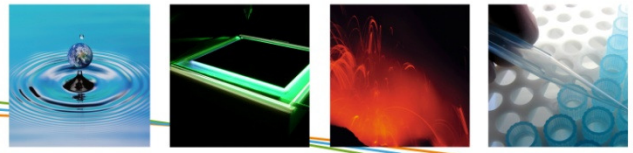
vito
vision on technology



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# Biomass for 2nd generation biofuels or for bio-electricity for electric vehicles ?

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# Contents

- 1st and 2nd generation biofuels
- Production technologies
- Pathway comparison
- Conclusions

# Biofuels – types & sources (1/2)

## *Oils & fats*

- → **Biodiesel,**
- → **pure plant oil,**
- → **hydrotreat.veg.oil**

rapeseed oil
palm oil
sunflower oil
soybean oil
jatropha oil
micro-algae
animal fats
used frying oils

## *Sugars & starch*

- → **ethanol,**
- → **butanol**

sugarcane
sugar beet
wheat / barley
maize (corn)
potato
cassava

## *Digestible products*

- → **bio-methane**

maize
sewage sludge
agricultural waste
industrial organic waste
(e.g. from food industry)
organic municipal waste
dry manure
liquid manure

Source: BIOSES

# Biofuels – types & sources (2/2)

***Cellulose***

- → **FT (synthetic) biodiesel / BTL,**
- → **bio-DME, bio-methanol**
- → **cellulose ethanol, butanol**
- → **bio-methane (SNG)**
- → **Bio-$H_2$**

fast growing grasses
(miscanthus, bamboe, cane)

farmed wood / short rotation coppice
(willow, poplar)

residues of agricultural crops
(straw, stalks)

black liquor (from paper pulp industry)

wood residues / waste wood

organic waste

microalgae

Source: BIOSES

# 2nd generation technologies (cellulose based)

*Bio-chemical: enzymatic hydrolysis & fermentation*

- 'cellulosic' ethanol, butanol

*Thermo-chemical: Gasification and synthesis*

- Fischer-Tropsch diesel (FT)
- di-methyl ether (DME)
- ethanol, butanol,…
- SNG (methane)
- Hydrogen

*Thermo-chemical: pyrolysis & hydrogenation*

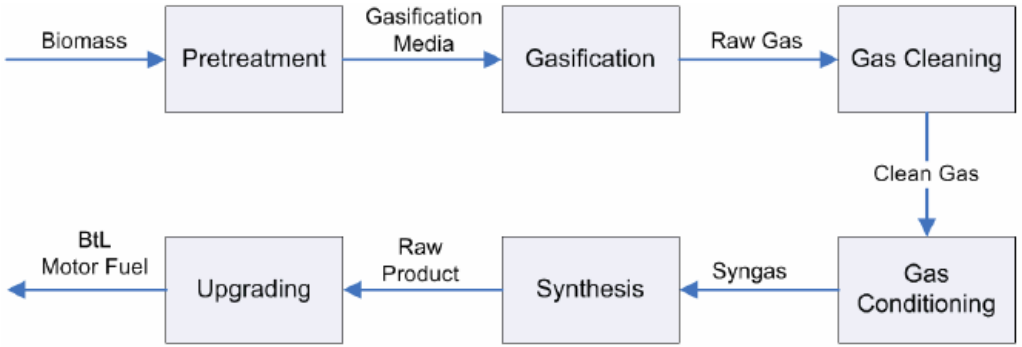
- Pyrolysis oil (can be input for crude oil refineries)

*Biological*

- hydrogen

Source: IEA Bioenergy Task 39 (2009)

# Renew project: concepts explored (gasification focus)




*Source: Renew, 2008*

EF = entrained flow gasification
CFB = circulating fluidized bed gasification

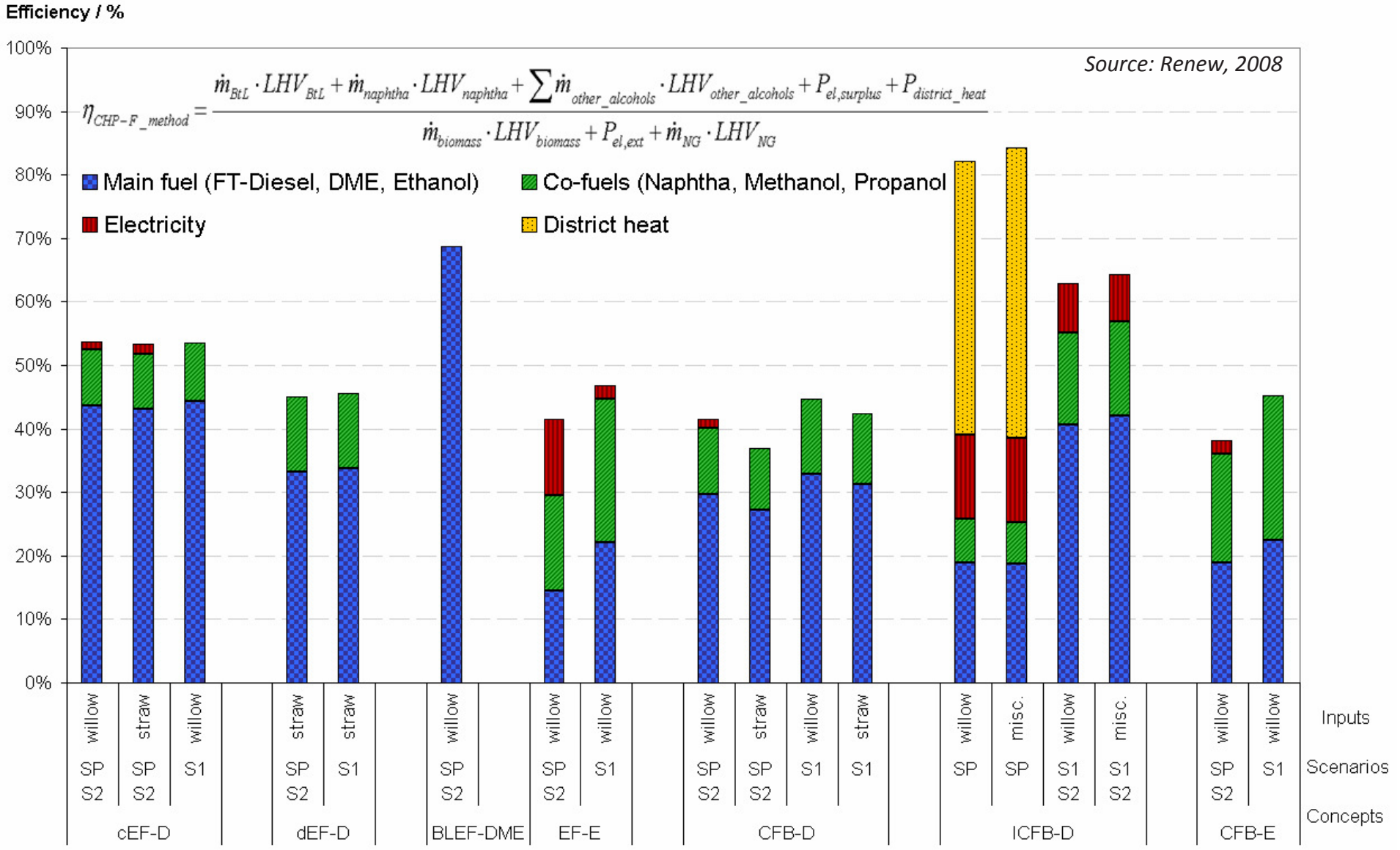
| Concept | cEF-D | dEF-D | BLEF-DME | EF-E | CFB-D | ICFB-D | CFB-E |
|---|---|---|---|---|---|---|---|
| Scale | Medium | Large | Medium | Medium | Medium | Small / (Medium) | Medium |
| End Product | FT-Diesel | | DME | Ethanol | FT-raw-product | | Ethanol |
| Gasification | EF | | | | CFB | | |
| - thermoch, pretreatment | carbonisation | pyrolysis | ——— | torrefaction | ——— | | |
| - Gas cleaning / conditioning | conventional physical absorbtion: | | | | dedicated technologies | | conv. physical absorbtion: |
| | Selexol | Rectisol | | Selexol | | | Selexol |
| Industrial Integration* | Stand alone / Location | Refinery Integration | Pulp mill | Stand alone / Location | Refinery Upgrading | District Heat +Refinery | Stand alone / Location |

*Main parameters:*

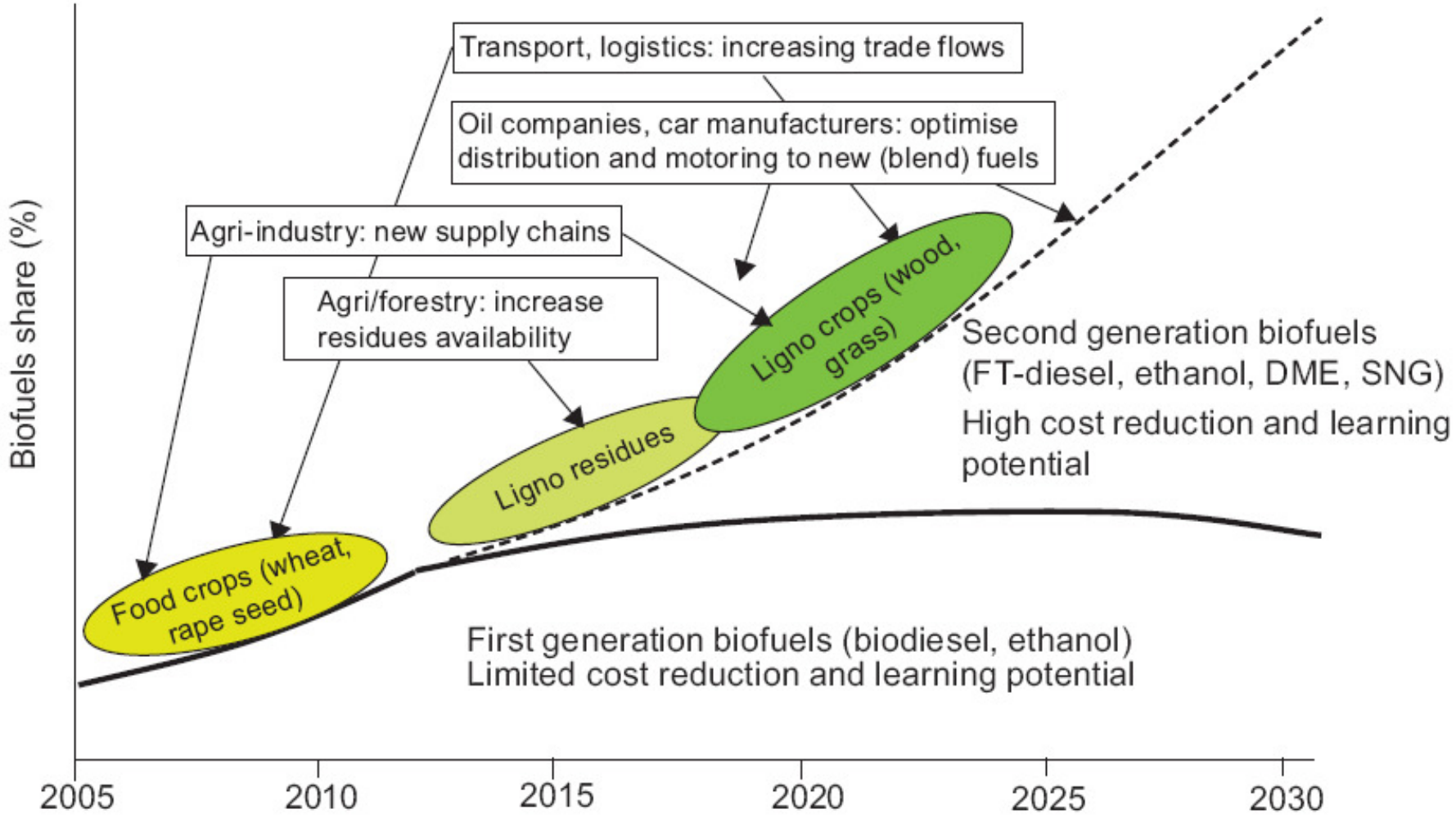
(a) the capacity/scale

(b) the integration of (by-)products within the energy system (stand alone concepts, district heat system, pulp mill or refinery integr.)

# Efficiency ?



# Demand for cellulose materials – 2nd generation biofuels




Source: REFUEL (2007)

# Pathway comparison

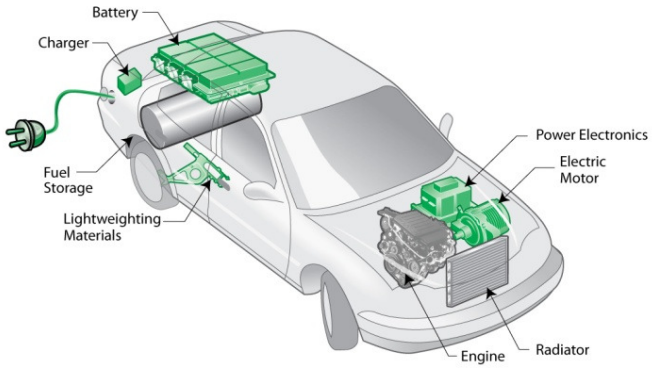
Biomass
(ligno-cellulose)

*conversion process*

Biofuel

*Steam power cycle*

Electricity



# Pathway comparison – assumptions ?

## Vehicle technology

- *Type of vehicle (cars, trucks, buses, … ?)*
  - Main focus for EVs on local traffic (passenger cars, delivery vans, public transport)
  - What about long distance (trucks, ships, aircraft) ?
- *Type of technology (basis = mid-sized family car)*
  - Both technologies have main roll-out in the future (by 2020 and later)

    => reference for “standard” vehicles driving on biofuels ?

    current vehicle technology @ 5-8 litre/100km

    vs. anticipated 2020-2030 technology (hybrid) @ 3-5 litre/100km

    => electric vehicle: pure EV or plug-in hybrid (which still needs fuel) & type of batteries ?

    anticipated electr. consumption 20-30 kWh/100 km

# Pathway comparison – assumptions ?

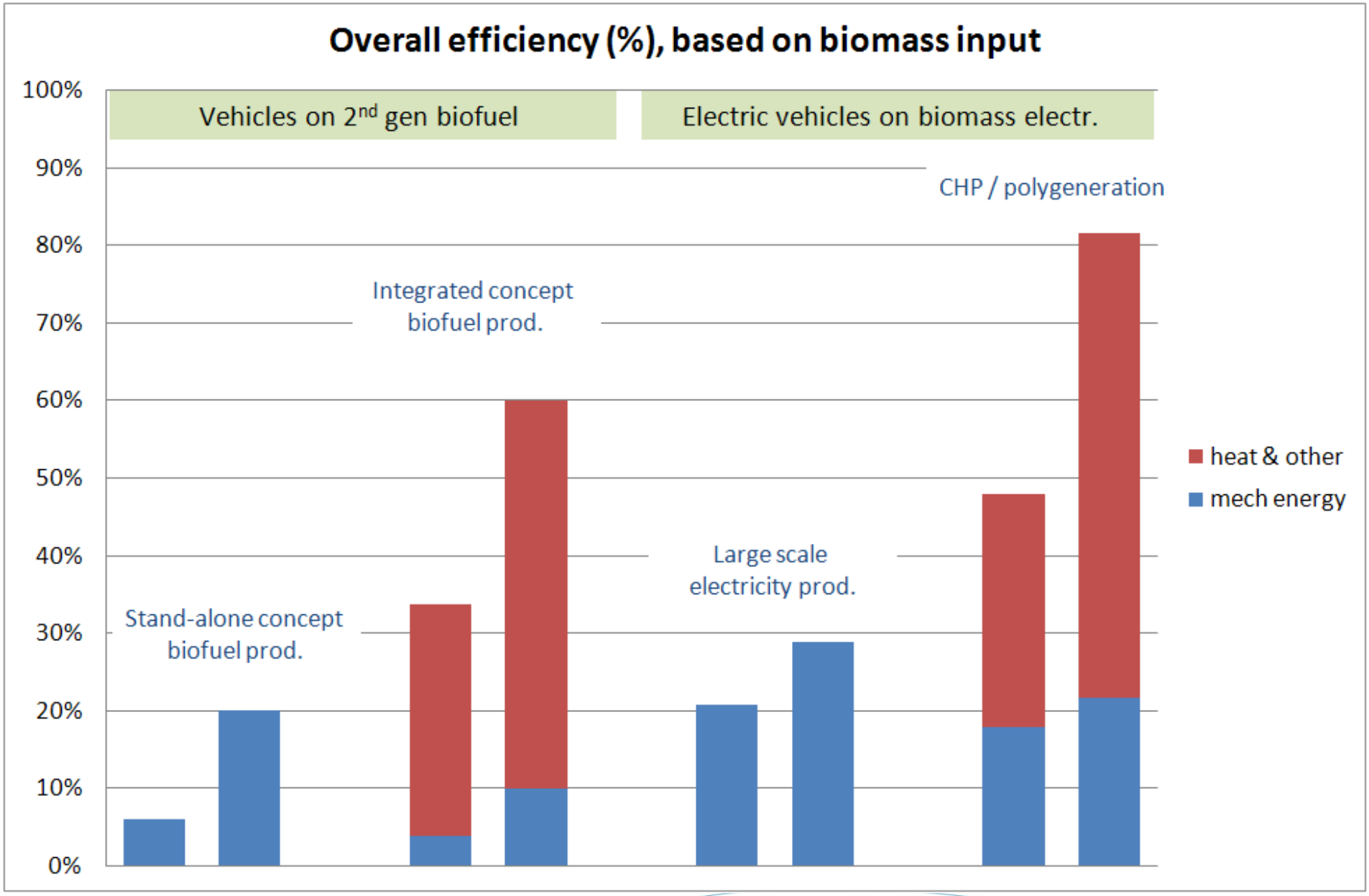
## Conversion technology

- *Type of input (feedstock)*
  - dry vs. wet material
  - basis = ligno-cellulose material
- *2nd generation biofuel technology*
  - further improvements can be expected
  - stand-alone vs. integration with bio-products & electricity /heat (bio-refinery concept)
- *Bio-electricity*
  - large vs medium & small scale
    - Large => co-firing in coal power or dedicated biomass large scale electricity production ; focus on electricity production, use of 'waste' heat (locally) difficult
    - Medium & small scale => also possibilities for using the heat locally
  - future: integration of electricity production in bio-refineries

# Matrices for comparison & efficiency assumptions

| 2nd gen biofuels | Current car technology<br>Thermal efficiency 15-20% | Future car technology (hybrid) & current heavy duty<br>Thermal efficiency 30-40% |
|---|---|---|
| Stand alone process<br>Thermal efficiency 40-50% | Output: mech energy | Output: mech energy |
| Integrated proces<br>Thermal efficiency 60-80%<br>(~25% towards biofuel) | Output: mech energy + heat & other | Output: mech energy + heat & other |

| Bio-electricity | EV drivetrain efficiency 85-90%<br>Electricity distribution & battery charging efficiency 70-80% |
|---|---|
| Large scale electricity thermal efficiency 35-40% | Output: mech energy |
| CHP or polygeneration thermal efficiency 60-90%<br>(~30% towards electricity) | Output: mech energy + heat |




*Own calculations*

# First conclusions from the pathway comparison

- In general the electric pathway performs better than the biofuel pathway, however:
  - the difference gets smaller for new types of **(hybrid) cars** on liquid or gaseous fuel (for heavy duty vehicles - higher average efficiency than cars - the difference is already limited),
  - **integration** (co-prod. of fuels, electricity, heat & other products) makes a big difference; biofuels from integrated technology show better overall efficiency than EVs on electricity from big power facilities.

- for the electric pathway there is a clear **preference for CHP & polygeneration**. However, most electricity from biomass – at least in Belgium - is produced through large scale installations & co-firing.

- Use of **(waste) heat** and integration is a crucial factor !!

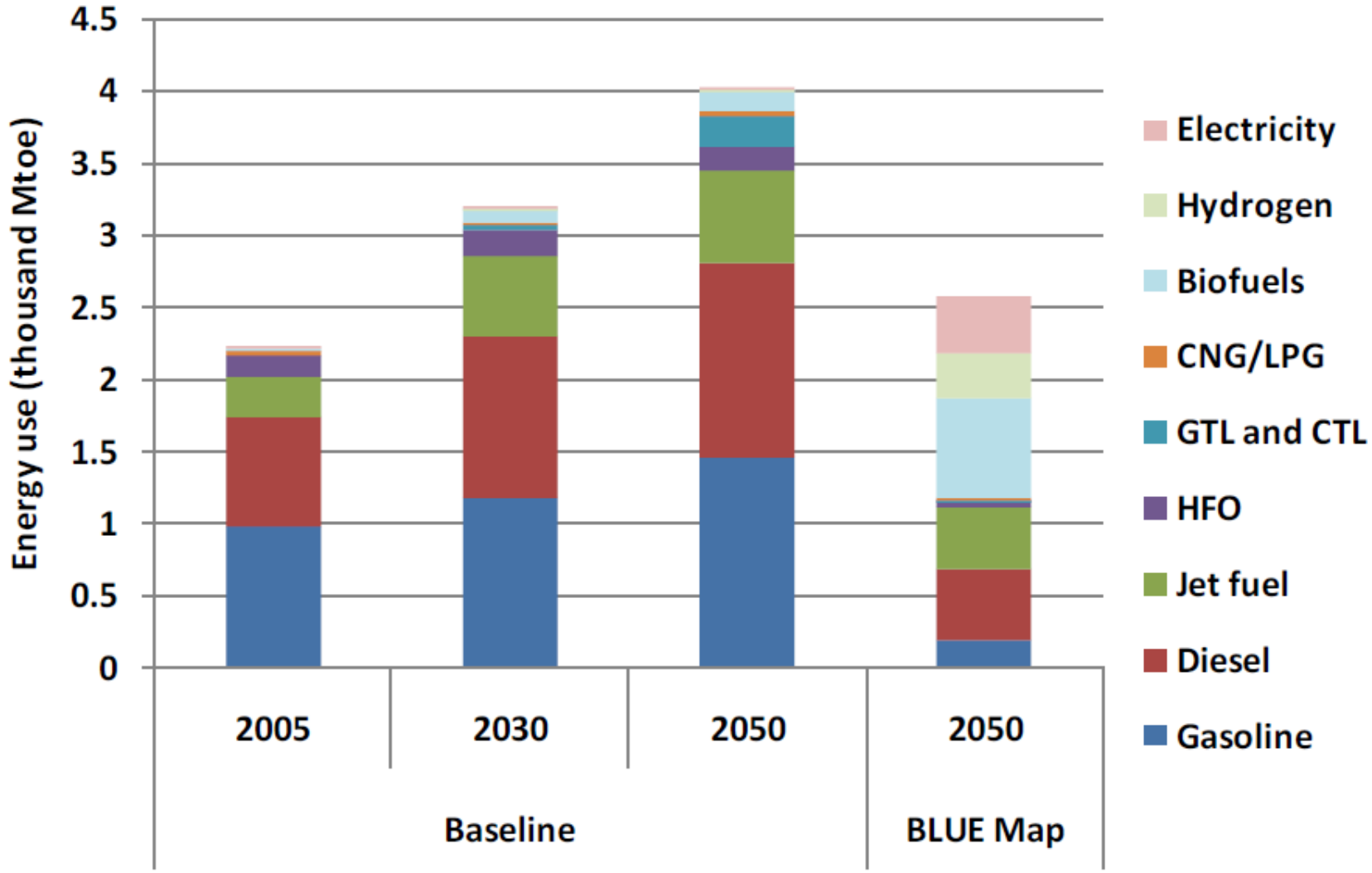
# Other factors

Efficiency (& GHG balance) not the only factor in the choice between 2nd gen biofuels and EVs on biomass electricity

- Future transport: **balance** between electricity & liquid (or gaseous) fuels
  - local traffic : perfect for electric mobility
  - longer distances (trucks, ships, aircraft): reliance on high density fuel
    exception = electric trains
  - plug-in hybrid electric vehicles: also rely on fuel for longer distances
  - *see IEA-ETP scenario*

- Higher **intrinsic value** for transport fuel than for electricity
  - less options to replace fossil fuel in transport than in electricity prod.

# IEA ETP Blue Map scenario (worldwide)




*Source: IEA ETP 2008*

*Basis Blue Map = 50% reduction in global energy-related GHG, from 2005 to 2050*

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