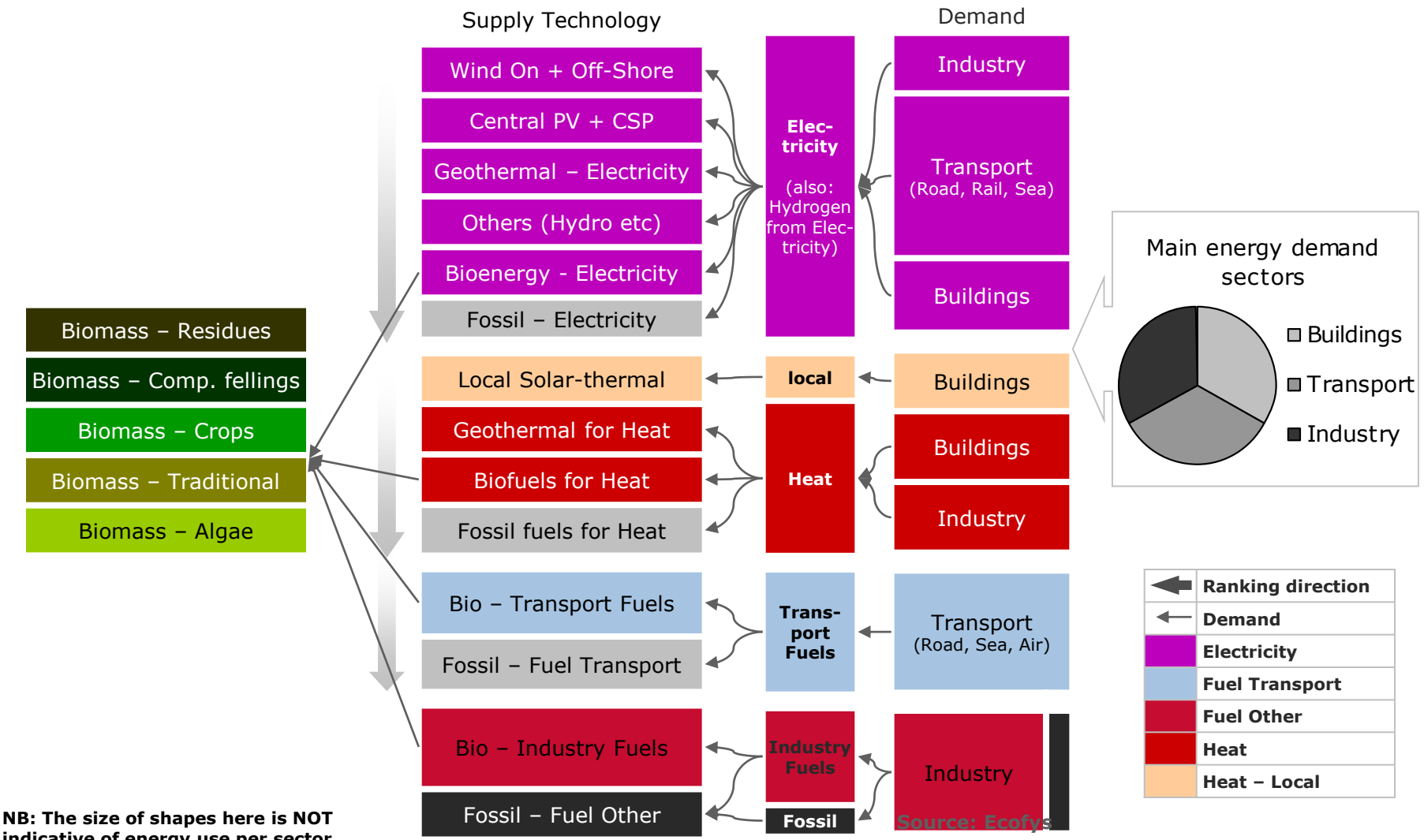
NB: The size of shapes here is NOT indicative of energy use per sector.

2 b i. Demand is matched with supply; non-bioenergy options are preferred



NB: The size of shapes here is NOT indicative of energy use per sector.

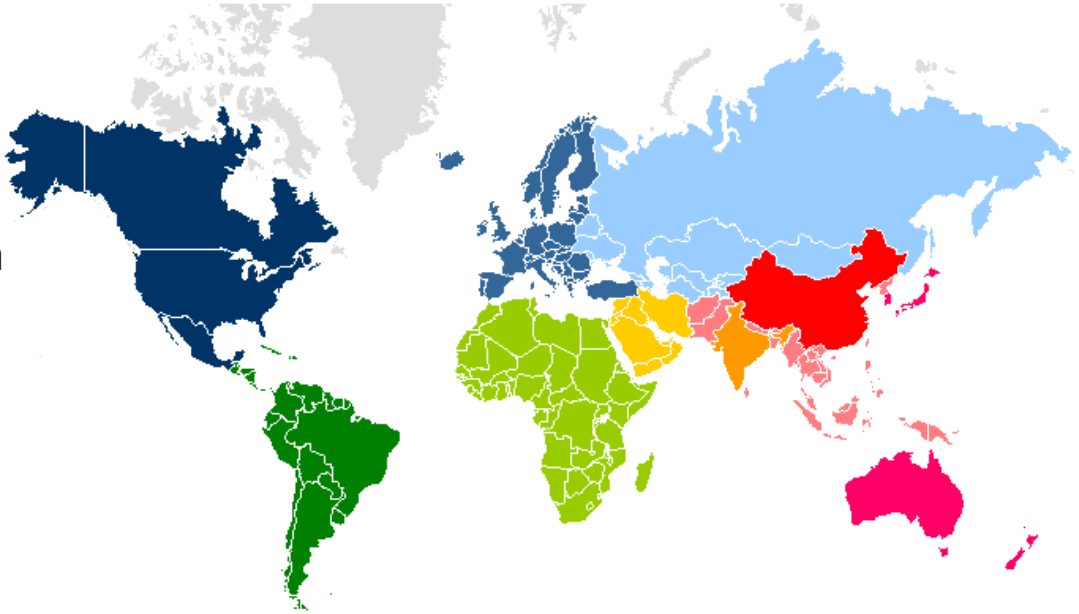
2 b ii,iii. Remaining demand is supplied from bioenergy up to the sustainable potential, then 'conventional' sources



NB: The size of shapes here is NOT indicative of energy use per sector.

Demand and supply are examined in 10 world regions

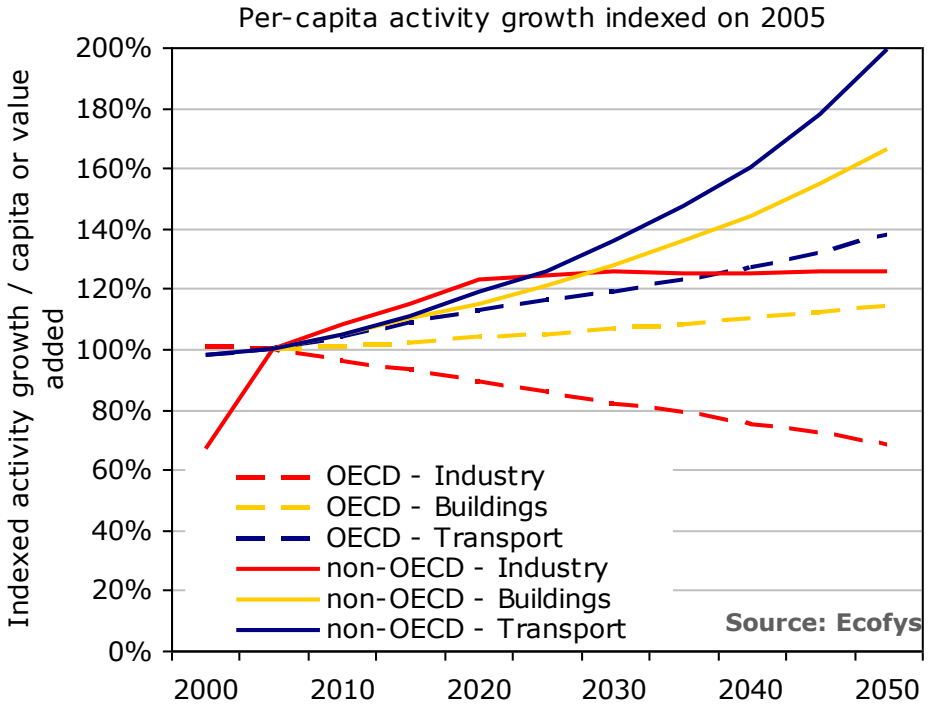
- Europe
- North America
- Latin America
- Russia and other Eurasia
- Middle East
- OECD Pacific
- China
- India
- Rest of Asia
- Africa

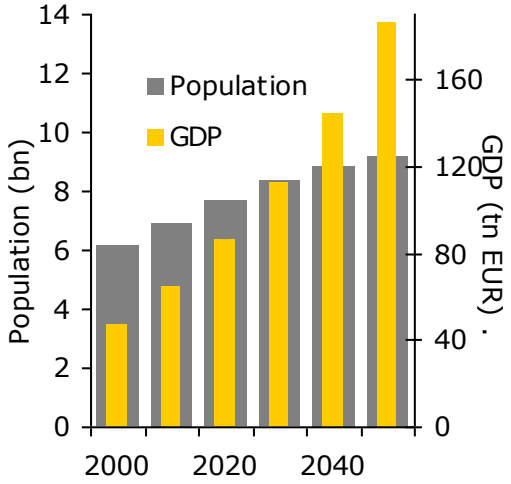


Currently, the Scenario is only valid at the global level, but future regional studies are possible

Activity increases, most strongly in non-OECD regions

> The only exception is the industry sector in OECD regions which sees a per capita and absolute activity decrease driven by ambitious material efficiency assumptions





Metrics shown in graphs

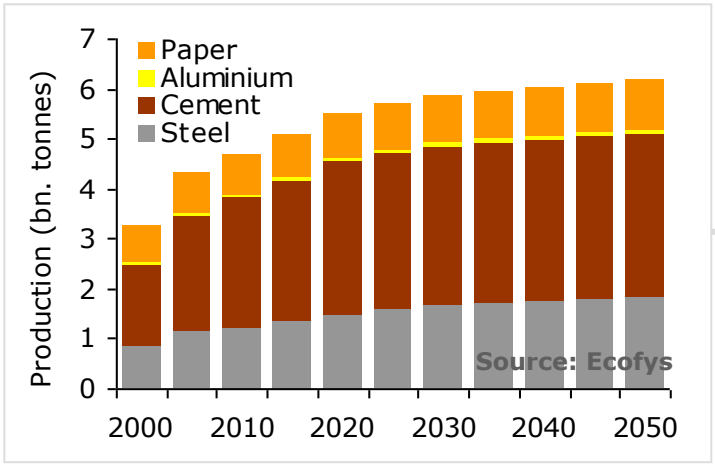
Industry: Tonnes produced per capita (steel, aluminium, cement, paper)

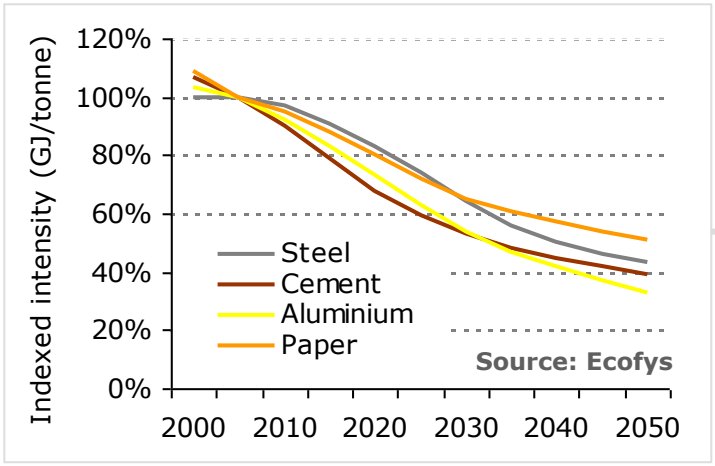
Buildings: Total floor space per capita

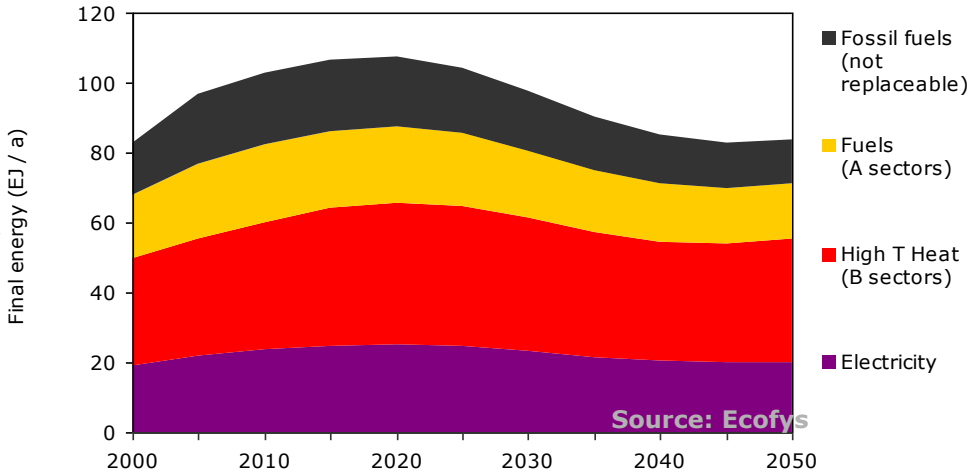
Transport: Passenger-km per capita

Sources used for these input assumptions:
Population: United Nations, World Urbanization Prospects: The 2006 Revision
GDP: IEA WEO GDP projections to 2030
Industry, Buildings: own assumptions
Travel: IEA/SMP (2004). Model Documentation and Reference Case Projection for WBCSD's Sustainable Mobility Project (SMP), plus own assumptions on modal shift

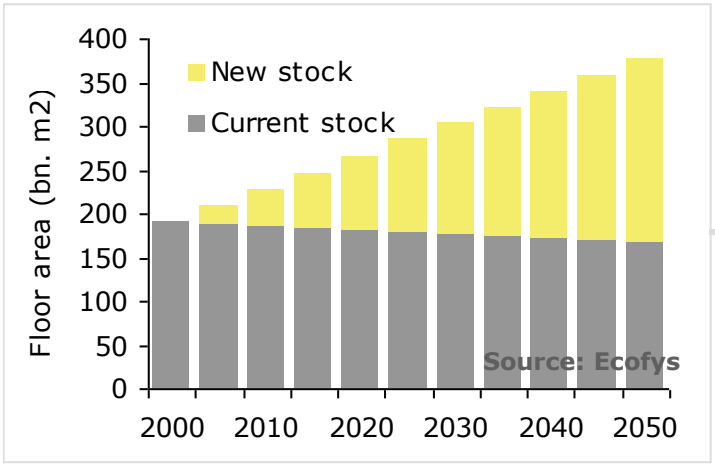
The stabilisation in energy demand in the industry sector results from ambitious efficiency improvements

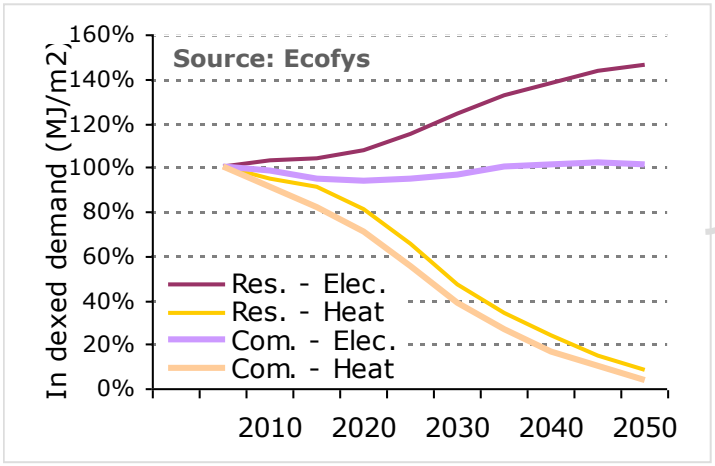


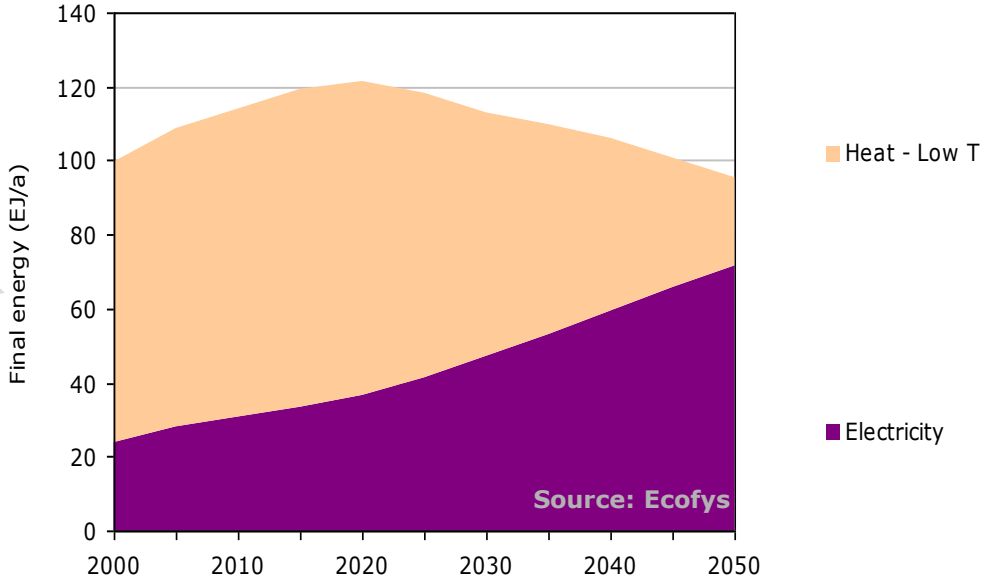




The stabilisation in demand in the built environment results from ambitious energy efficiency improvements

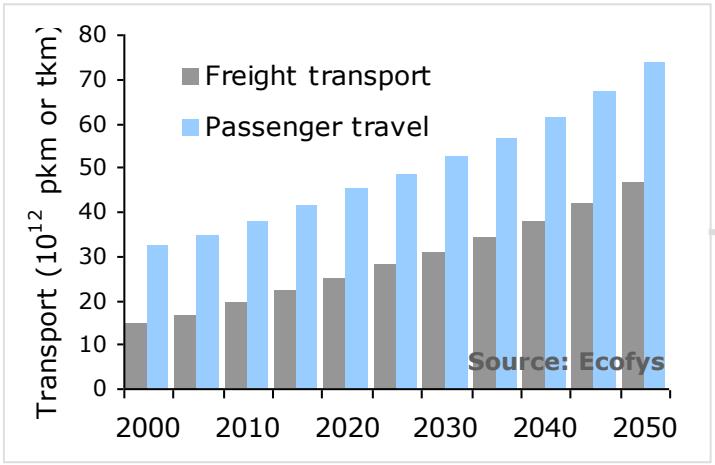


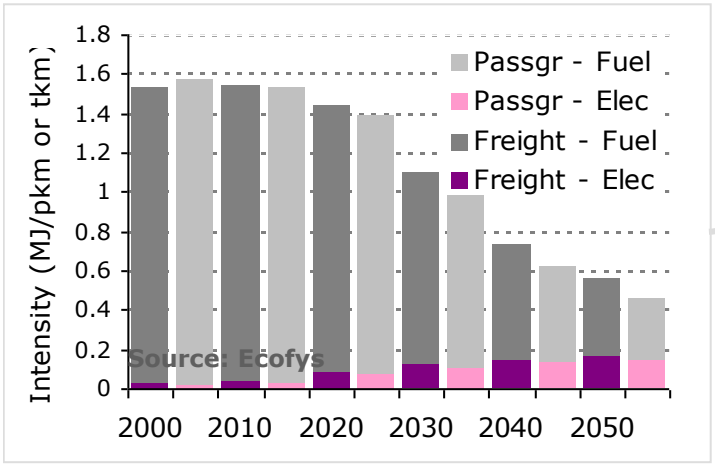


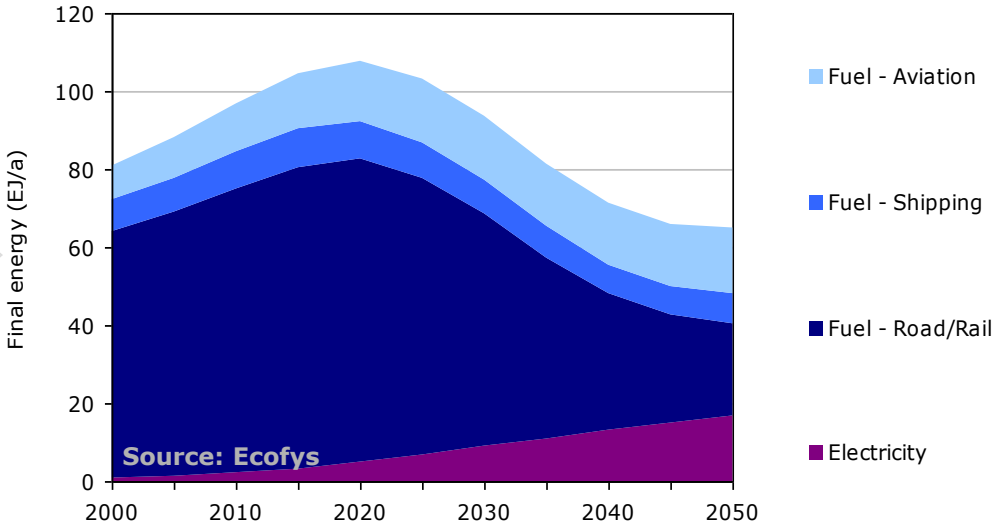


Floor area and specific energy use are shown for Residential sector only for illustrative purposes.

The stabilisation in demand in the transport sector results from ambitious energy efficiency improvements

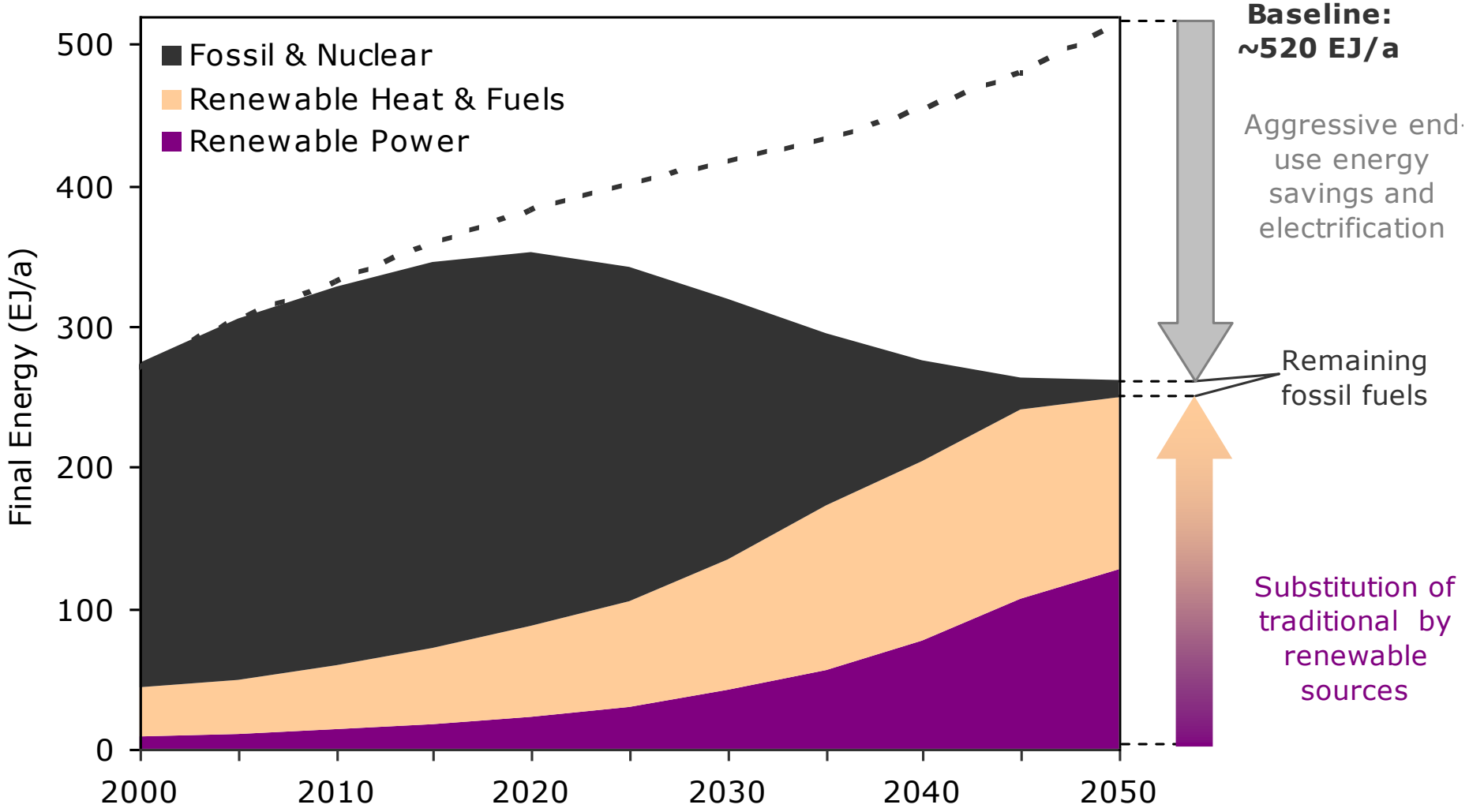






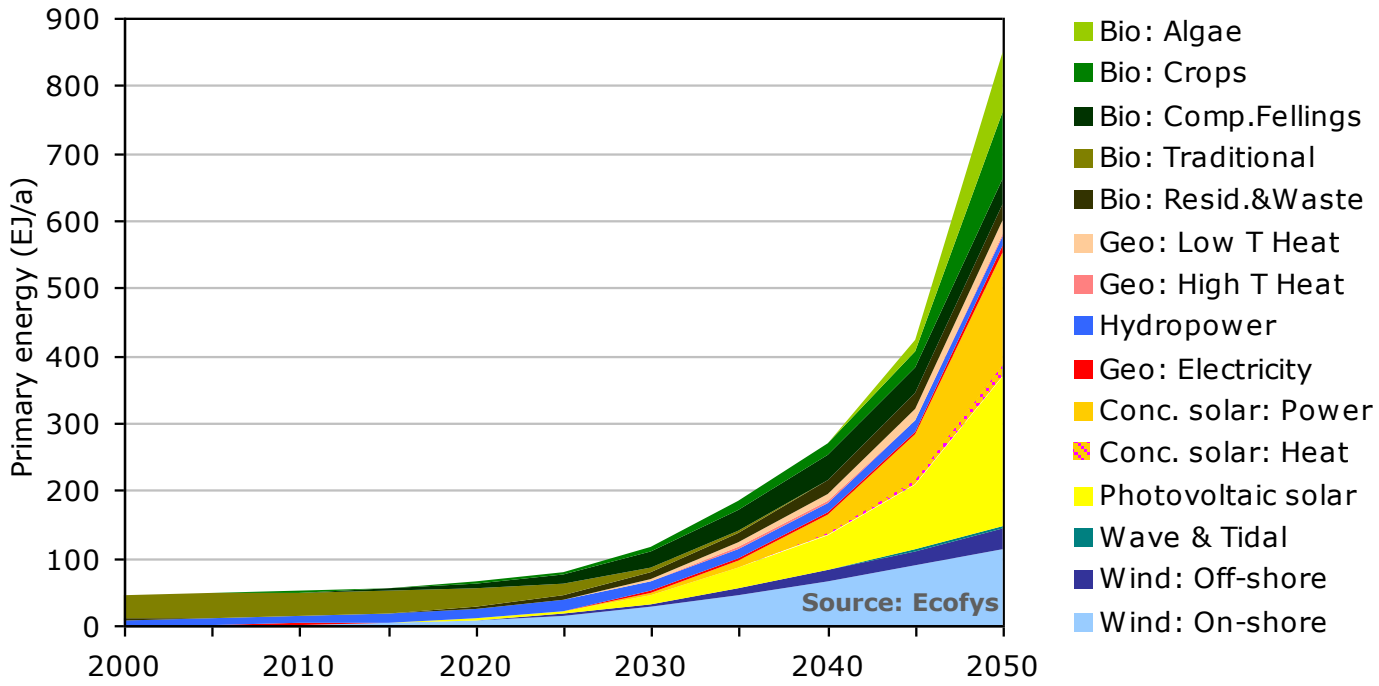
Activity graph excludes shipping. Shipping energy demand is based on GDP growth and relative efficiency savings in line with other modes.

Absolute energy use can be reduced without a reduction in energy services

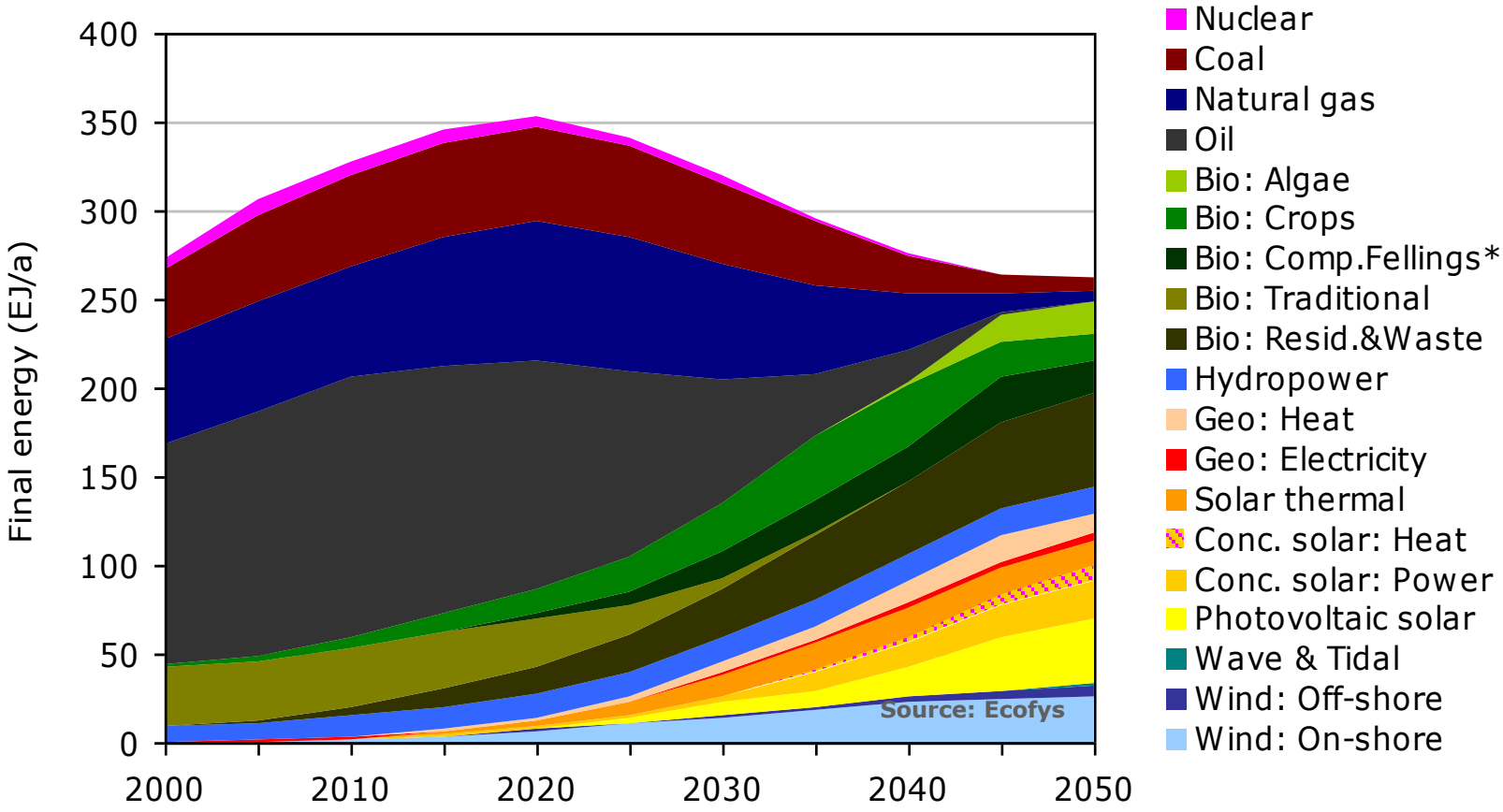


Renewable energy options will be prioritised in the development of our future energy system

- Renewable energy sources are largely untapped today
- Given the right incentives and legislative framework, this potential could be unleashed very quickly



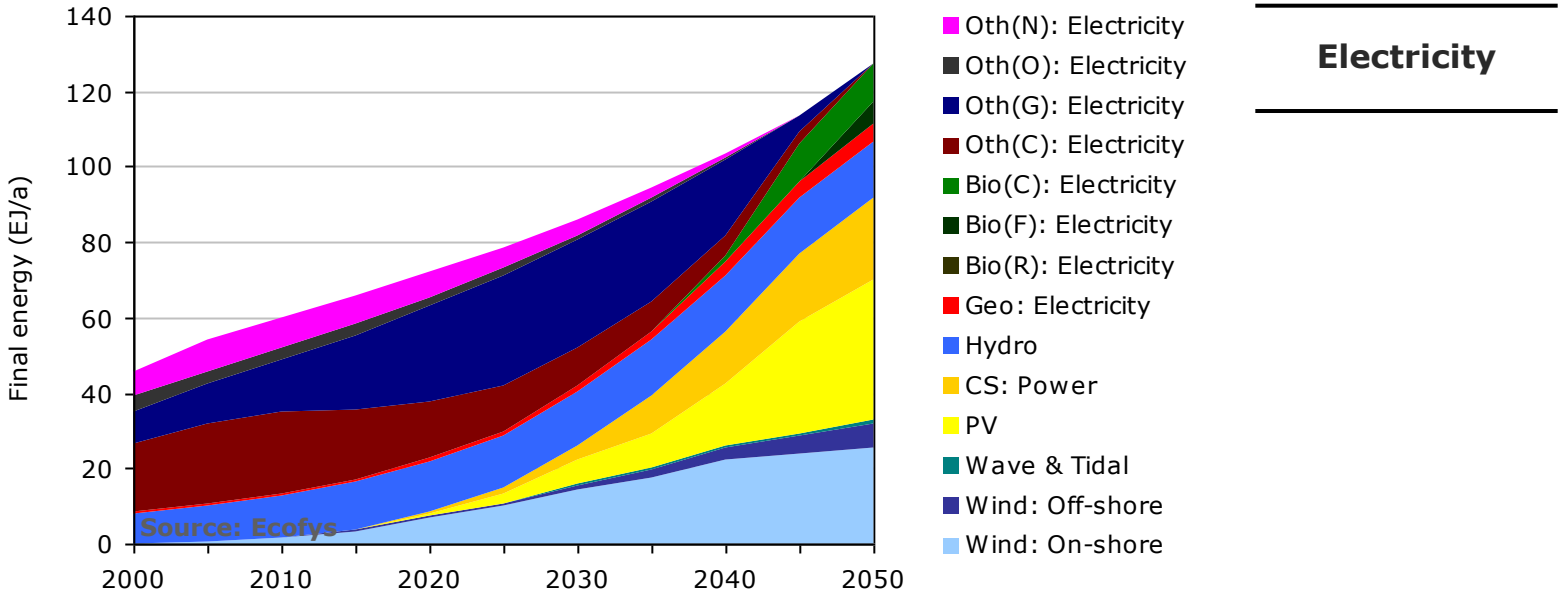
95% renewable energy worldwide by 2050 is possible…



* incl. sustainable share of traditional use

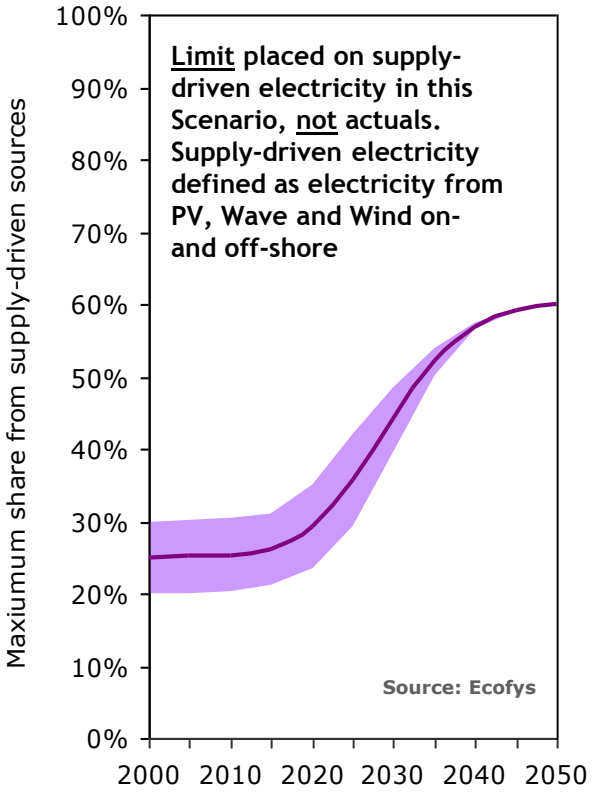
Renewable electricity growth potential will outpace electricity demand growth by 2050

- By 2050 exploitation of renewable electricity sources will be widespread
  - Renewable electricity will be so abundant that options will compete against each other even before 2050
- Supply-driven renewable sources are limited by grid capacity / stability in later years
- Hydro, Geothermal, CSP* and Bioelectricity will provide demand-driven electricitv



*CSP=Concentrated Solar Power

Regional electricity grids need to be upgraded and extended to be ready for RES power



> To equilibrate load patterns, electricity grids should be well-connected regionally

➔ **Remove bottlenecks to distribution by**

- increasing capacity and
- increasing range of transmission lines

➔ **Efforts to start <u>now</u> for results by 2030**

> Beyond 2020 may require better grid stability

➔ **Re-focus R&D <u>now</u> to prepare our grids**

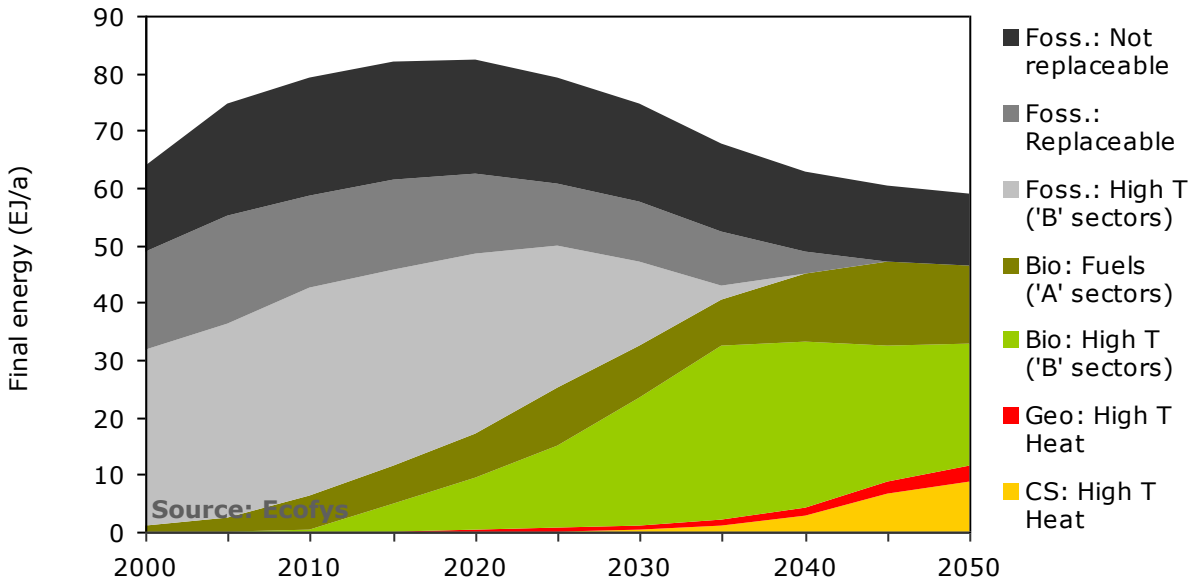
- For ultra-high RES shares beyond 2030 all of the following levers need to be employed:
  1. Grid improvements
  2. Demand side management
  3. Storage

➔ Note that to go beyond 60% supply-driven RES share, large over- and/or storage capacities would need to be built to provide peak loads

Biomass can provide a large share of industry energy needs

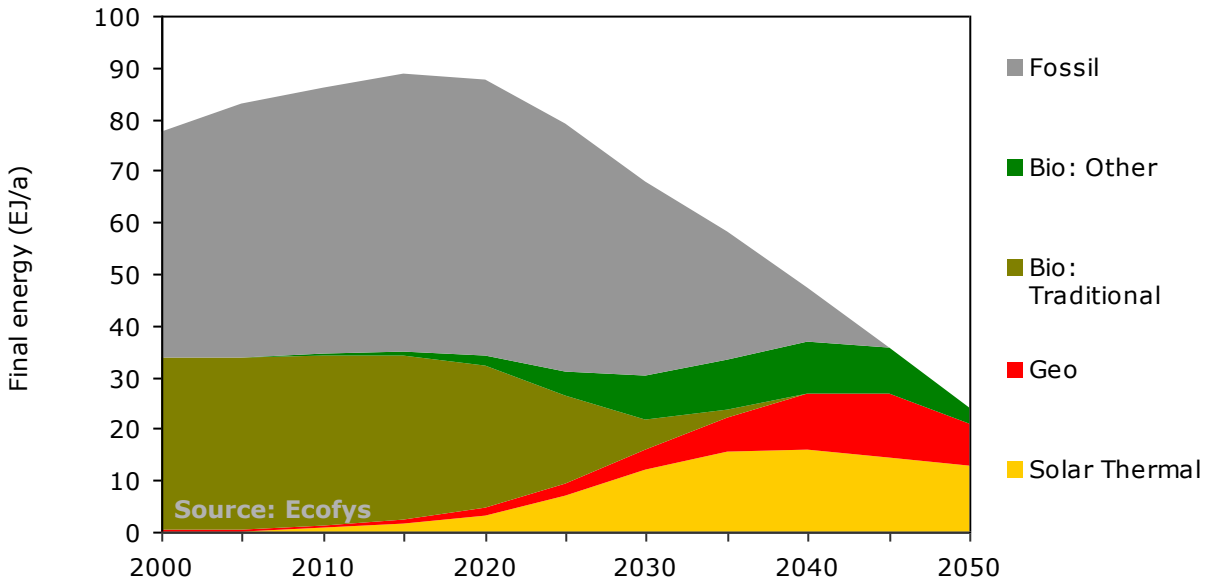
- Remaining heating for industry process heat, primarily for steam generation, will mostly be provided by renewable sources
  - Biomass will take the largest share of this, providing ~65%
- In addition, biomass will provide some fuel needs in industry
  - A residual need for fossil fuels remains, mainly for steel and cement production: These production processes rely on the specific properties of traditional fuels. Replacing these fuels will require the development and adoption of as yet unavailable new technologies

Industry Heat + Fuels



Renewables are expected to provide all building heat needs

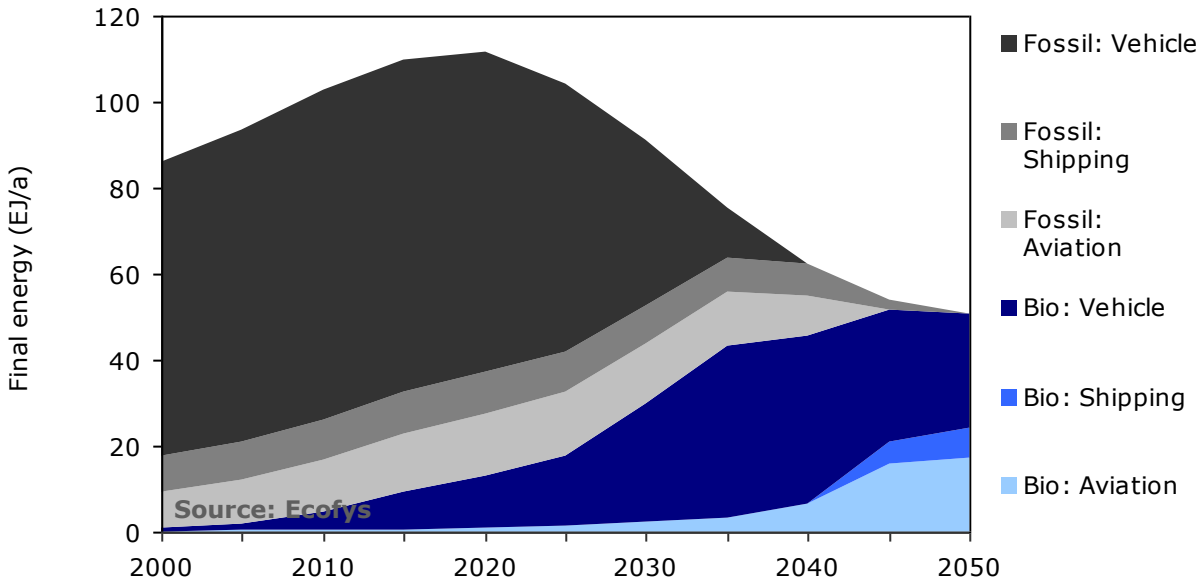
- Remaining space heating needs for buildings will be provided by
  - Decentralised solar heating and
  - Centralised or district-level renewable sources
    - Mostly geothermal heat and some bioenergy



*Solar water heating in buildings is a decentralised energy source but shown here for completeness

The largest requirement for biomass comes from liquid fuel transport

- This is primarily due to passenger air travel demand and freight transport which cannot (yet) be shifted to rail / electric transport
- NB: travel volume[1] used as activitiy indicator includes large increase in travel volume per capita in ALL regions

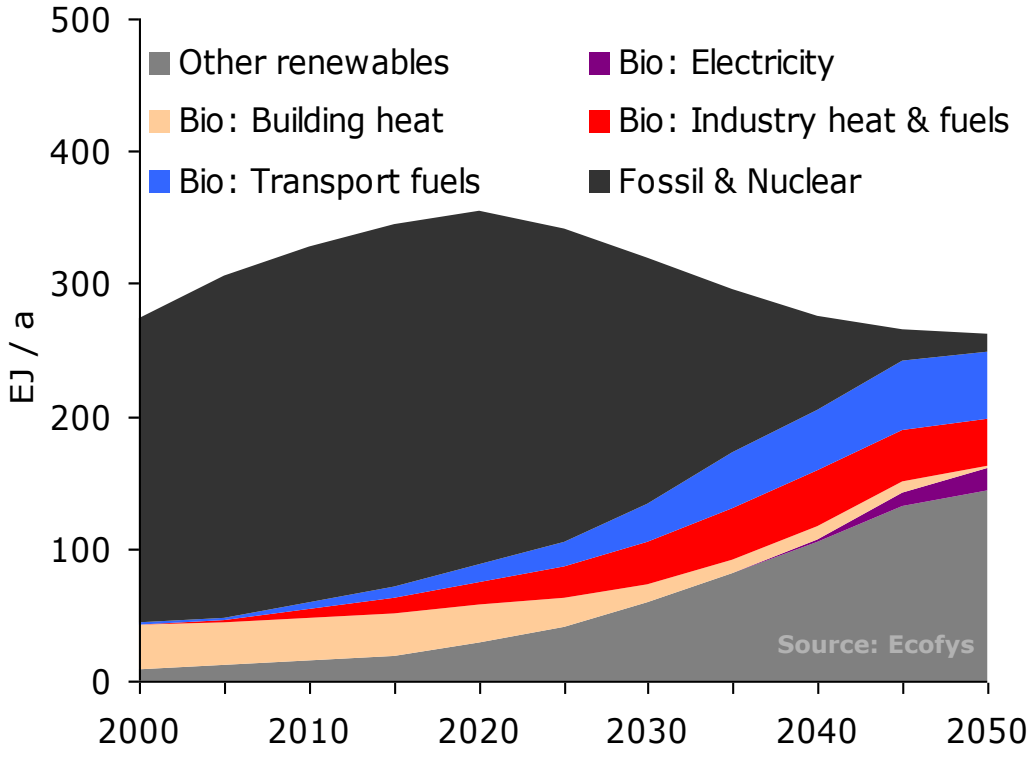


[1] IEA/SMP (2004). Model Documentation and Reference Case Projection for WBCSD's Sustainable Mobility Project (SMP)

Bioenergy is an important element of the energy supply

Bioenergy can fill energy demands where other renewables provide no or no complete alternative, e.g.:

- Transport fuels; especially:
  - Long distance road transport
  - Aviation
  - Shipping
- Industrial fuels; especially:
  - Applications that require very high temperature
  - Applications that require a specific energy carrier (e.g. gaseous fuel, solid fuel)

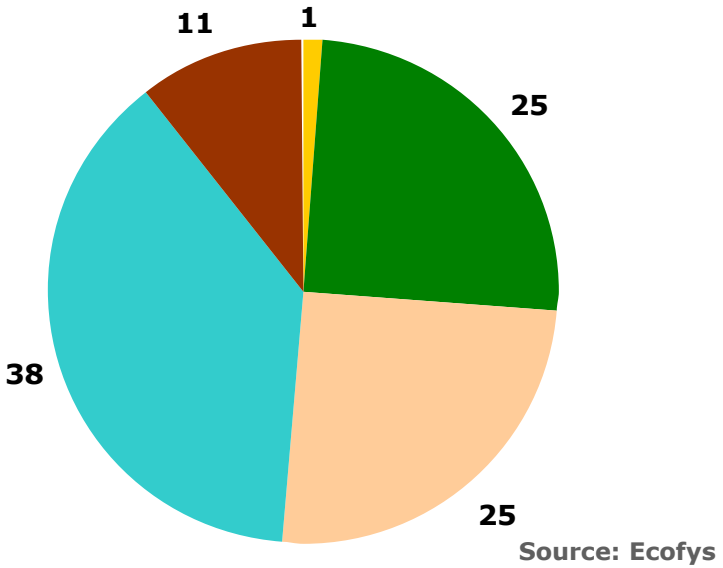


Results on residues and waste

In total, ~100 EJ of potential for residues and waste was found for 2050, divided into 5 categories

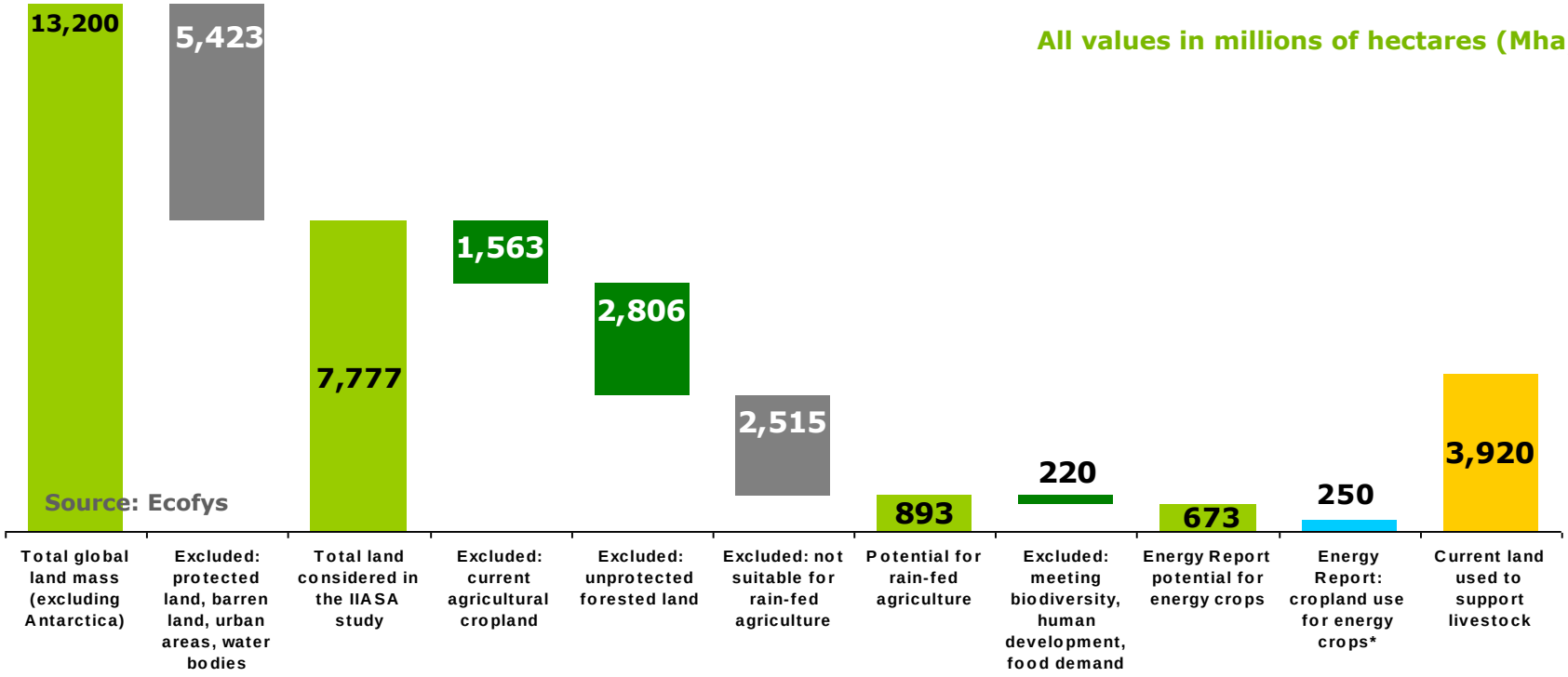
- Oils and fats (1 EJ):
  - Animal fat
  - Used cooking oil
- Forestry residues and wood waste (25 EJ):
  - Logging residues - ~5 EJ
  - Wood processing residues - ~10EJ
  - Wood waste - ~10EJ
- Agricultural residues (25 EJ):
  - Cereals
  - Rapeseed
  - Coffee
  - Soy
- Wet waste and residues (38 EJ):
  - Sugar beet processing residues
  - Potato processing residues
  - Manure
  - Oil palm empty fruit bunches
  - Palm oil mill effluent
  - Sugar cane
  - Cassava
  - Wet municipal solid waste
- Dry waste (11 EJ):
  - Dry municipal solid waste

Residue and waste potential found in the Scenario for 2050, divided into 5 categories



All values in EJ, for 2050

Results on land potential for rain-fed agriculture of energy crops in the Energy Report

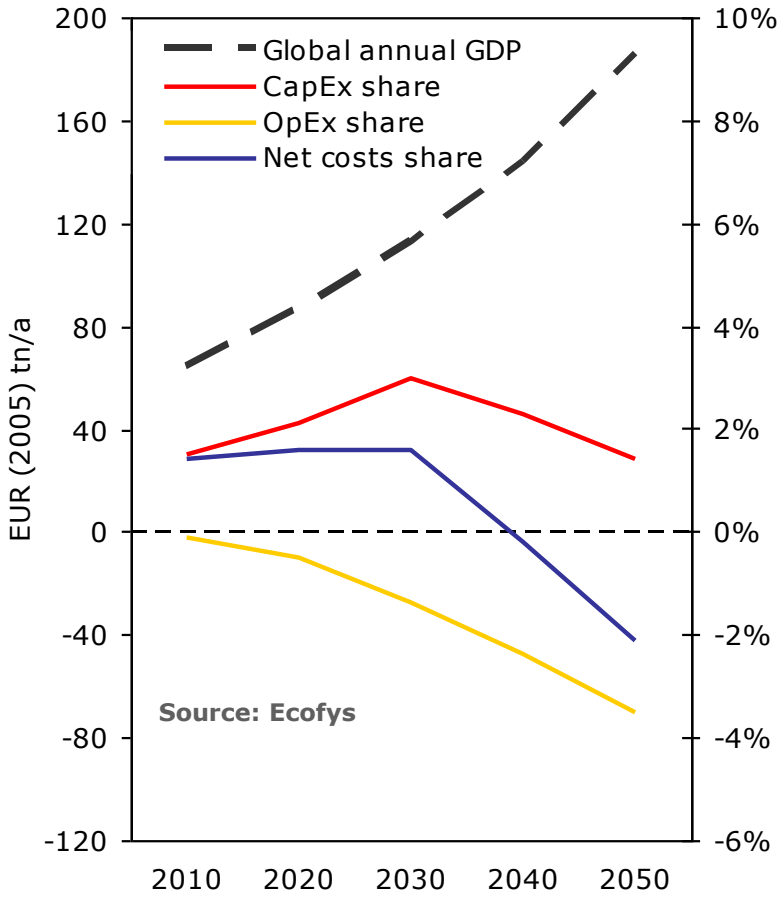


The following slides will explain how we arrived at these results

*** Cropland use for energy crops in Energy Scenario is maximum amount used during the 2005 – 2050 timeframe. This maximum occurs in 2050.**

Global net costs will peak below 2% of GDP, and will turn to net savings after 2035

- Net annual costs peak just below ~2% in 2025, and turn into more than ~2% annual savings worldwide in 2050
- CapEx peaks at ~3% in 2030, then decreases to below ~1.5% in 2050
- Savings from saved energy rise constantly to ~3.5% in 2050, with increased growth after 2020



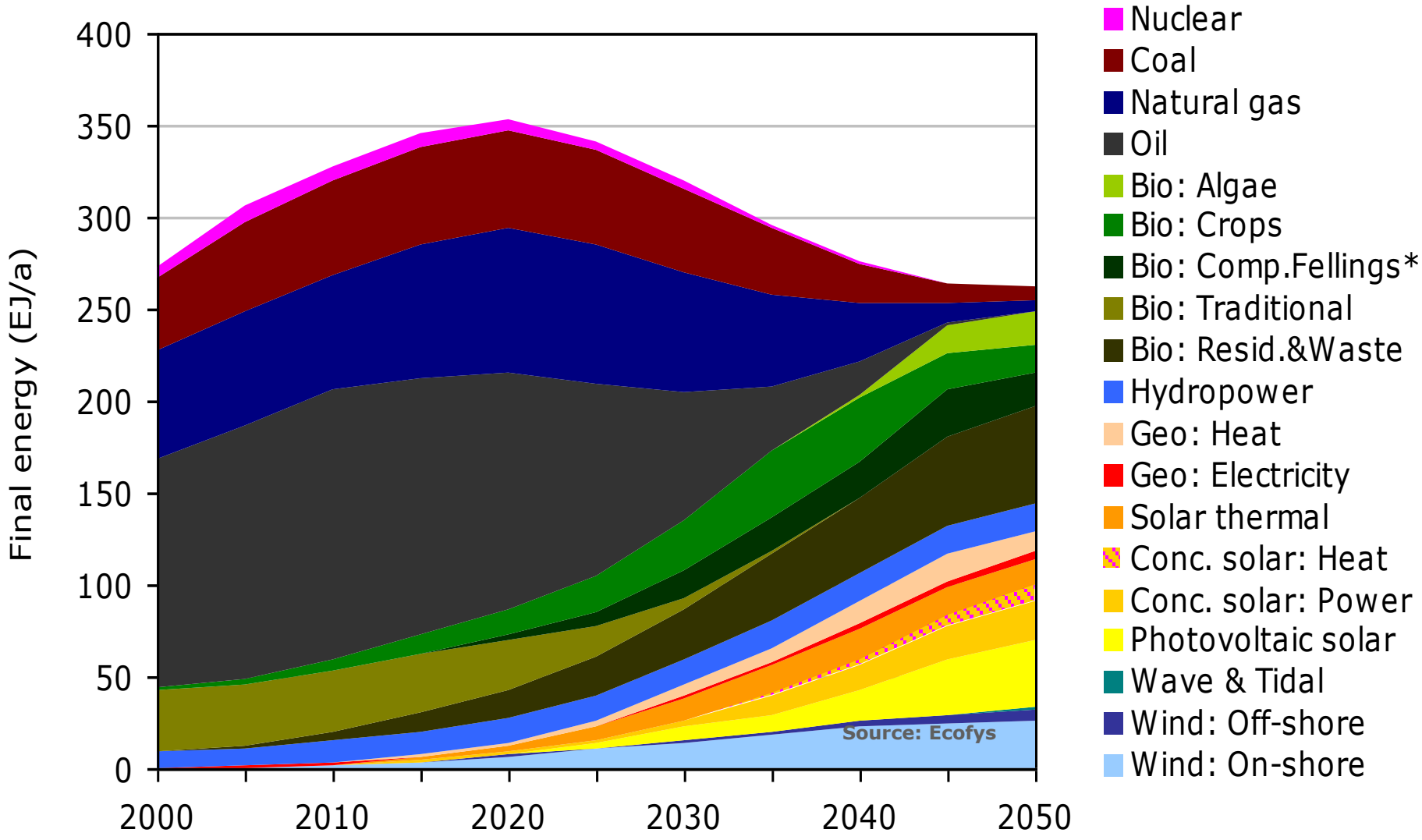
Strong leadership is required to make this transformation happen

	Demand			Supply
	Buildings	**Transport**	**Industry**	

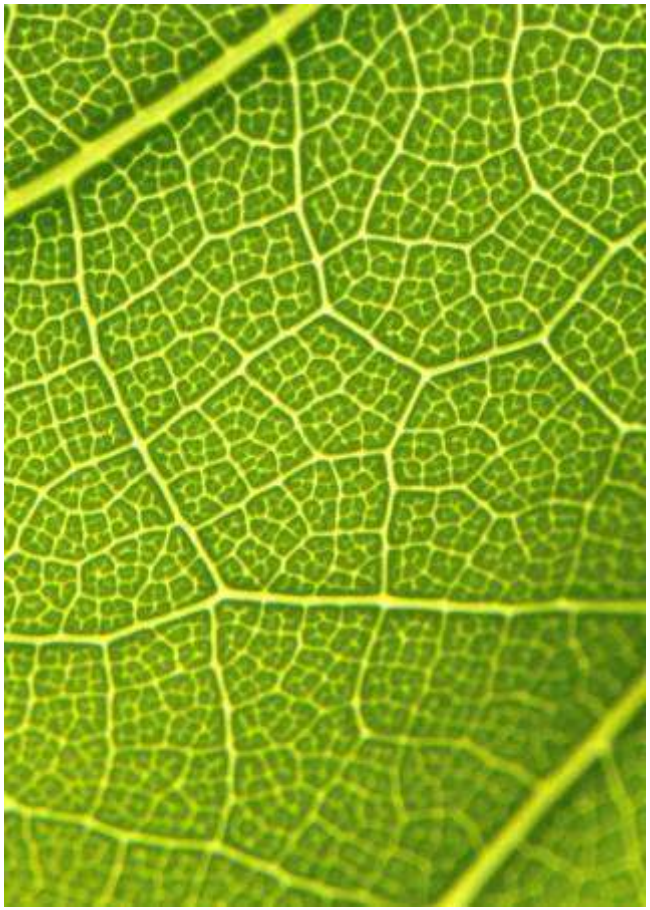
Setting consistent and ambitious **frame-works**	▪ Incentives to achieve **performance levels** of BAT*
	  ▪ in 5-10 yrs for all new stock
	  ▪ in 20-30 yrs for existing stock (retrofit)
	▪ "Top-runner" approach to appliances
		▪ **Performance standards** on fuel efficiency for all transport modes
		▪ Incentives to shift to rail, especially for freight
			▪ Incentives to achieve **performance levels** of BAT*
			  ▪ now for new plants
			  ▪ in 10-20 yrs for existing plants
			▪ Optimal recycling rates
			▪ Incentives to stimulate Industry R&D
				▪ **Comprehensive**, reliable and flexible **support schemes** to incentivise deployment of renewable energy technologies
				▪ Connection obligations for grid operators
				▪ Optimisation of planning processes
				▪ Incentives to stimulate grid **infrastructure** investments

Public **invest-ments**	▪ Investment support for building retrofits	▪ Investments into public transport, e.g. (electric) rail **infrastructure**	▪ R&D into new production processes ▪ Recycling infrastructure	▪ R&D into dynamic grid stability and smart grids
Private leadership	▪ Incorporating **highest performance levels** into all building projects	▪ Pushing the development and deployment of **highest performance** transport modes	▪ Incorporating **highest performance** levels into all new plants ▪ Improving performance of existing plants with **long-term vision**	▪ Pushing the **development and deployment** of renewable power sources

*** BAT = best available technology, for buildings this would mean near-zero energy-use**


Final energy (EJ/a)
400
350
300
250
200
150
100
50
0
2000
2010
2020
2030
2040
2050
Source: Ecofys
Nuclear
Coal
Natural gas
Oil
Bio: Algae
Bio: Crops
Bio: Comp.Fellings*
Bio: Traditional
Bio: Resid.&Waste
Hydropower
Geo: Heat
Geo: Electricity
Solar thermal
Conc. solar: Heat
Conc. solar: Power
Photovoltaic solar
Wave & Tidal
Wind: Off-shore
Wind: On-shore

Thank you!



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sustainable energy

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