The future of bioenergy – an outlook

Prof. Univ.-Doz. Dipl.-Ing Dr. Ingwald Obernberger

BIOS BIOENERGIESYSTEME GmbH

Inffeldgasse 21b, A-8010 Graz, Austria

TEL.: +43 (316) 481300; FAX: +43 (316) 4813004

E-MAIL: office@bios-bioenergy.at

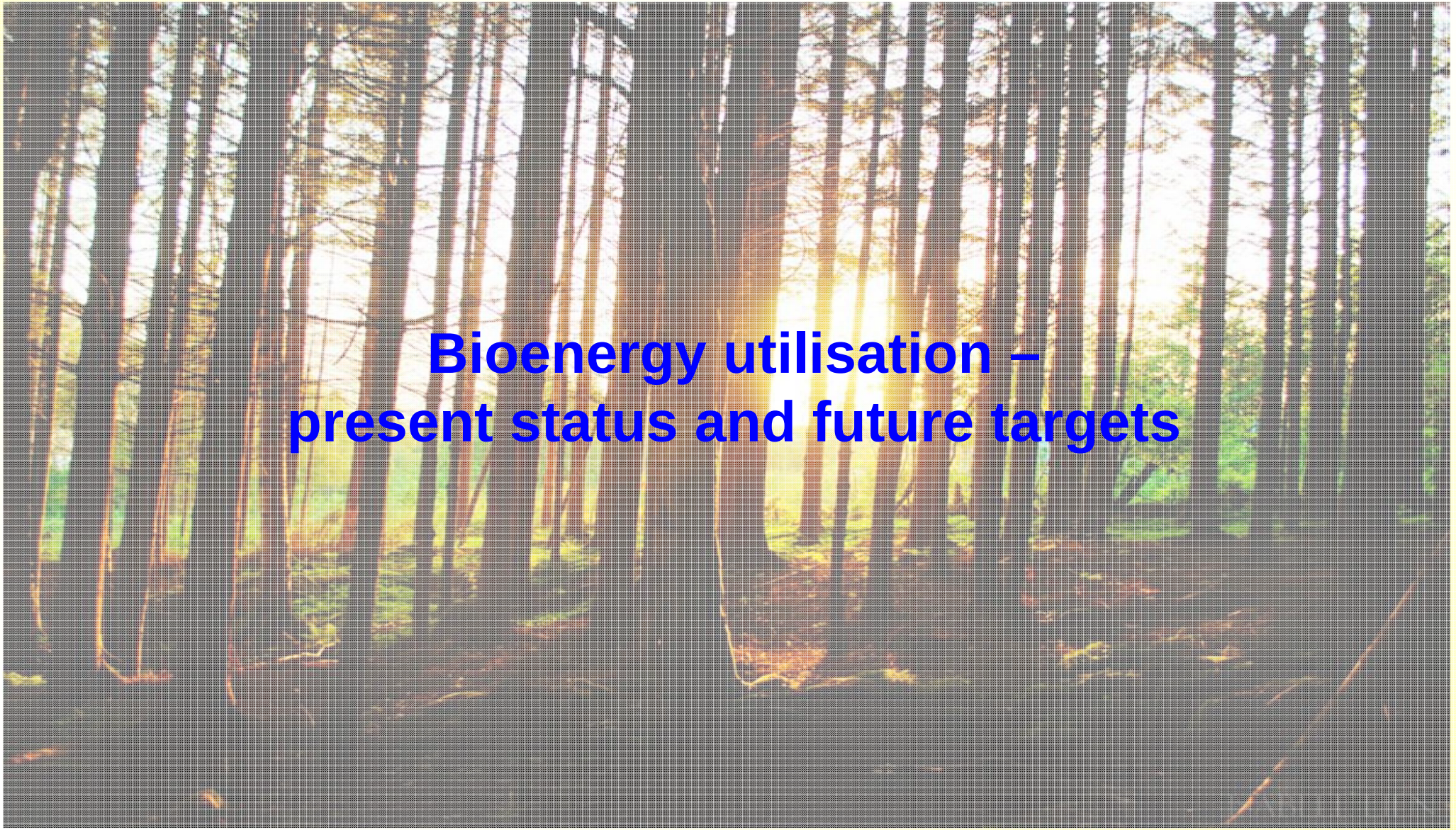
HOMEPAGE: http://www.bios-bioenergy.at

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Contents

- **Bioenergy utilisation – present status and future targets**
  - Worldwide
  - Europe
- **Development directions and future trends**
  - Resources, fuels
  - Heating and cooling
  - Power production and CHP
  - Biofuels and syngas
  - Biorefineries
- **Summary**

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

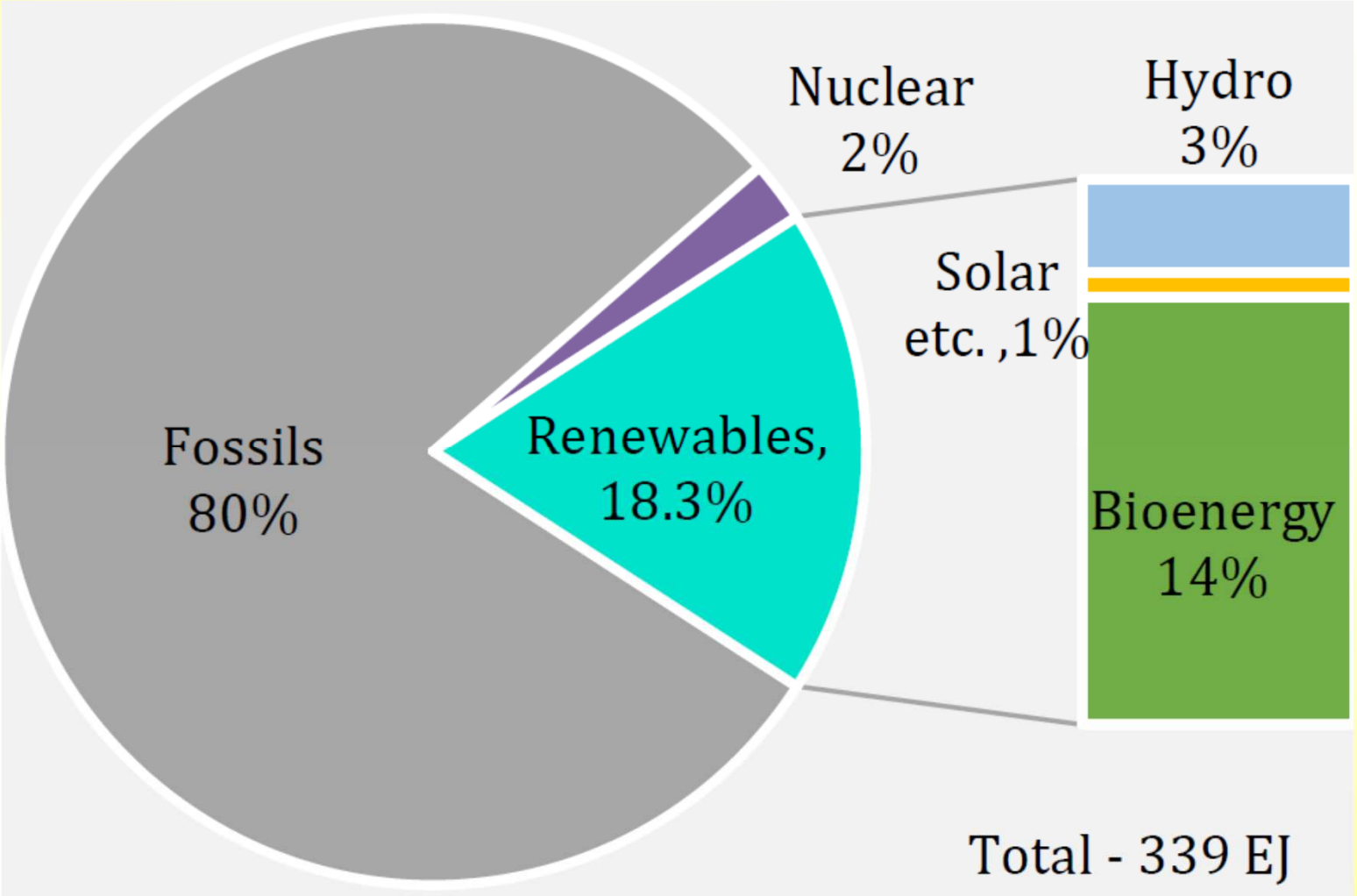


Bioenergy utilisation – present status and future targets

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Present status of bioenergy – worldwide (I)

Gross final energy consumption of energy sources in 2011

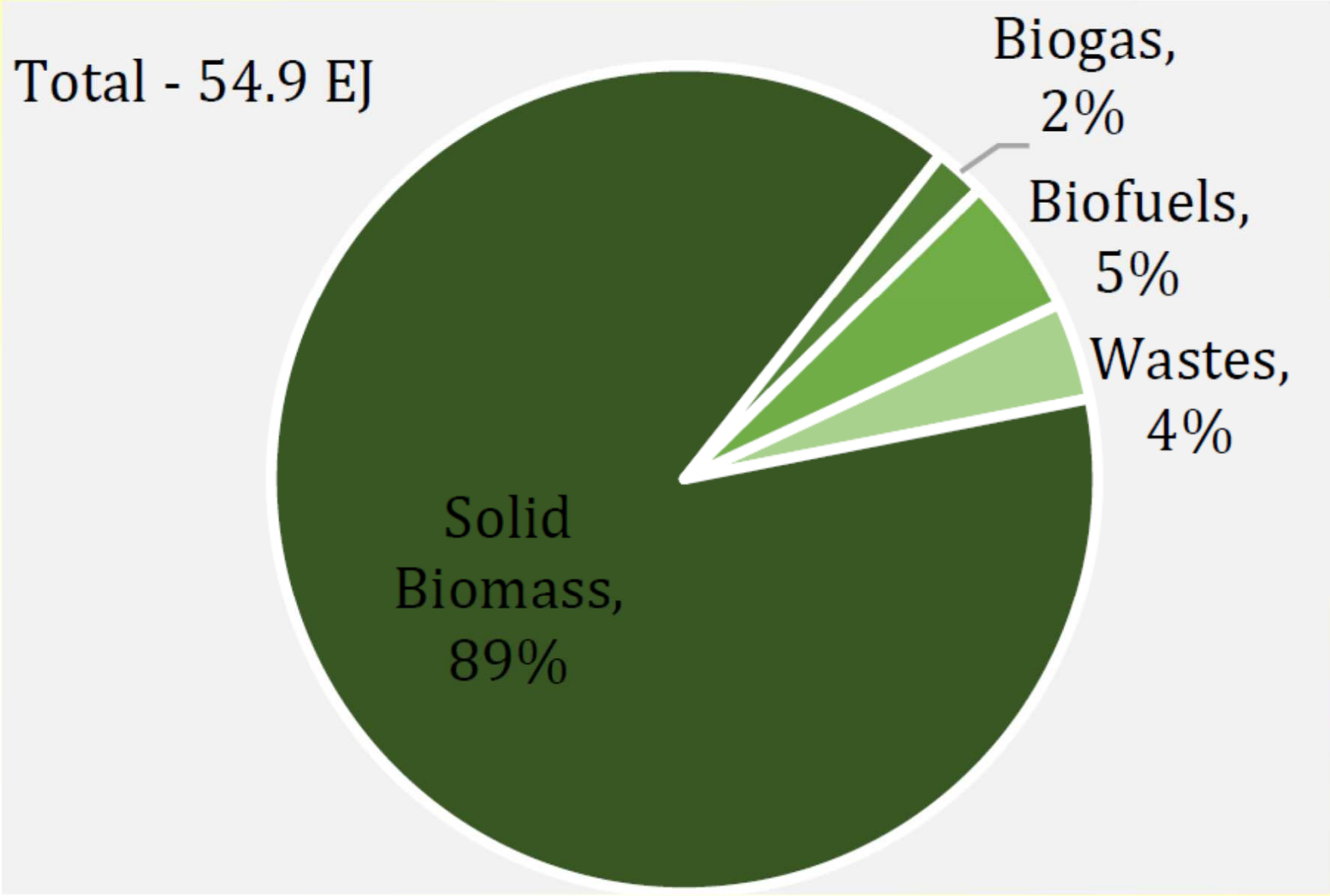


Source: World Bioenergy Association: WBA Global Bioenergy Statistics 2014

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Present status of bioenergy – worldwide (II)

Total primary energy supply of biomass in 2011



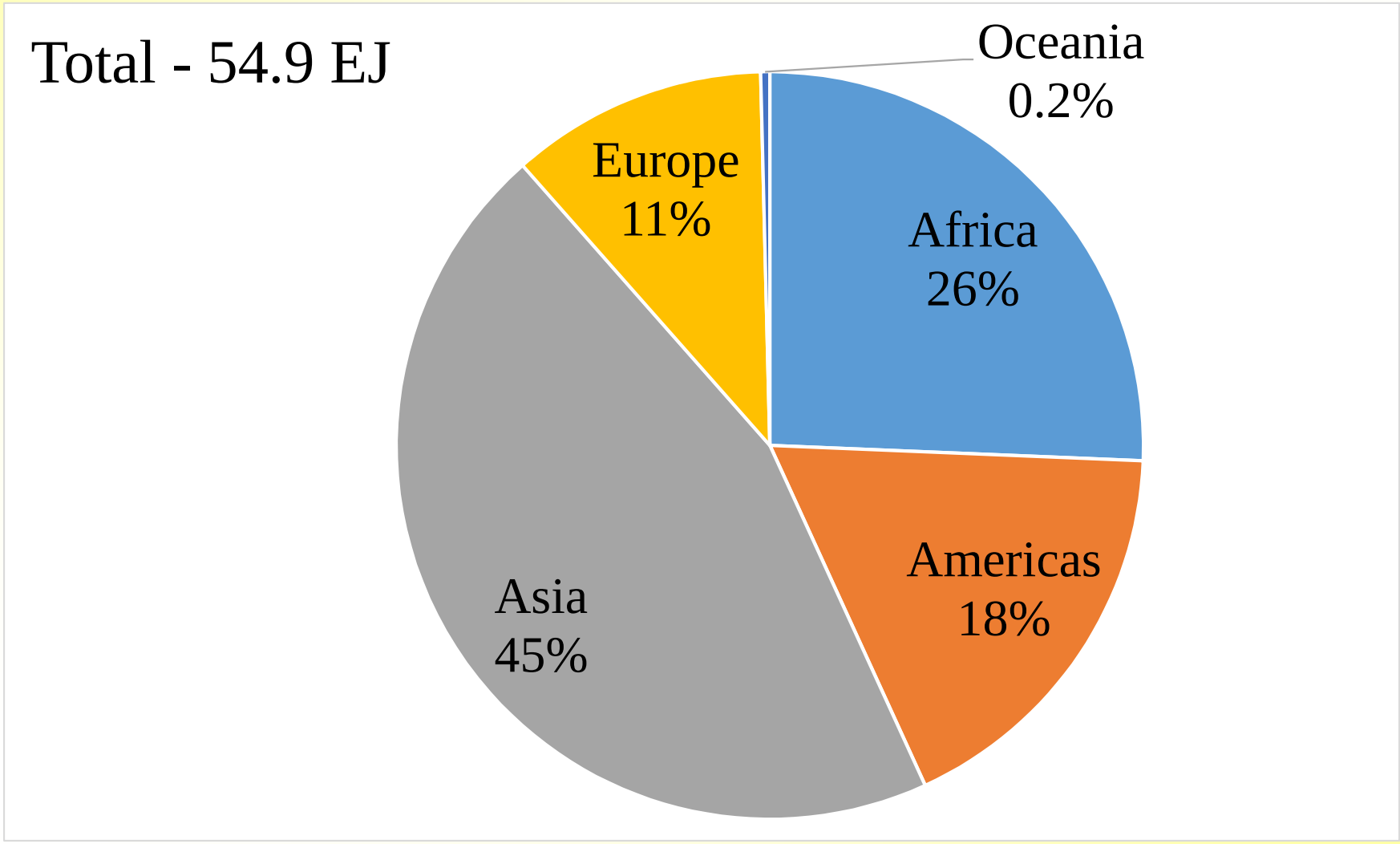
Biomass for electricity	5.84 EJ	11 %
Biomass for liquid biofuels	2.76 EJ	5 %
Biomass for heat	46.30 EJ	84 %

Source: World Bioenergy Association: WBA Global Bioenergy Statistics 2014

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Present status of bioenergy – worldwide (III)

Total primary energy supply of biomass in continents in 2011

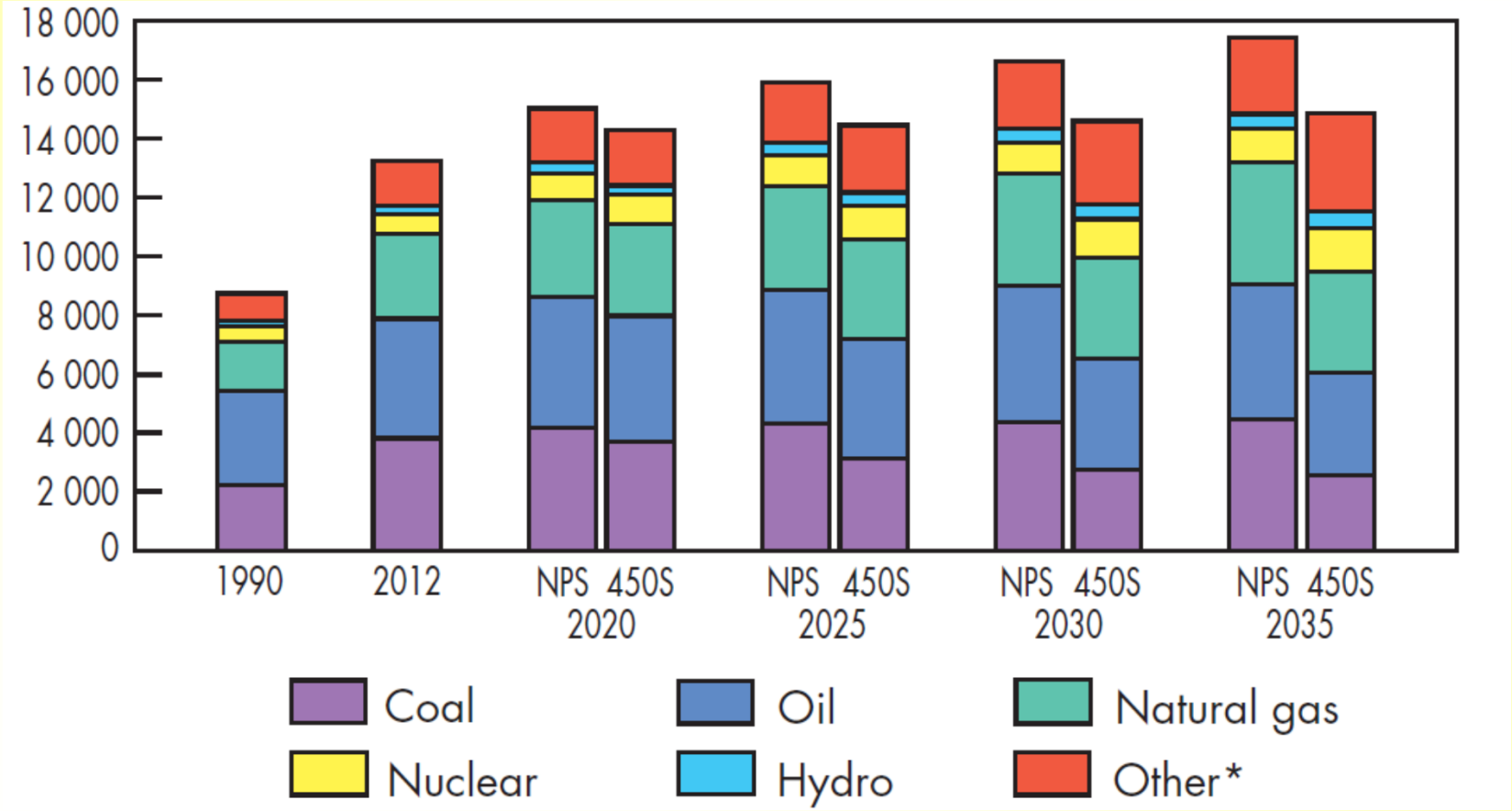


Source: World Bioenergy Association: WBA Global Bioenergy Statistics 2014

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Development and future targets of bioenergy – worldwide (IV)

Total primary energy supply (Mtoe) - outlook

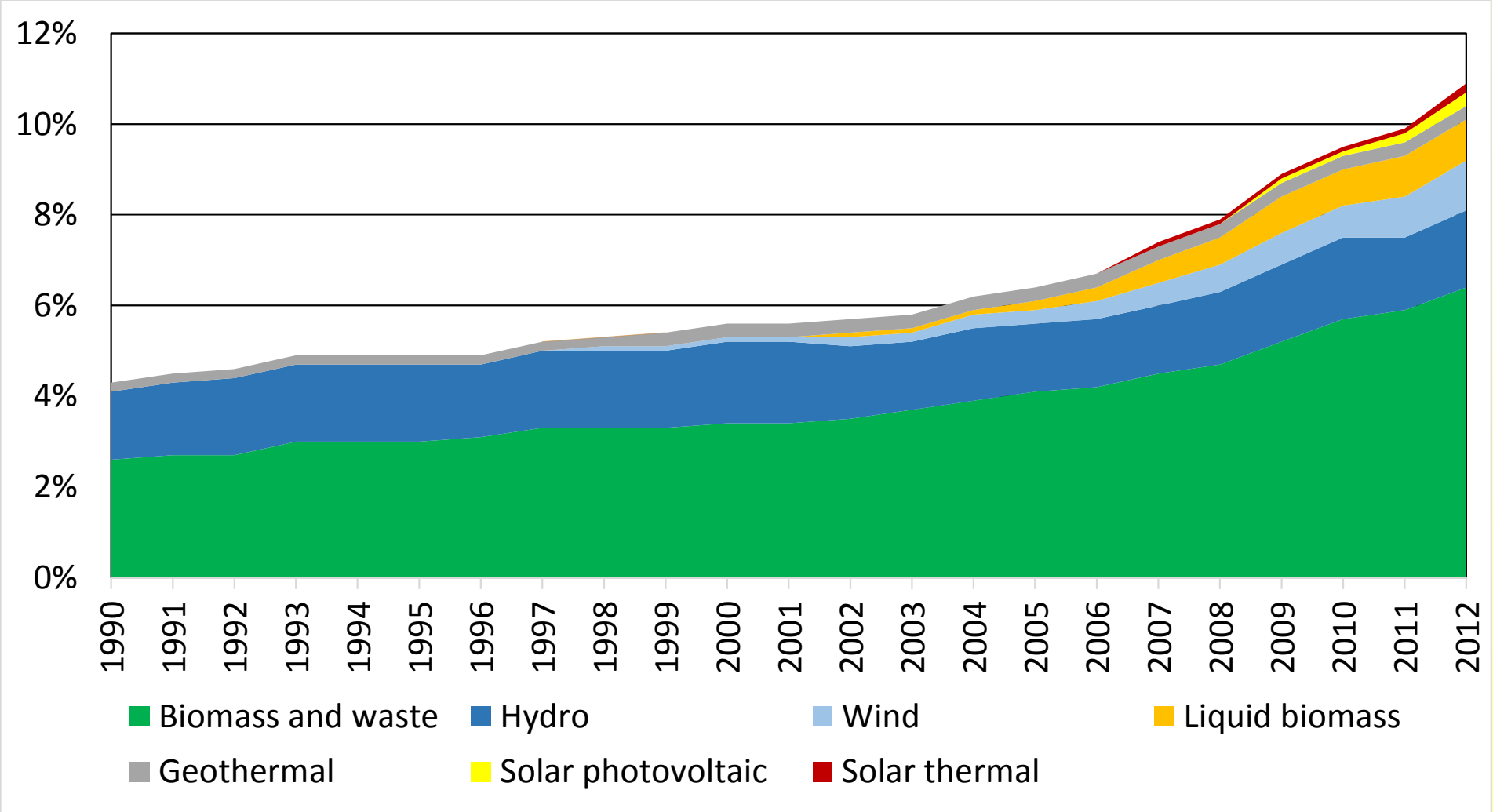


Explanantions: NPS_ New Policies Scenario (based on policies under consideration)
450S: Scenario based on a plausible post-2013 climate-policy framework to stabilise the long-term concentration of global greenhouse gases at 450 ppm CO_2-equivalent
*) *biofuels and waste, geothermal, solar, wind, tide, etc.*
Source: IEA Key World Energy Statistics 2014

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Development and future targets of bioenergy – EU level (I)

Contribution of renewable energy sources to gross energy consumption in EU28

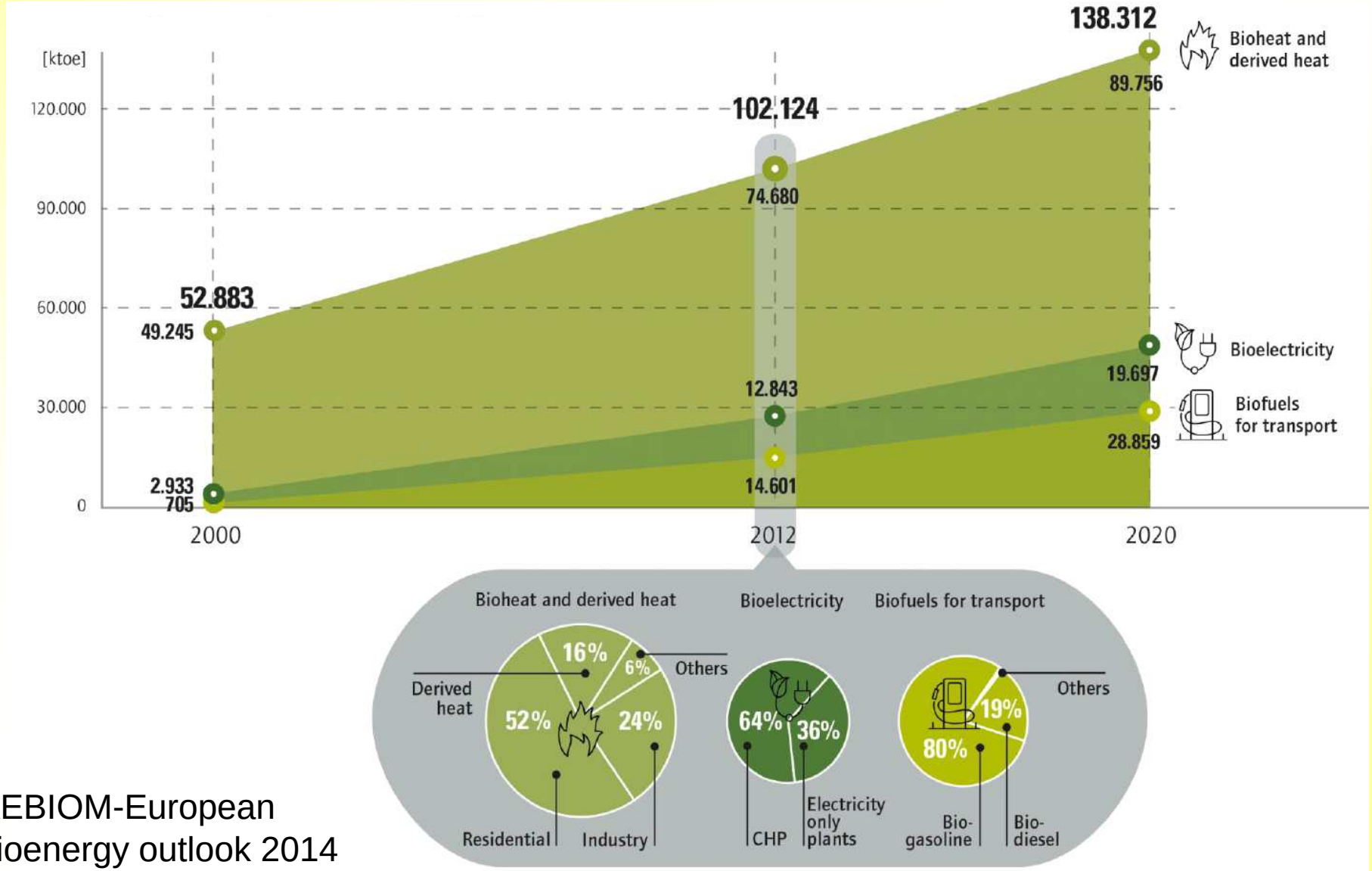


Source: Eurostat 2014

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Development and future targets of bioenergy – EU level (II)

Final energy consumption for bioenergy in EU28



Source: AEBIOM-European Bioenergy outlook 2014

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Present status and future targets of bioenergy – EU level (VI)

➢ EU Policies

- **2020 climate and energy package:**
  - 20% reduction in EU greenhouse gas emissions from 1990 levels
  - Raising the share of EU energy consumption produced from renewable resources to 20%
  - 20% improvement in the EU's energy efficiency.
- **2030 framework for climate and energy policies**
  - a 40% cut in greenhouse gas emissions compared to 1990 levels
  - at least a 27% share of renewable energy consumption
  - a 30% improvement in energy efficiency (compared to projections)

➔ **Bioenergy has the largest short and medium-term potential to contribute to the achievement of these targets**

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Development and future targets of bioenergy – EU level (V)

- **About 500,000 jobs created from bioenergy in 2012**

Source: AEBIOM-European Bioenergy outlook 2014

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Development directions and future trends

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – resources, fuels

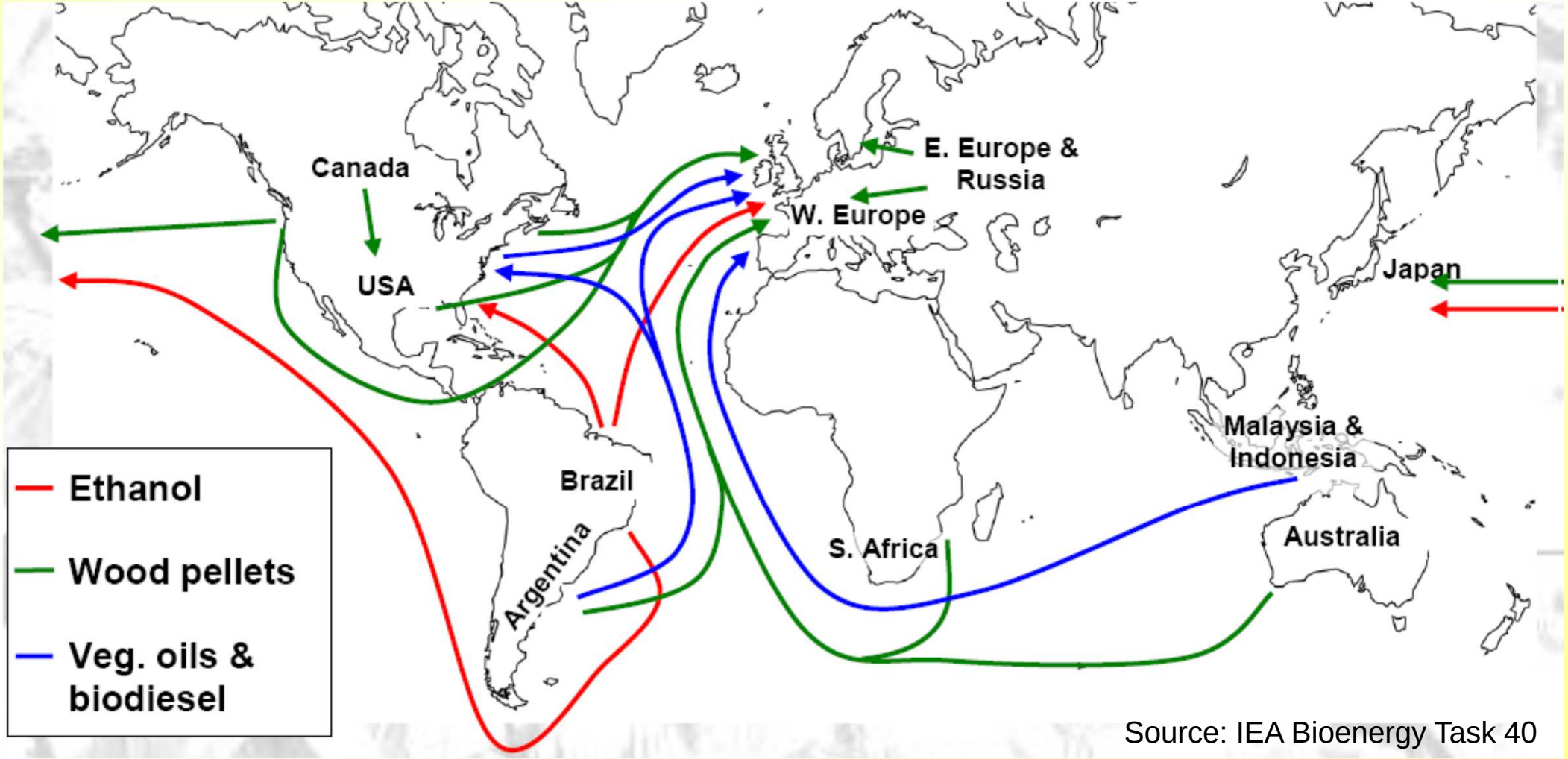
- From conventional wood fuels to new wood fuels (e.g. SRF) and agricultural fuels

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – resources, fuels

➢ From regional to international markets

Current main shipping lanes for biomass and biofuels for energy



Source: IEA Bioenergy Task 40

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – resources, fuels

➢ From conventional feedstocks to “designer fuels”

- **Objectives**
  - improve energy density
  - improve homogeneity
  - enhance conversion related fuel properties (e.g. ash melting properties)
- **Technologies**
  - pelletising
  - torrefaction
  - fuel blending + additives
  - Bio-char / bio-slurries
  - Bio-oil
- **Standardisation of designer fuels is an important issue for market development**

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends

➢ Heating and cooling

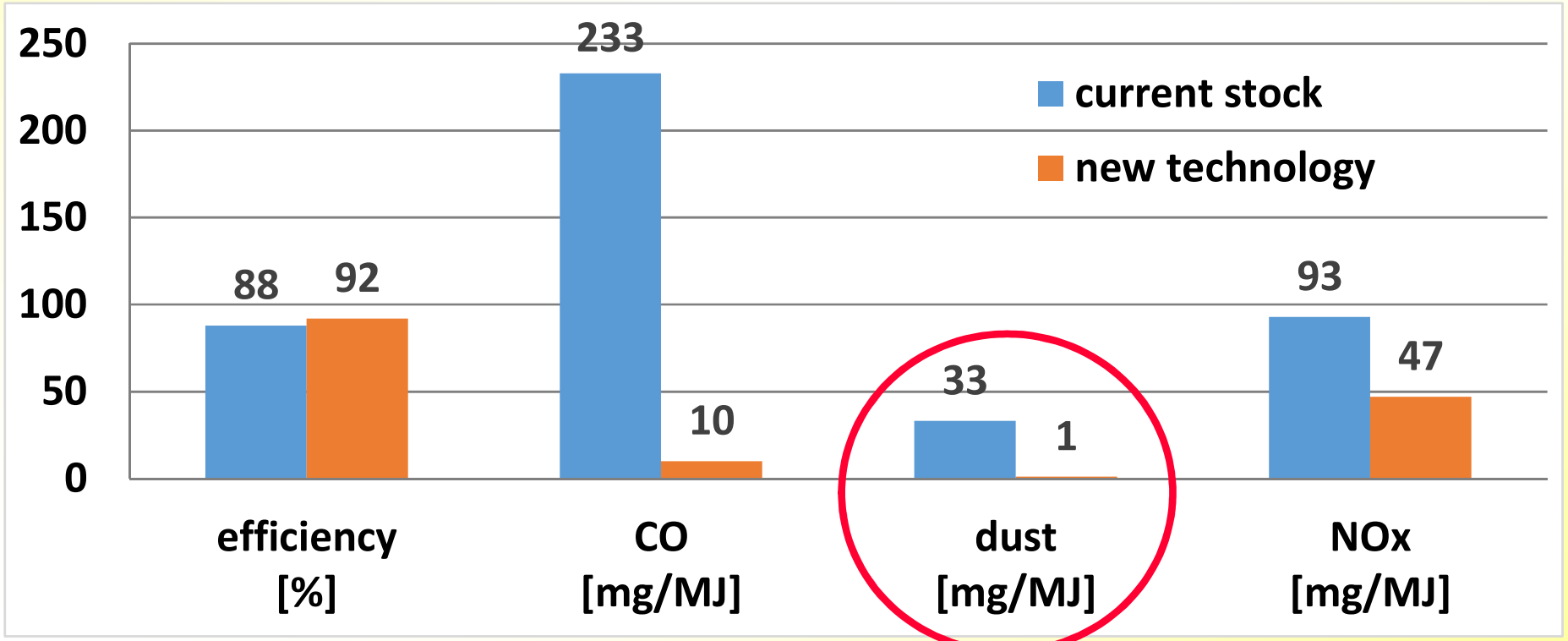
- Efficient and ultra-low emission residential combustion
- Clean and automatic stoves
- Hybrid and combined systems
- Process heating and cooling

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – heating and cooling

➢ Efficient and ultra-low emission residential biomass combustion

- Almost zero dust, CO and OGC emission operation without secondary measures seems possible
- Proven by results from the FP7 project EU-UltraLowDust (2010 – 2014)



Source: EU FP7 project EU-UltraLowDust
full load measurement results from a new 20 kW_{th} pellet/wood chip boiler technology

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – heating and cooling

➢ Clean and automatic logwood stoves

- **Represent a huge European market (about 400.000 sold units/year)**
- **Stock of applications is known to provide significant contributions to ambient air pollution regarding fine particulate matter, CO, OGC and PAHs**
- **Ongoing R&D shows that when implementing**
  - optimised combustion concepts
  - appropriate materials
  - automated process control

  significant emission reductions can be achieved
- **Goals for emission reduction by primary measures (improved combustion technology) and comparison with the current stock** (Ecodesign Lot 15 Prep. Study)
  - CO: <100 mg/MJ current stock: 3,000 mg/MJ
  - OGC <10 mg/MJ current stock: 233 mg/MJ
  - particulate matter: <20 mg/MJ current stock: 133 mg/MJ

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – heating and cooling

➢ Residential-scale hybrid and combined systems

- **Combinations of biomass boilers, solar heating, heat pumps, chillers and buffer storages**
  - increase overall system efficiencies
  - reduced emissions due to intelligent system combination
  - combined heating and cooling systems

55 kW pellet boiler
35 kW absorption chiller

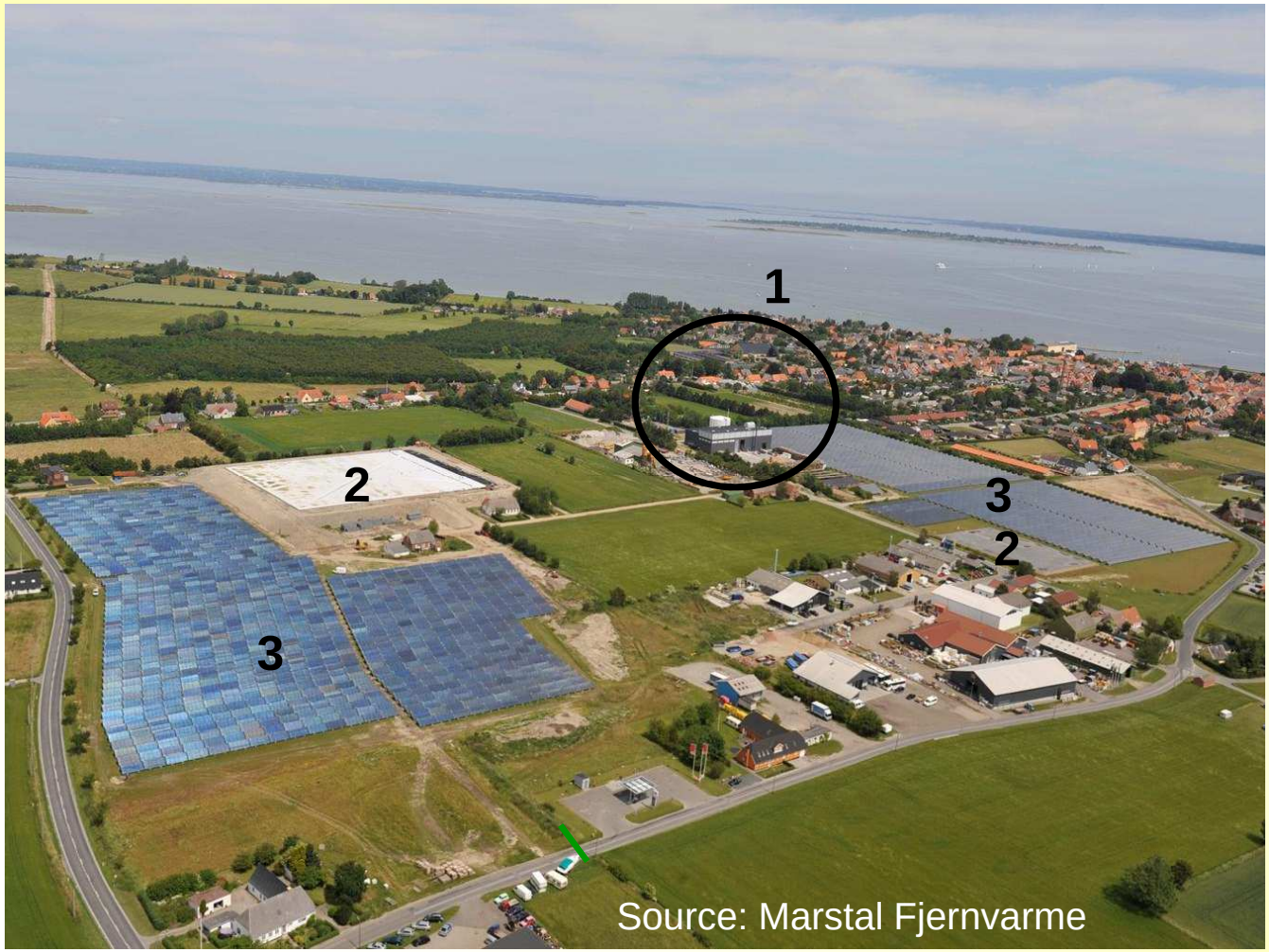
Source: ProEcoPolyNet, Best practice Sheet

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – heating and cooling

➢ Industrial-scale combined systems

- **Example: EU FP7 project SUNSTORE 4**



Source: Marstal Fjernvarme

(1) CHP plant including

- **4 MW_{th} biomass thermal-oil boiler**
  1 MW_{th} flue gas condensation unit
  750 kW_{el} ORC

  Output: heat: 19,300 MWh/a
  electricity: 3,000 MWh

- **1.5 MW_{th} CO_2 compressor driven heat pump;**
  Output: 1,200 MWh/a

(2) 85,000 m³ pit heat storage

(3) 33,300 m² solar collectors
Output: 13,500 MWh/a

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – heating and cooling

➢ Process heating and cooling

- **Integration in industrial processes (non-wood industry)**
- **Example: CHPC plant in the packing solutions sector**
  - 5.8 MW_{th} thermal oil boiler
  - 1.1 MW_{el} ORC unit
  - 2.4 MW absorption chiller
  - fuel: waste wood

Source: BIOS BIOENERGIESYSTEME GmbH (AT)

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends

- **Power production and CHP**
  - **Micro and small-scale CHP systems**
  - **Towards higher fuel flexibility and efficiency**

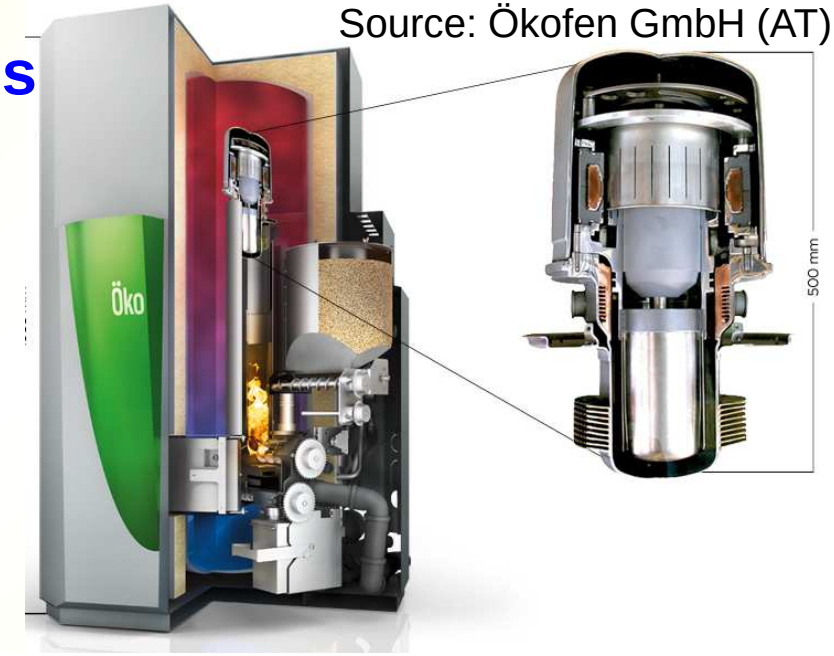
BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

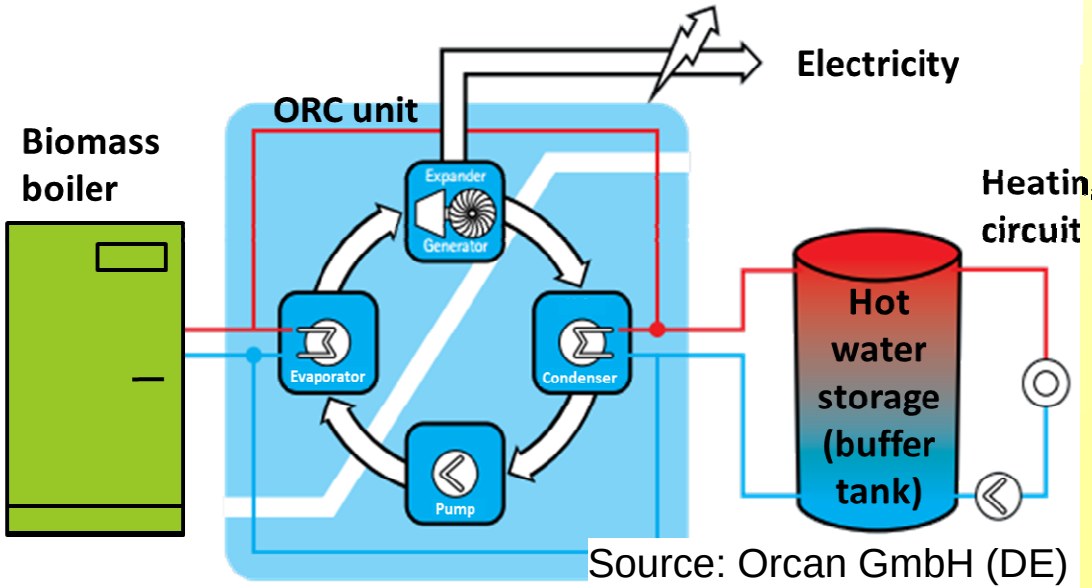
EU development directions and future trends – biomass micro CHP systems

➢ Combustion-based micro CHP systems

- **Thermoelectric generators**
  - nominal capacity: 10 - 100 W_{el}
  - application: grid-independent operation of stoves and boilers
- **Stirling engines**
  - nominal capacity: presently up to 5 kW_{el}
  - application: cover the heat and electricity consumption of buildings
- **Micro ORC systems**
  - nominal capacity: about 1 kW_{el}
  - application: cover the heat and electricity consumption of buildings

Source: Ökofen GmbH (AT)





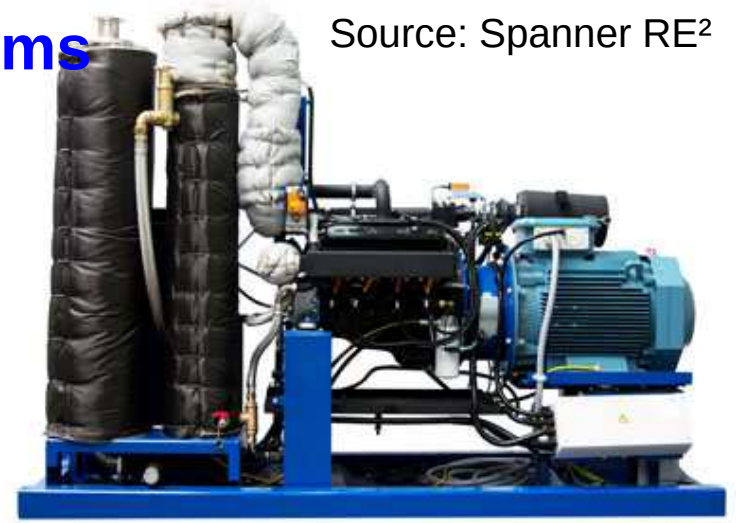
Source: Orcan GmbH (DE)

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – biomass small-scale CHP systems

➢ Gasification-based small-scale CHP systems

- **Spanner RE² (DE): 30 / 45 kW_{el}**
- **Entrade (DE): 22 kW_{el}**
- **Burkhardt GmbH (DE): 165 / 180 kW_{el}**



Source: Spanner RE²

Source: Burkhardt GmbH

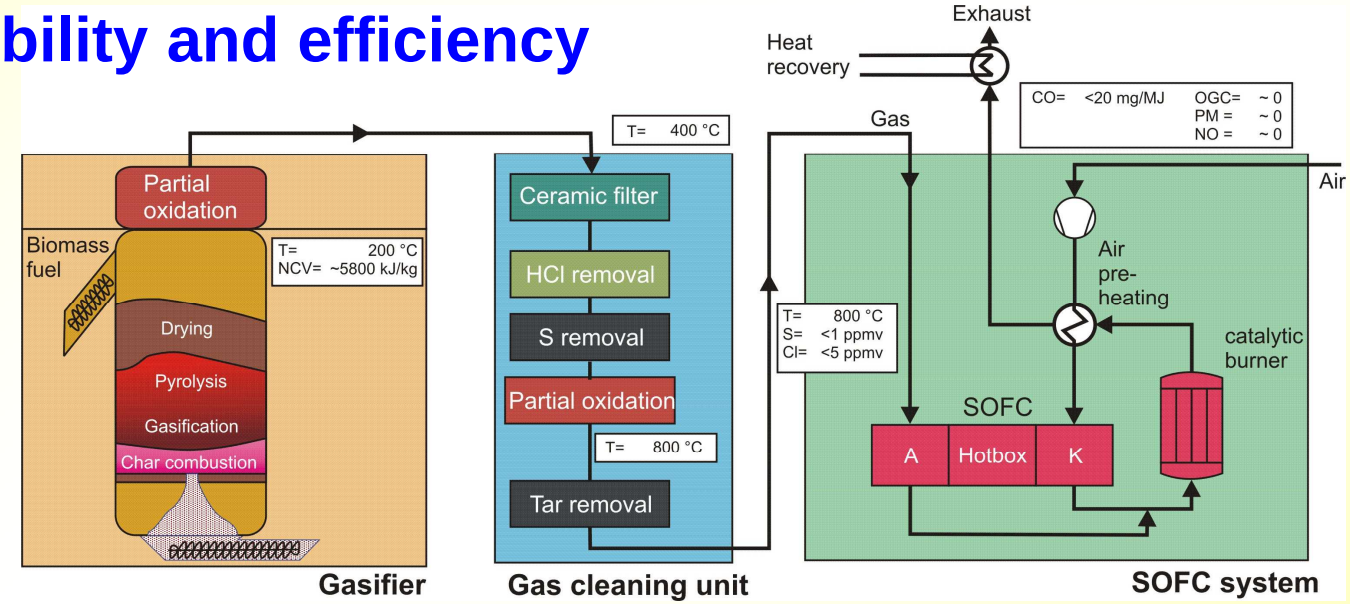
Source: ENTRADE AG

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – power production and CHP

➢ Towards higher fuel flexibility and efficiency

- **Medium-scale**
  - development of multi-fuel combustors and gasifiers
  - combined cycles
  - application of fuel cells (electric efficiencies of 40% possible)



- **Large-scale**
  - from cofiring to 100% biomass input
  - from power to combined power and heat (towards 100% overall efficiency)

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends

- **Biofuels and syngas**
  - **Biogas upgrading and integration in gas networks**
  - **Bio-SNG production**
  - **Thermal gasification and syngas utilisation**

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – biofuels and syngas

➢ Biogas upgrading and integration in gas networks

- High flexibility regarding gas utilisation (fuel, CHP, energy storage)
- Higher efficiency in comparison to conventional engine-only systems
- Contribution to a reduction of the natural gas imports and therefore the energy dependency
- Energy production on regional scale ➔ local added value

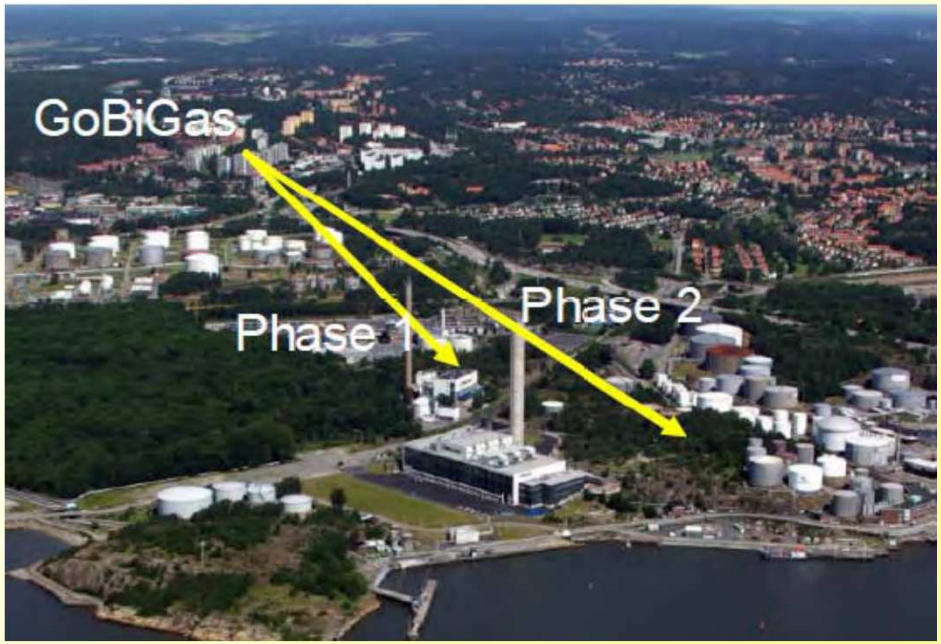
Source: Deutsches Biomasseforschungszentrum, DE

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – biofuels and syngas

➢ Bio-SNG production

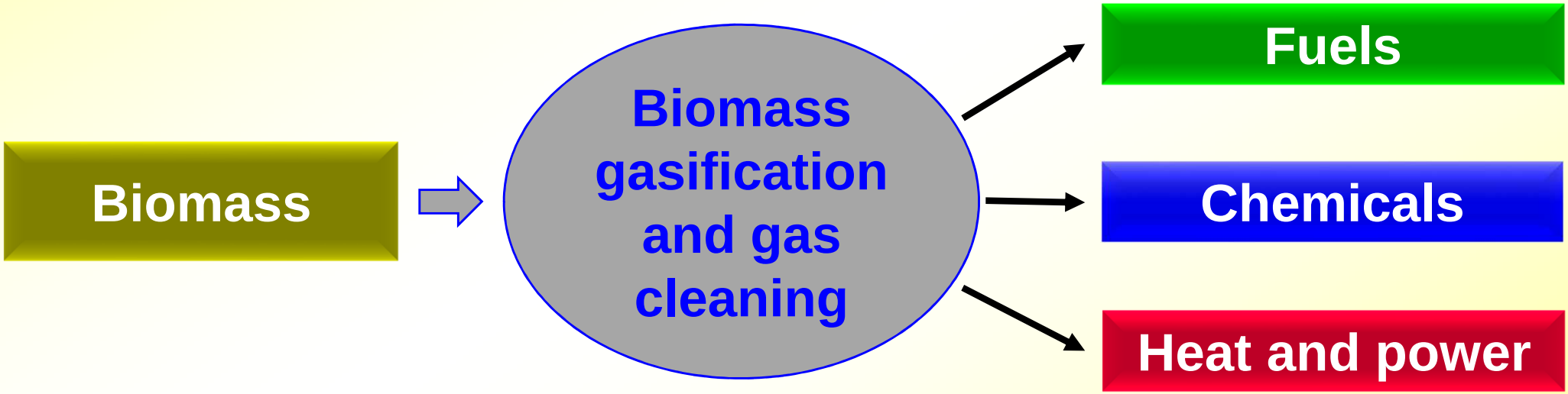
- **1 MW demonstration plant at Güssing (AT)**
- **GoBiGas Project (Gothenborg, SE)**
  - Phase 1 (demonstration plant): 20 MW SNG
  - Phase 2 (commercial plant): 80 MW SNG



BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – biofuels and syngas

➢ Thermal gasification and syngas production / utilisation



BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends

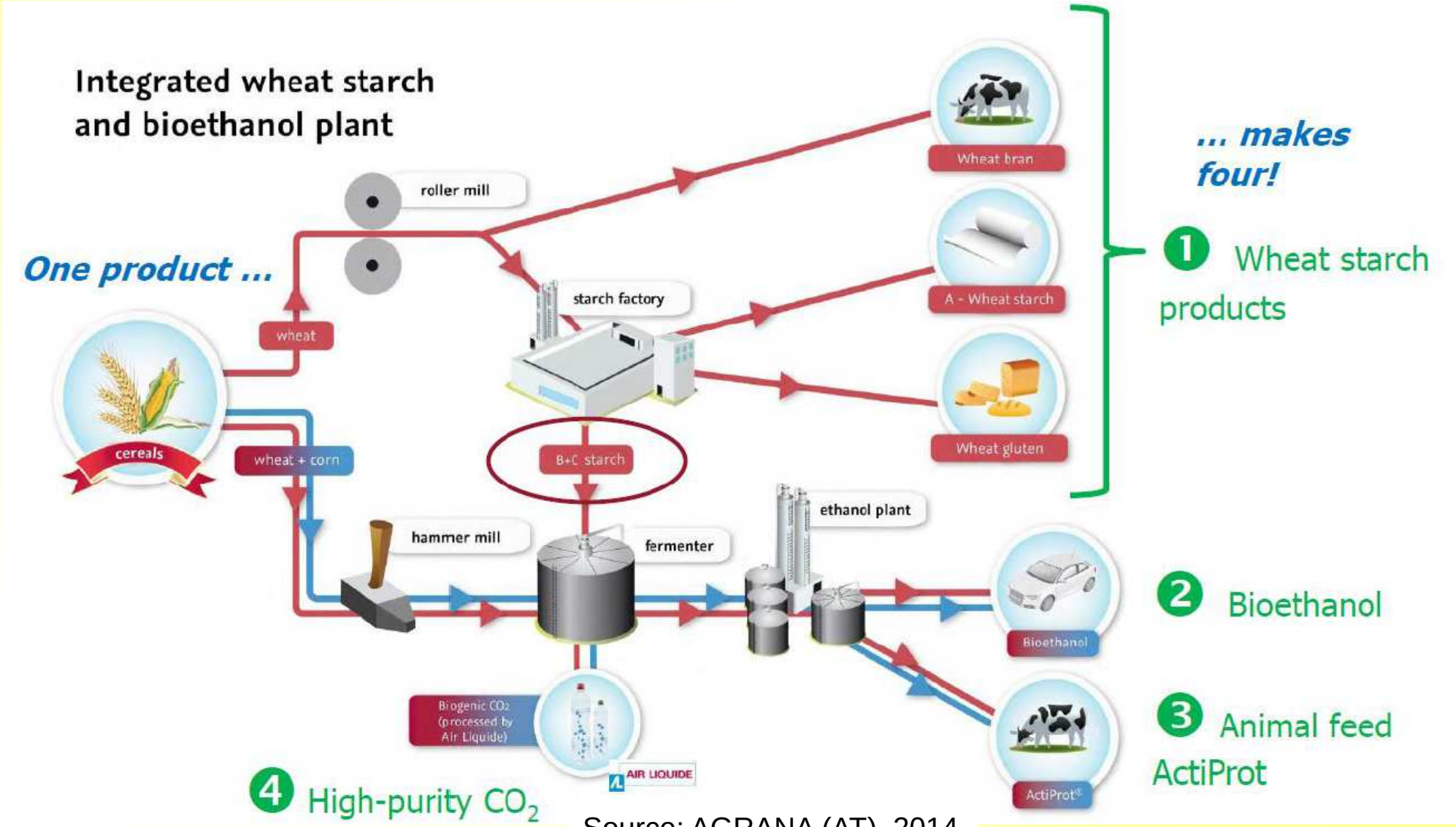
➢ Biorefineries

- **Sustainable processing of biomass into a spectrum of marketable biobased products and bioenergy**
- **Energy-driven Biorefineries**
  - Production of one of more secondary energy carriers (fuels, power and/or heat)
  - Process residues are upgraded and valorised to biobased products
- **Product-driven Biorefineries**
  - Production of one of more biobased products (chemicals, materials, food and/or feed)
  - Process residues are used for the production of bioenergy for internal/external use
- **Numerous options of potential feed stocks**
  (algae, slurries, agricultural feedstocks)

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – biorefineries (I)

➢ Example: Biorefinery based on agricultural feedstock (wheat)

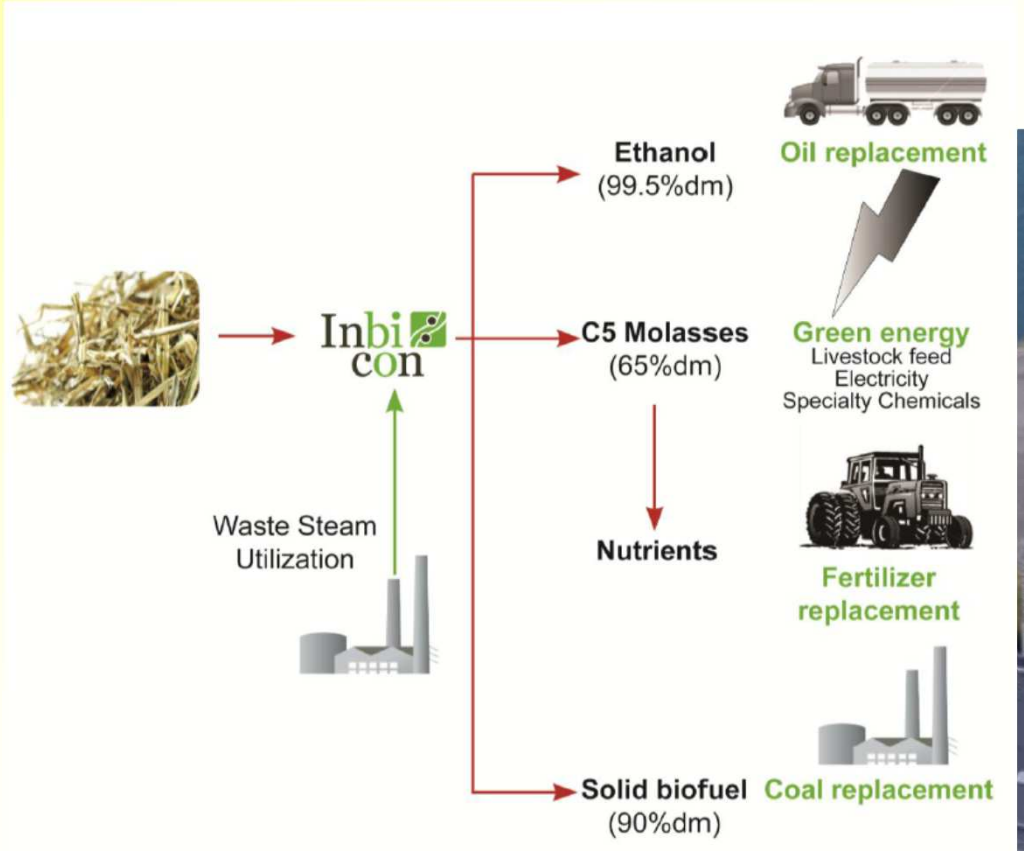


Source: AGRANA (AT), 2014

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – biorefineries (II)

➢ Example: Biorefinery based on agricultural residues (straw)



Source: Kalundborg Demonstration plant, Inbicon (DK), 2014

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – biorefineries (III)

➢ Example: Biorefinery based on wood fuels

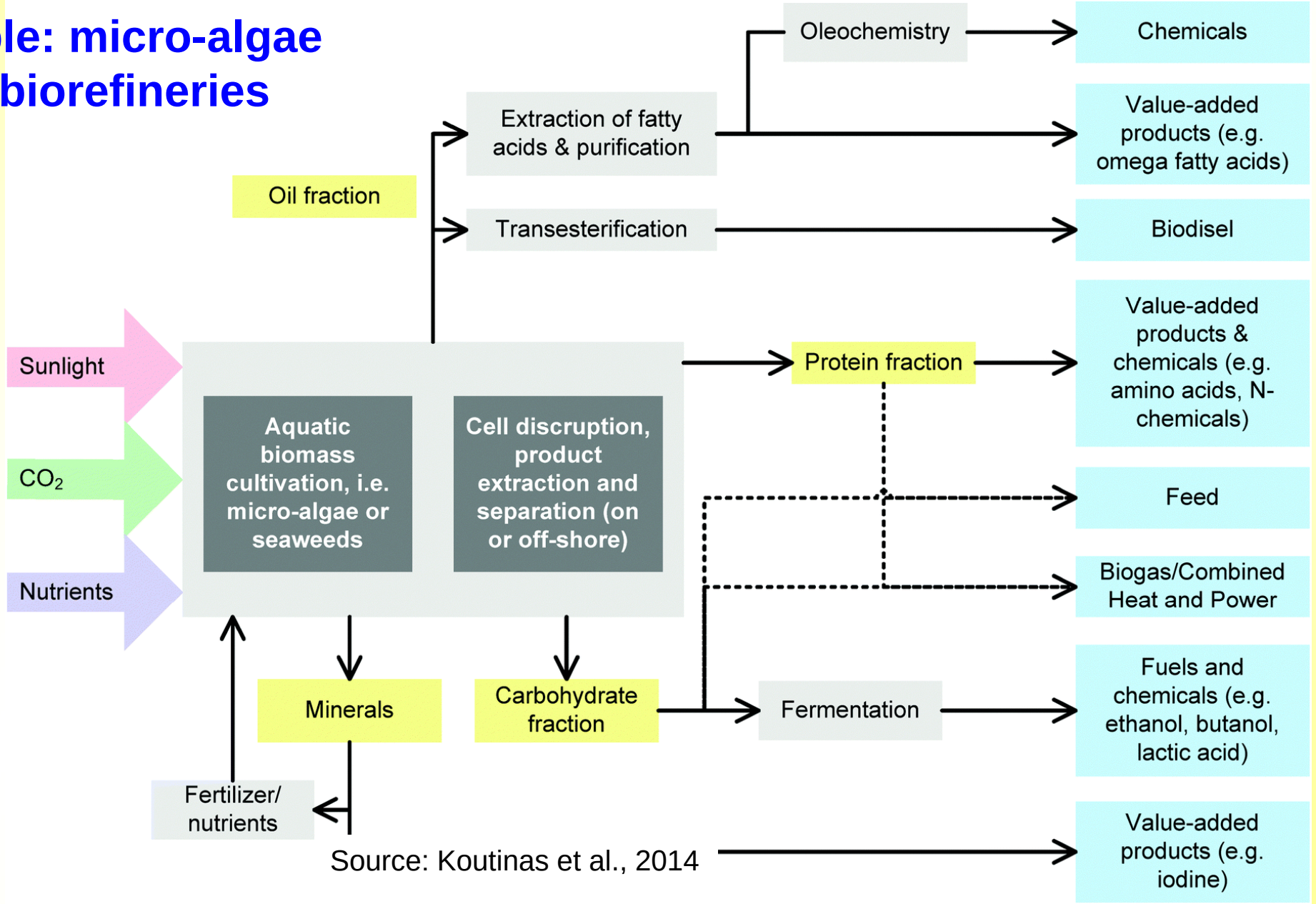
- **Feedstocks: Woody biomass (input material: crude tall oil, a residue of pulp production)**
- **Products: diesel**

UPM Lappeenranta Biorefinery

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

EU development directions and future trends – biorefineries (IV)

➢ Example: micro-algae based biorefineries



Source: Koutinas et al., 2014

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Summary (I)

➢ Advantages of biomass

- highly flexible application possible
- utilisation on demand (stored solar energy)
- largest short to medium-term application potential of renewables

➢ To fully utilise these advantages

- increase feedstock flexibility
- think regionally and internationally
- utilisation at low emissions and high efficiencies
- cascading approach of high relevance
- system integration and combination of renewables important

Summary (II)

- **Sound technologies for the future – approaches are already available**
  - **Clear strategies and policies on EU and national levels are needed regarding**
    - **market introduction and penetration**
    - **further development**
    - **support of developing countries and worldwide cooperation**

BIOENERGIESYSTEME GmbH
Inffeldgasse 21b, A-8010 Graz

Thank you for your attention

Contact:

Prof. Dipl.-Ing. Dr. Ingwald Obernberger
Inffeldgasse 21b, A-8010 Graz, Austria
TEL.: +43 (316) 481300; FAX: +43 (316) 4813004
Email: obernberger@bios-bioenergy.at
HOMEPAGE: http://www.bios-bioenergy.at