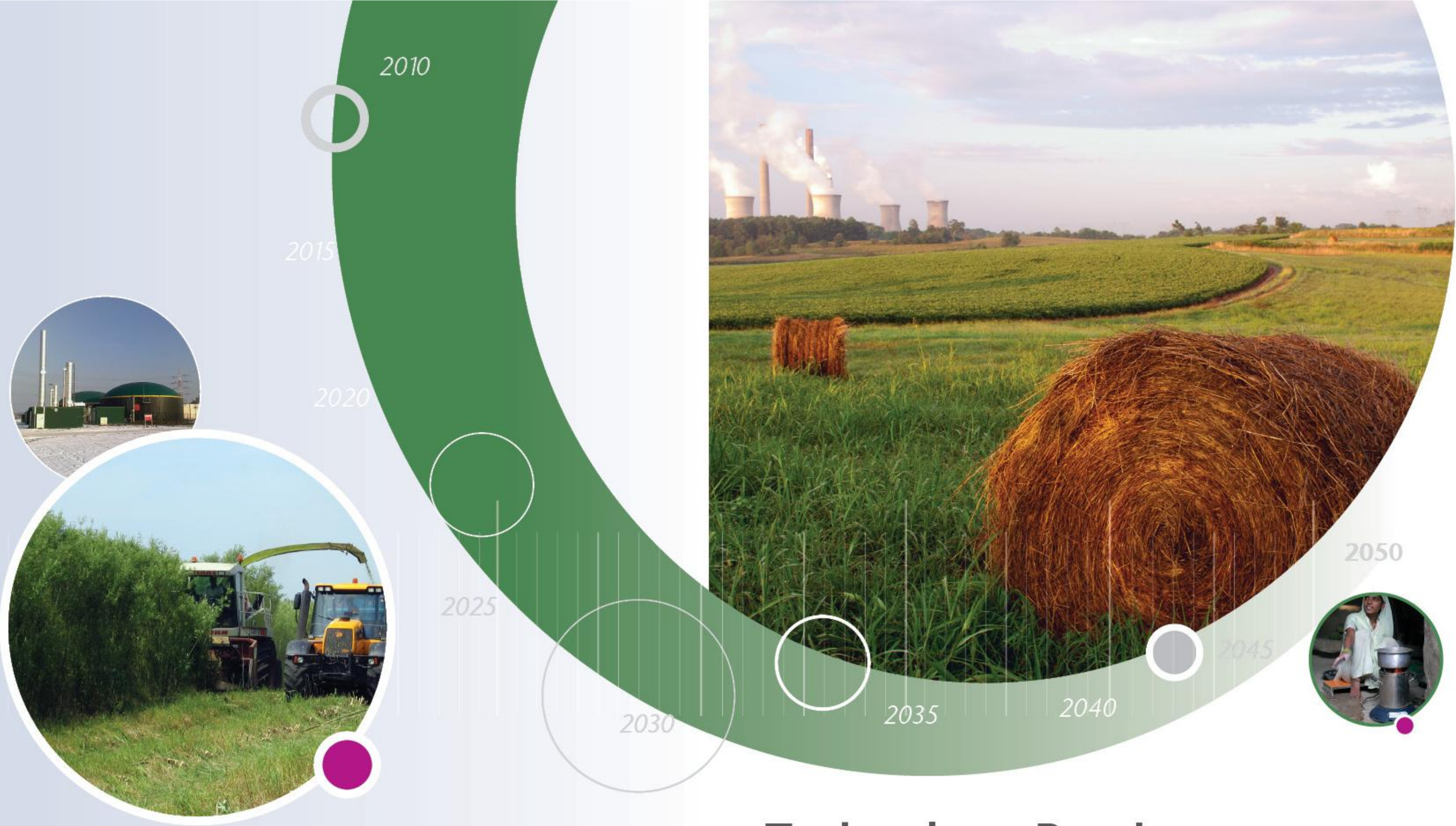

Technology Roadmap

Bioenergy for Heat and Power

International Energy Agency

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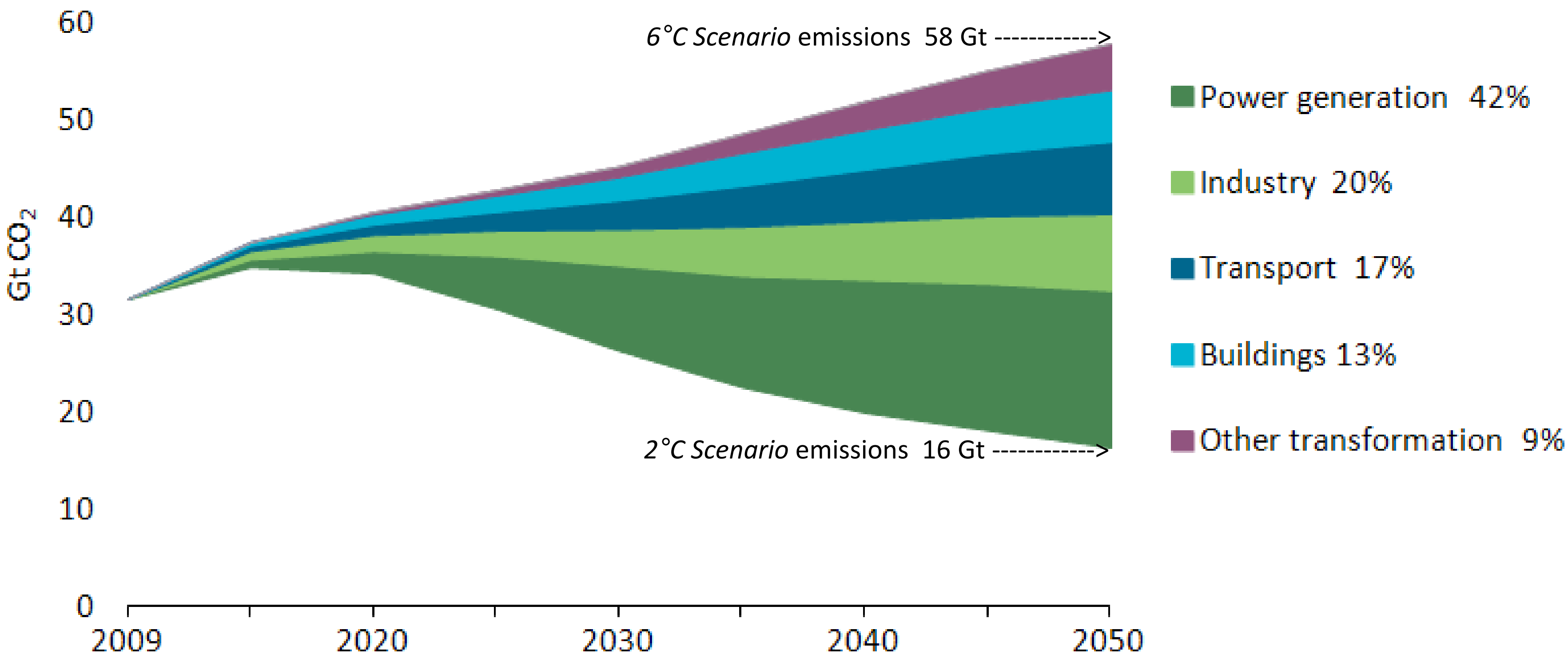
Bioenergy Analyst

Moscow, 04.06.2012

2°C Scenario – towards a low-carbon energy sector



Source: Energy Technology Perspectives 2012 (to be released 11 June 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 support policies

Overview on Bioenergy Technologies

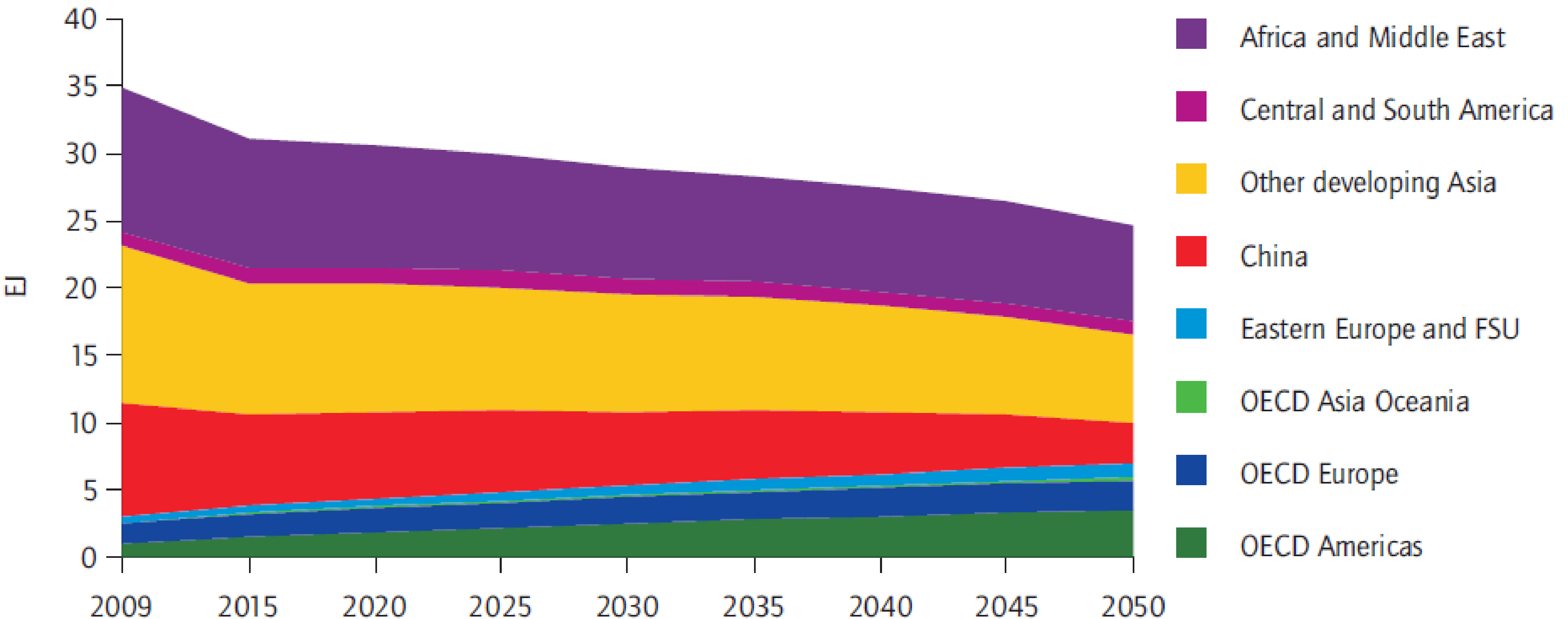
	Basic and applied R&D	Demonstration	Early commercial	Commercial
Biomass pretreatment	Hydrothermal treatment	Torrefaction	Pyrolysis	Pelletisation/ briquetting
Anaerobic digestion	Microbial fuel cells		2-stage digestion Biogas upgrading	1-stage digestion Landfill gas Sewage gas
Biomass for heating			Small scale gasification	Combustion in boilers and stoves
Biomass for power generation				
Combustion		Stirling engine	Combustion with ORC	Combustion and steam cycle
Co-firing		Indirect co-firing	Parallel co-firing	Direct co-firing
Gasification	Gasification with FC	BICGT BIGCC	Gasification with engine	Gasification with steam cycle

Note: ORC = Organic Rankine Cycle; FC = fuel cell; BICGT = biomass internal combustion gas turbine; BIGCC = biomass internal gasification combined cycle

Source: Modified from Bauen *et al.*, 2009

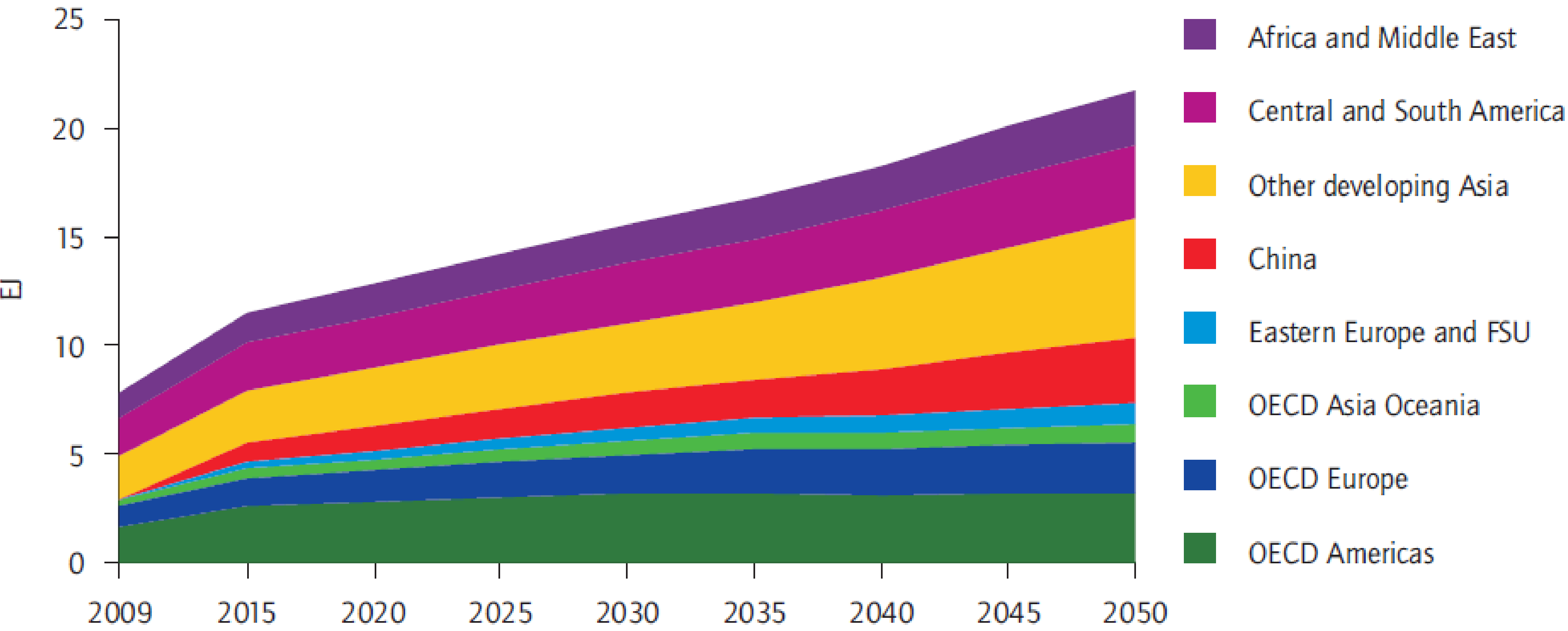
- A large number of conversion routes for heat and/or power exist
- More RD&D is needed to get promising pre-commercial technologies to the market to prove they can meet cost and GHG targets

Bioenergy consumption in buildings declines



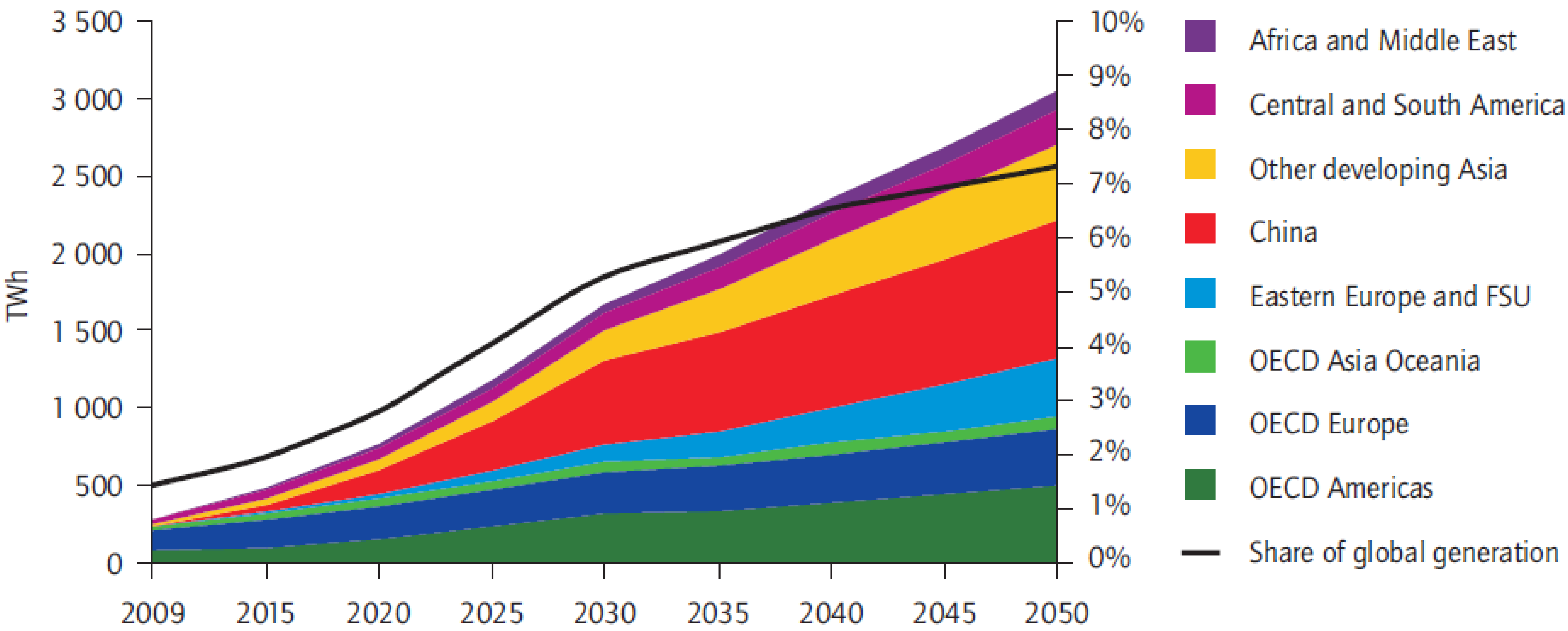
- **Traditional biomass use is replaced with more efficient cookstoves, and alternative fuels**
- **Buildings becoming more energy-efficient**

Industry set to triple consumption of bioenergy

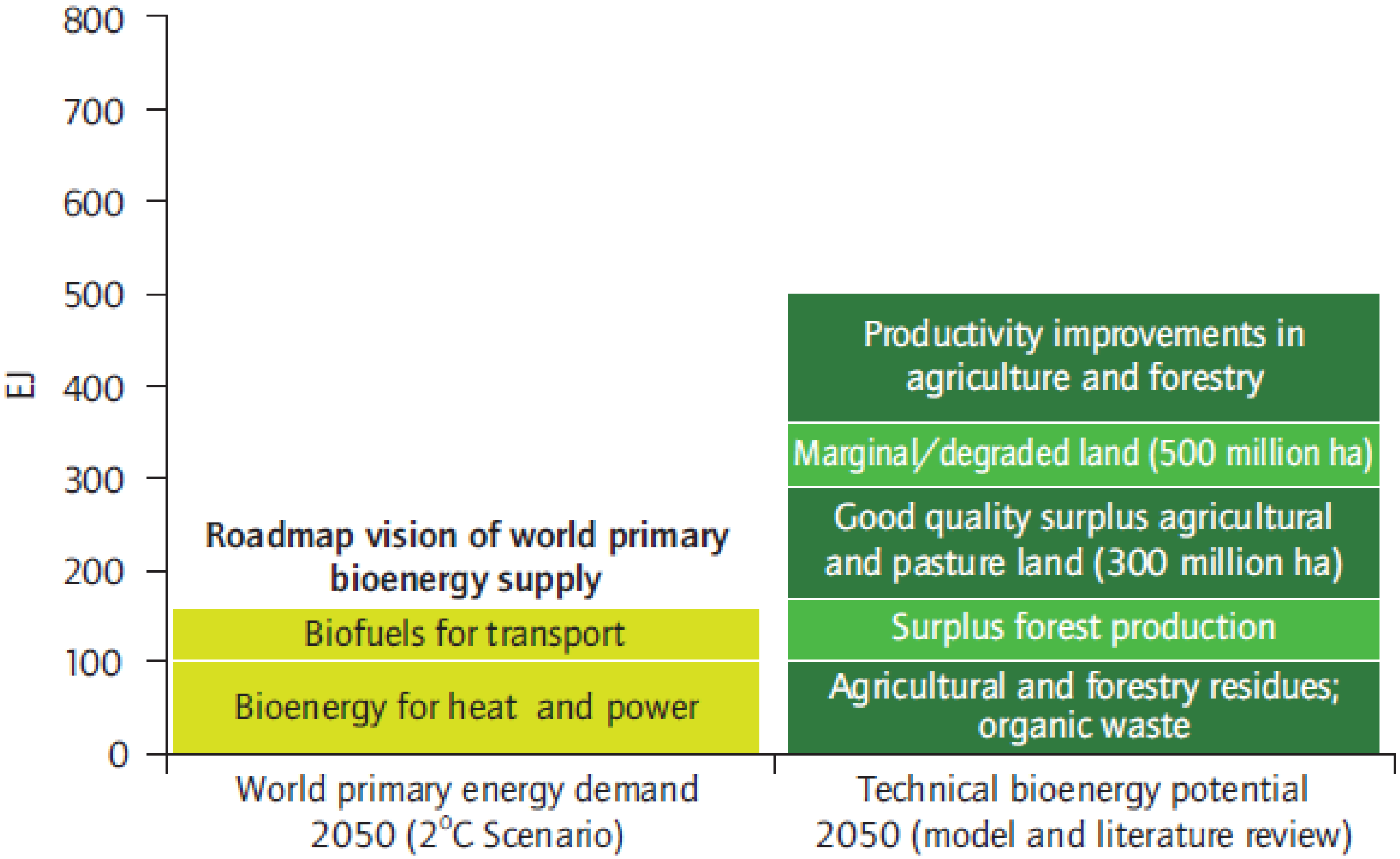


- **Bioenergy becoming increasingly important for production of <u>high temperature</u> heat**

World bioenergy electricity supply to grow more then ten-fold



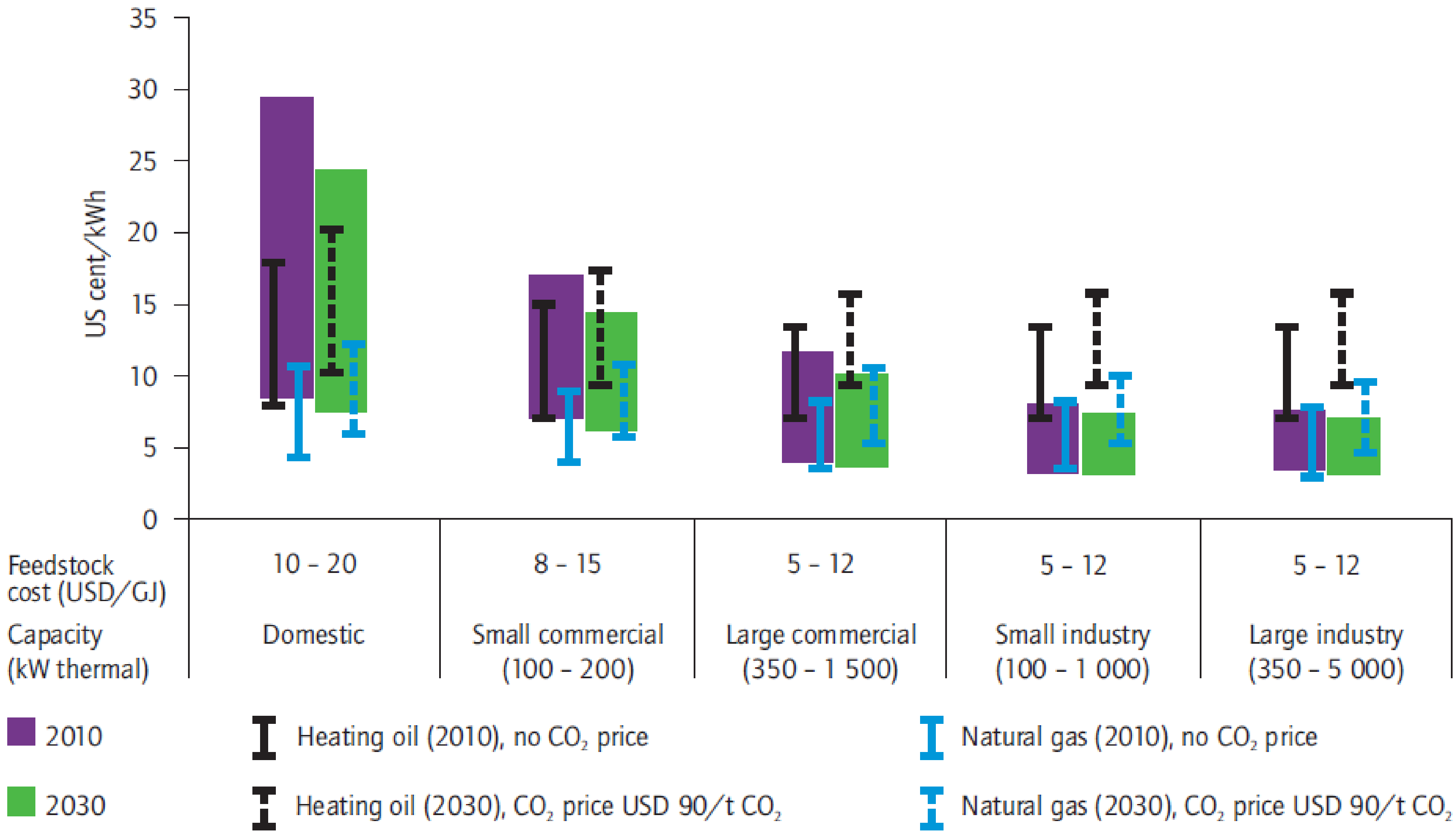
Biomass supply prospects - uncertainties remain



Source: Based on IPCC SRREN, 2011

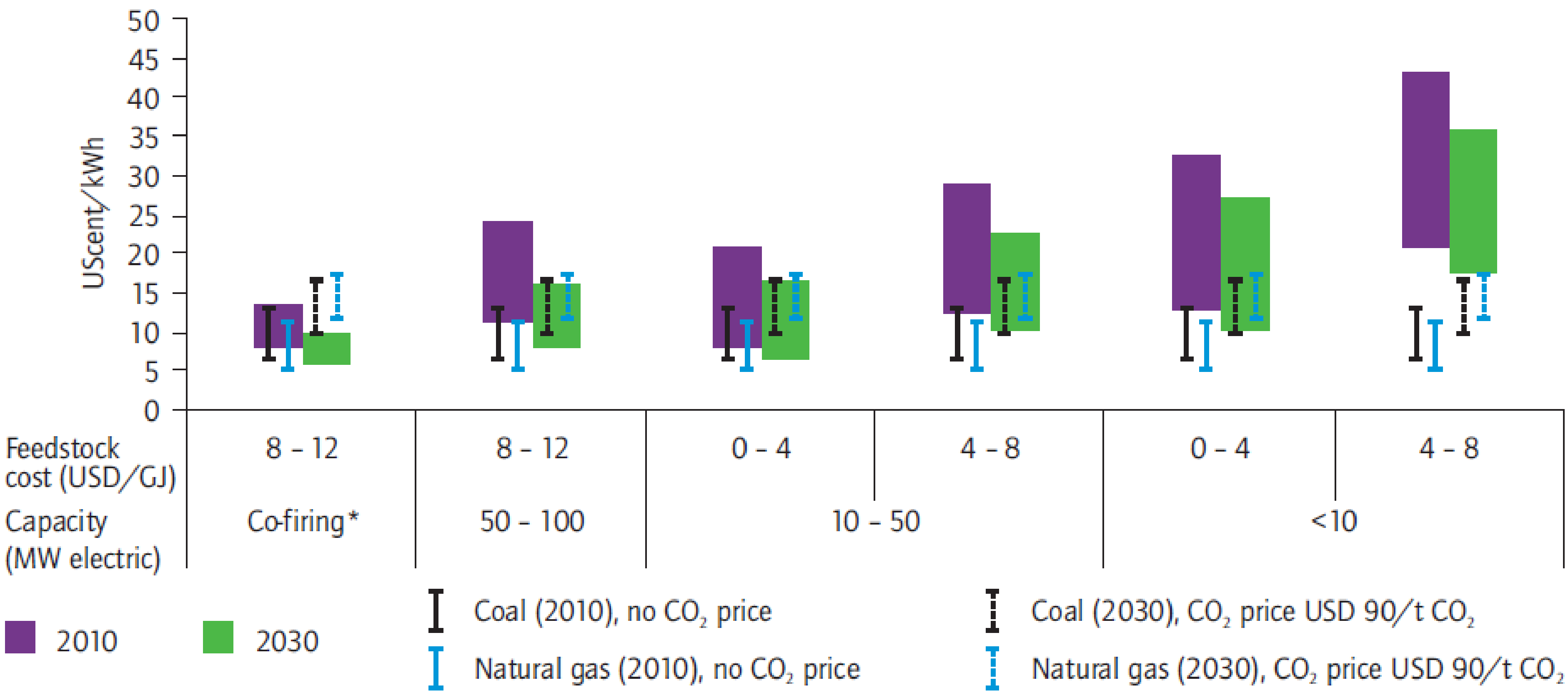
- **Biomass demand for heat and power reaches 5-7 billion tons in 2050**
- **Intermediate targets should be adopted to enhance international biomass trade, and assess costs and sustainability impact**

Bioenergy – a competitive heat source in many circumstances



Source: IEA analysis based on AEA (2011), DECC (2011), IPCC (2011), Mott MacDonald (2011), Uslu *et al.* (2012).

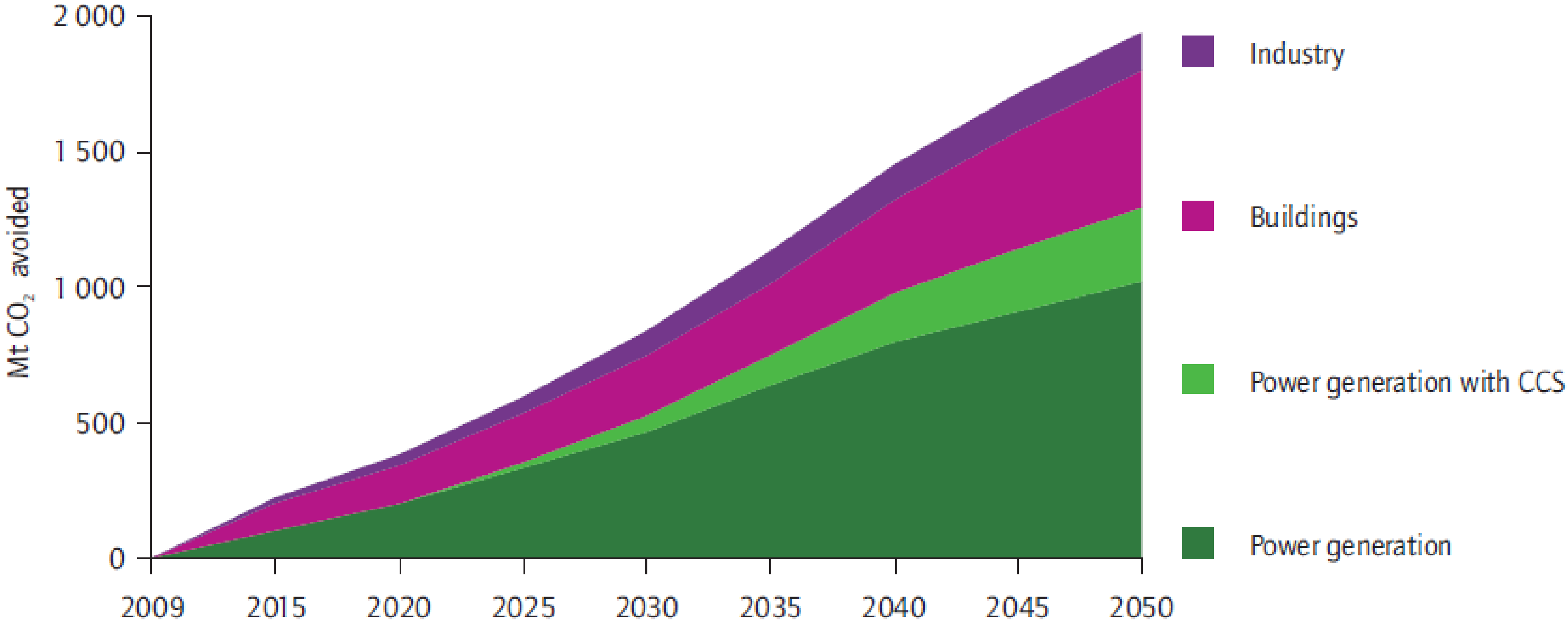
Bioenergy electricity generation costs are strongly scale-dependend



*Co-firing costs relate only to the investment in additional systems needed for handling the biomass fuels, with no contribution to the costs of the coal-fired plant itself. Fossil electricity generation costs are not capacity specific.

Source: IEA analysis based on DECC (2011), IPCC (2011), Mott MacDonald (2011), Uslu *et al*. (2012).

2 Gt $CO_{2\text{-eq}}$ emission reductions through bioenergy heat and power



Note: This assumes that biomass is sourced sustainably with very low life-cycle GHG emissions.

- Compared to a business-as-usual (6°C) scenario bioenergy could provide substantial emission savings:
  - 1 Gt CO_2-eq. through bioenergy electricity + 0.3 Gt CO_2-eq. through bioenergy electricity equipped with CCS
  - A total of 0.7 Gt CO_2-eq. in industry and buildings

Technology milestones

2012 | 2015 | 2020 | 2025 | 2030

1st commercial-scale plant

- Torrefaction
- Pyrolysis
- Bio-SNG
- BIGCC

- Commercial deployment

Efficiency & cost improvements

- Low-cost, advanced biomass cookstoves

- Sustained deployment through economically viable supply chains

- Create "off the shelf" plant design

- Increase average electricity generation efficiency of new plants by 5%

Key Policy Actions

- **Ambitious policy framework:**
  - Create a long-term policy framework for bioenergy, taking into consideration specifics of electricity and heat markets
- **Sustainability:**
  - Implement internationally agreed sustainability criteria for bioenergy
  - Set medium-term targets for sustainable biomass supply to help establish supply chains
- **International Collaboration:**
  - Engage in international collaboration on capacity building and technology transfer
  - Introduce technical standards for biomass feedstocks to promote international trade
  - Promote the alignment of biofuel and other related policies (agriculture, forestry, rural development)