Potential in Europe future opportunities for growth

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POTENTIAL in EUROPE
future opportunities for growth

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CONTENT

- Status
- Feedstock
- Products
- Innovations

STATUS

EXISTING GASIFICATION PLANTS

in Europe

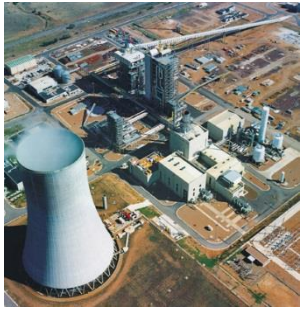
Scale (MW input capacity)

1 — 10 — 100 — 1000

Pitea - DME
Harboore - CHP
Kalundborg - cofiring
Gussing CHP
Obertwart - CHP
Villach - CHP
Ulm - CHP
Skive - CHP
Goteborg - SNG
Joutseno - Lime kiln
Amer - cofiring
Teesside - IGCC
Lahti - boiler
Vaasa - cofiring
Buggenum - IGCC
Puertollano - IGCC





GASIFICATION EUROPE

planned plants (selection)

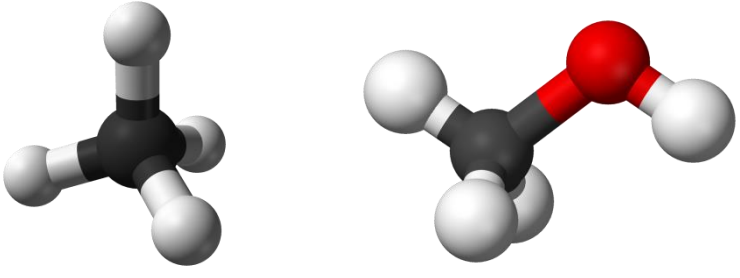
Scale (MW input capacity)

1 10 100 1000

Gaya - SNG

BioTfuel - FT
Alkmaar - SNG

Varmlandsmetanol - Methanol
UPM Strasbourg - FT
Bio2G - SNG
Forest - FT
Woodspirit - Methanol

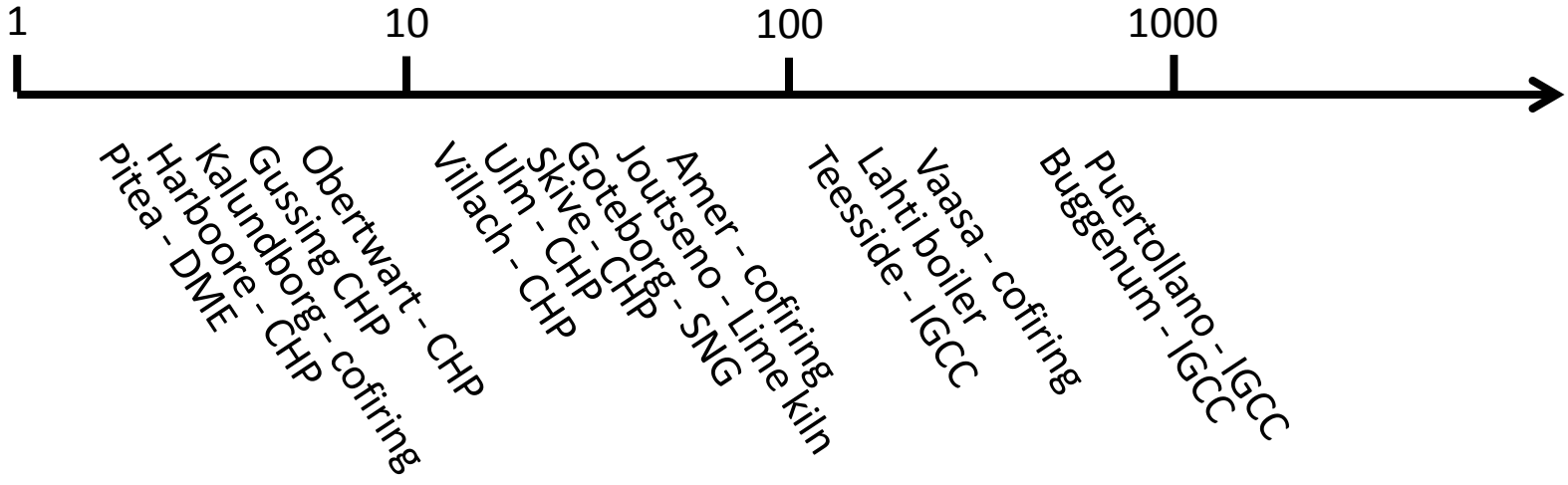


FEEDSTOCK

FEEDSTOCK

existing plants

Scale (MW input capacity)



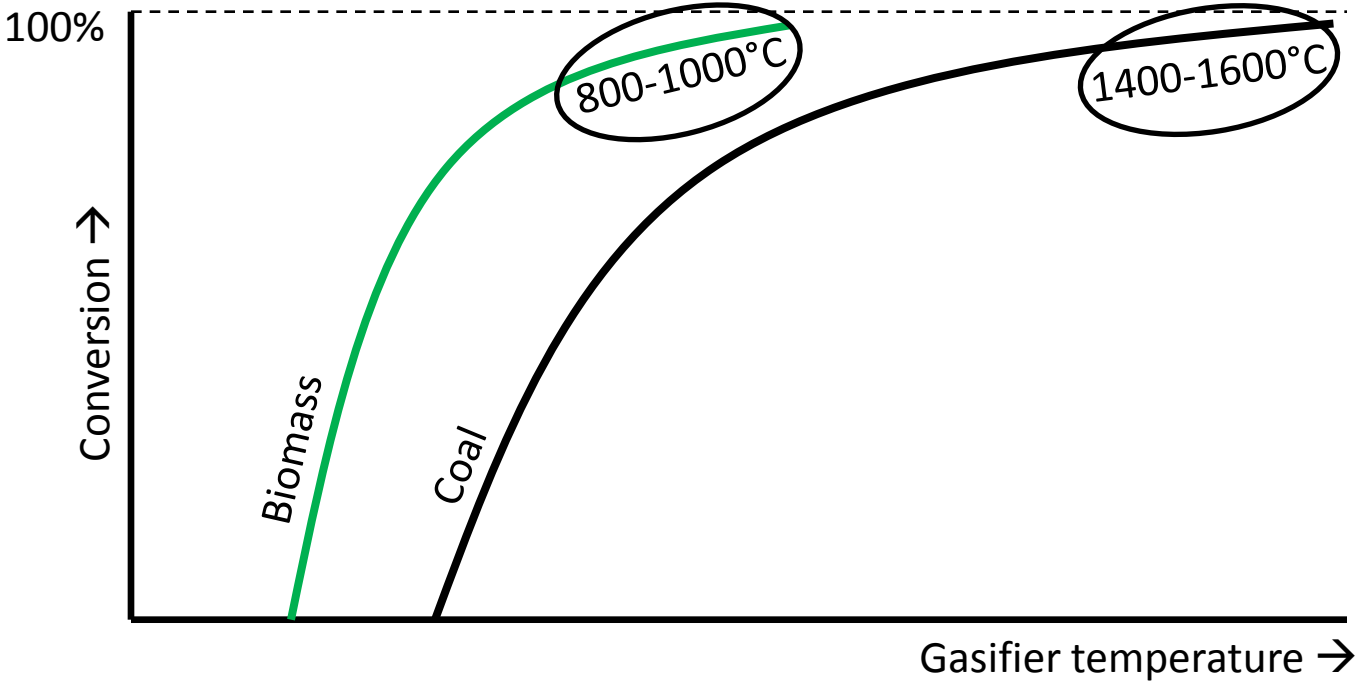
Wood pellets – Waste wood – Black liquor – Straw – SRF – MSW – Coal (plus wood)





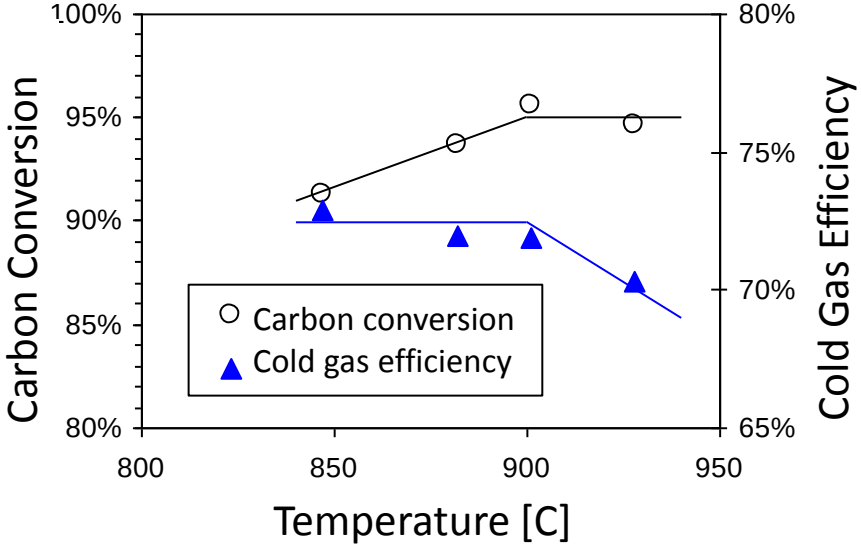

CONVERSION and TEMPERATURE

biomass is easier than coal



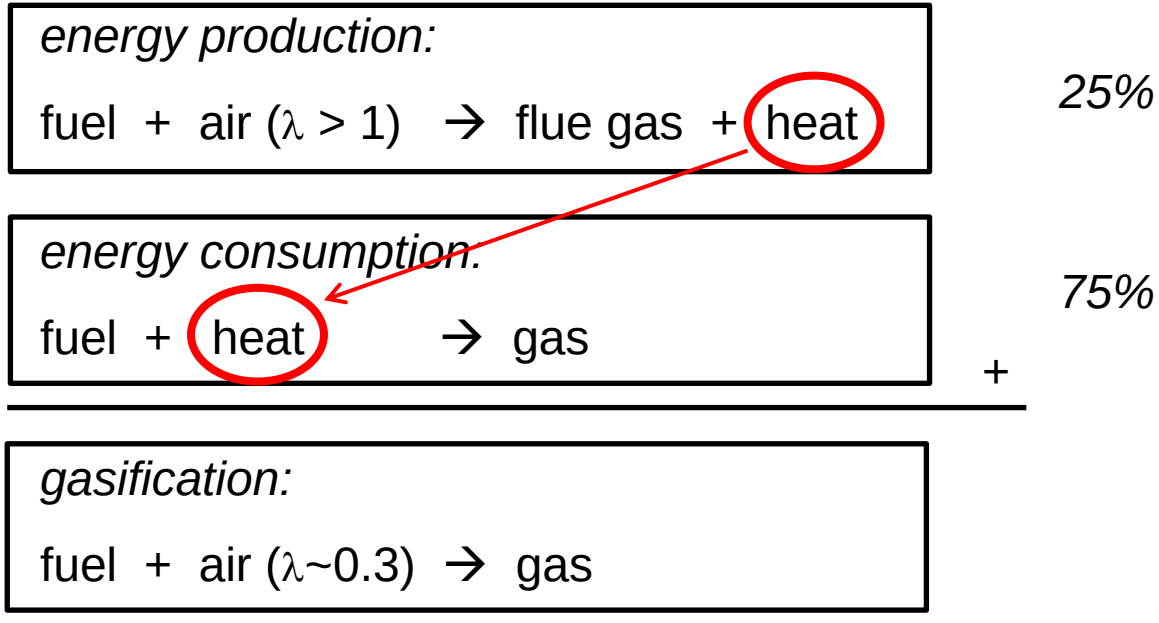
CONVERSION and EFFICIENCY

- General: higher temperature results in higher conversion
  - Higher conversion → higher cold gas efficiency
  - Higher temperature → lower cold gas efficiency
- No net effect on efficiency (tests air-blown CFB gasifier)
- But carbon in ash remains operational issue
- And accumulation of char in reactor endangers temperature control



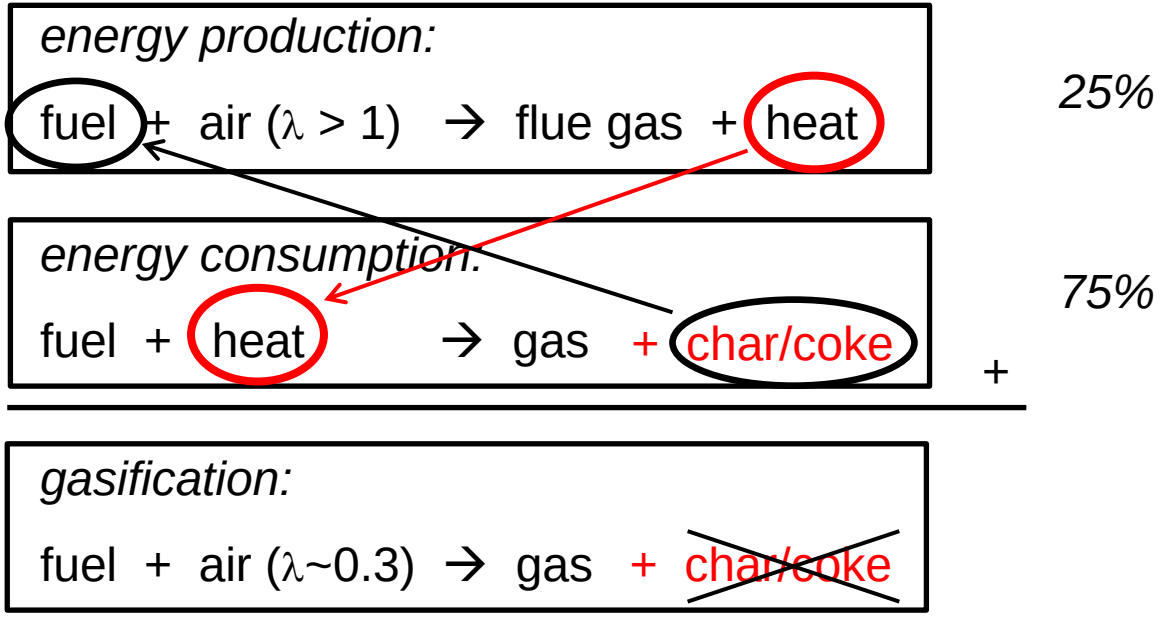
GASIFICATION

balancing heat use and heat production



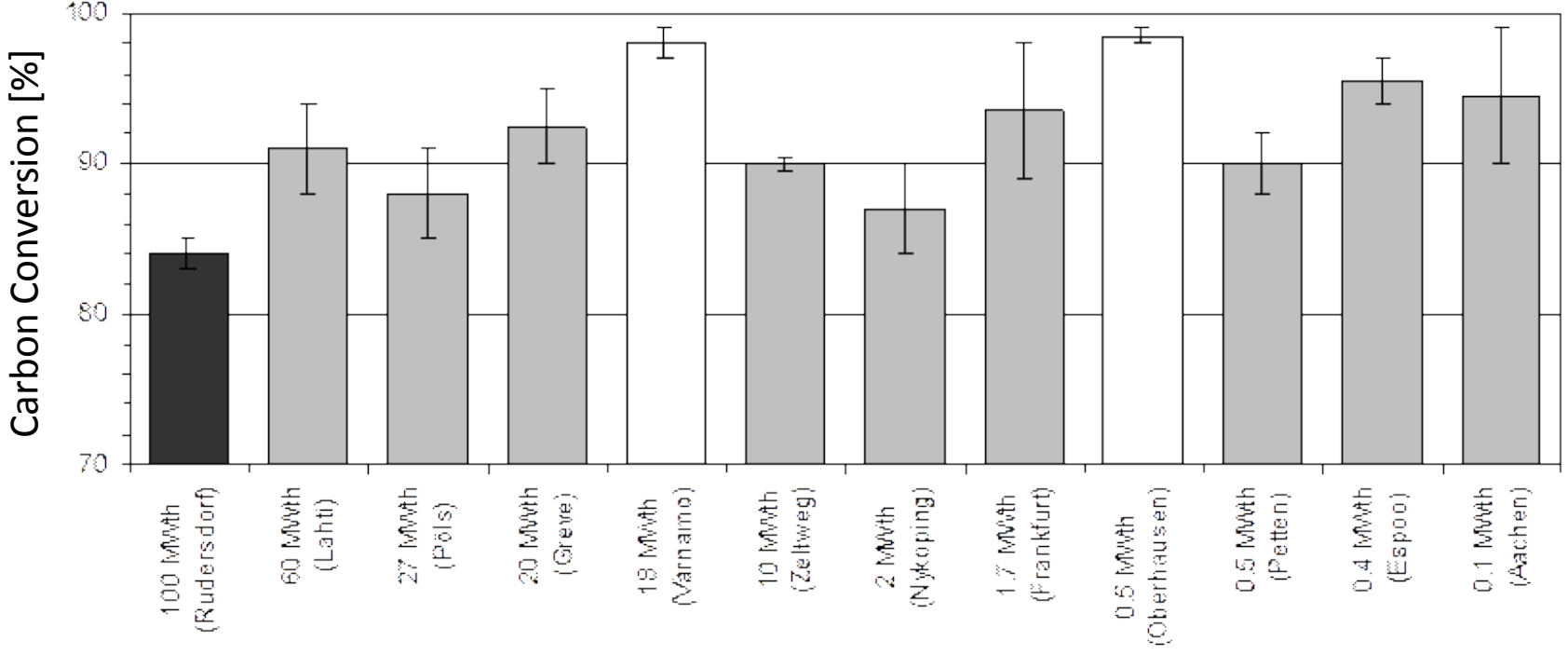
IDEAL GASIFICATION

balancing char production and fuel for combustion



CARBON CONVERSION [%]

existing CFB gasifier plants (2002)

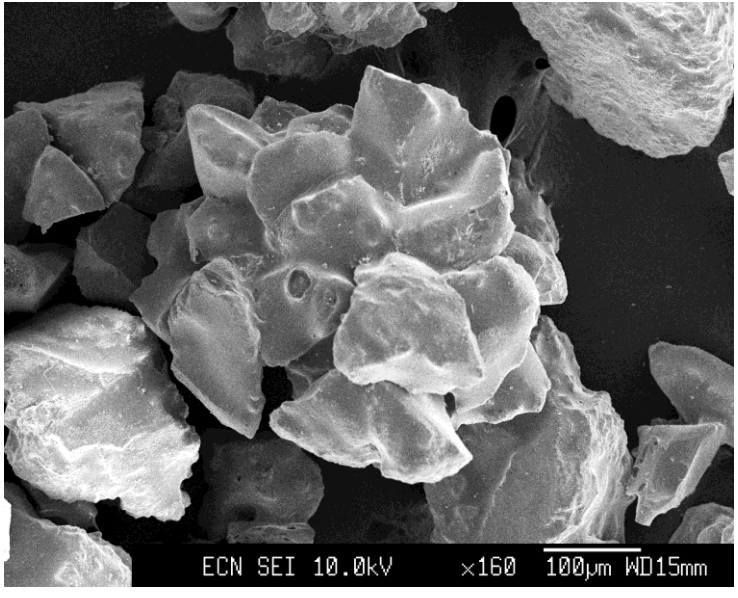


ROOM for IMPROVEMENT

example: biomass

- Biomass gasification typically:
  - Leaves 10% carbon unused

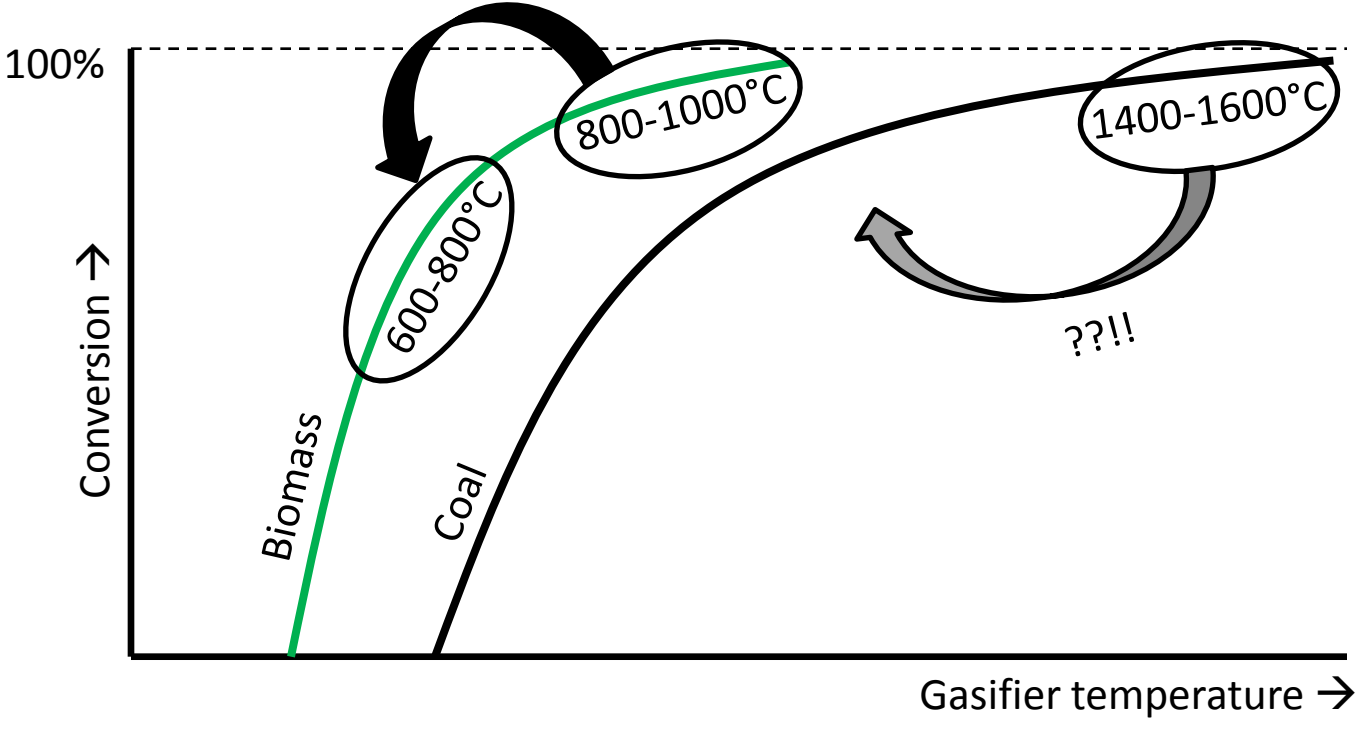
    AND
  - Needs 25% of fuel as energy source
- Room for improvement:
  - Use 10% carbon residue as energy source
  - Even lower conversion is not a problem: lower gasifier temperature accepted
  - Or additional fuel outlet (e.g. waste tars, waste water, tail gas, …)
- That means: less challenges for risky biomass like straw, grass, … (fast growing, cheap, but alkali-rich and risk of ash melting)



Fluidized bed particles glued together due to ash melting: de-fluidization, temperature control lost

ROOM for IMPROVEMENT

lower temperature! fuel flexibility!



SO…

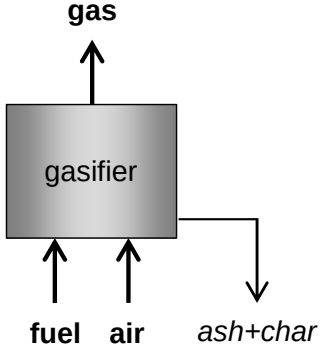
- First generation gasifiers:
  - Matching heat demand and heat production leads to the use of gas as energy source
  - High temperature required to have sufficient conversion
  - You're loosing what you're winning: efficiency roughly remains unchanged
  - But mind the carbon residue!

- Second generation gasifiers:
  - The carbon issue becomes a benefit: carbon loss becomes energy source
  - Relaxed demand on carbon conversion
  - Lower gasifier temperature accepted
  - Efficiency increases
  - Feedstock flexibility increases

GASIFICATION
generations

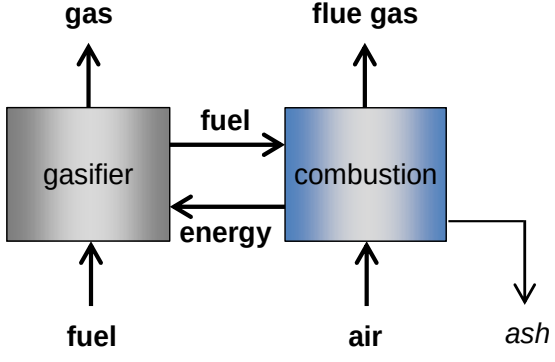
First generation

- One reactor, one gas
- N_2-free gas requires ASU
- Incomplete carbon conversion
- High temperature, high steam, small fuel size, large residence time needed for acceptable conversion

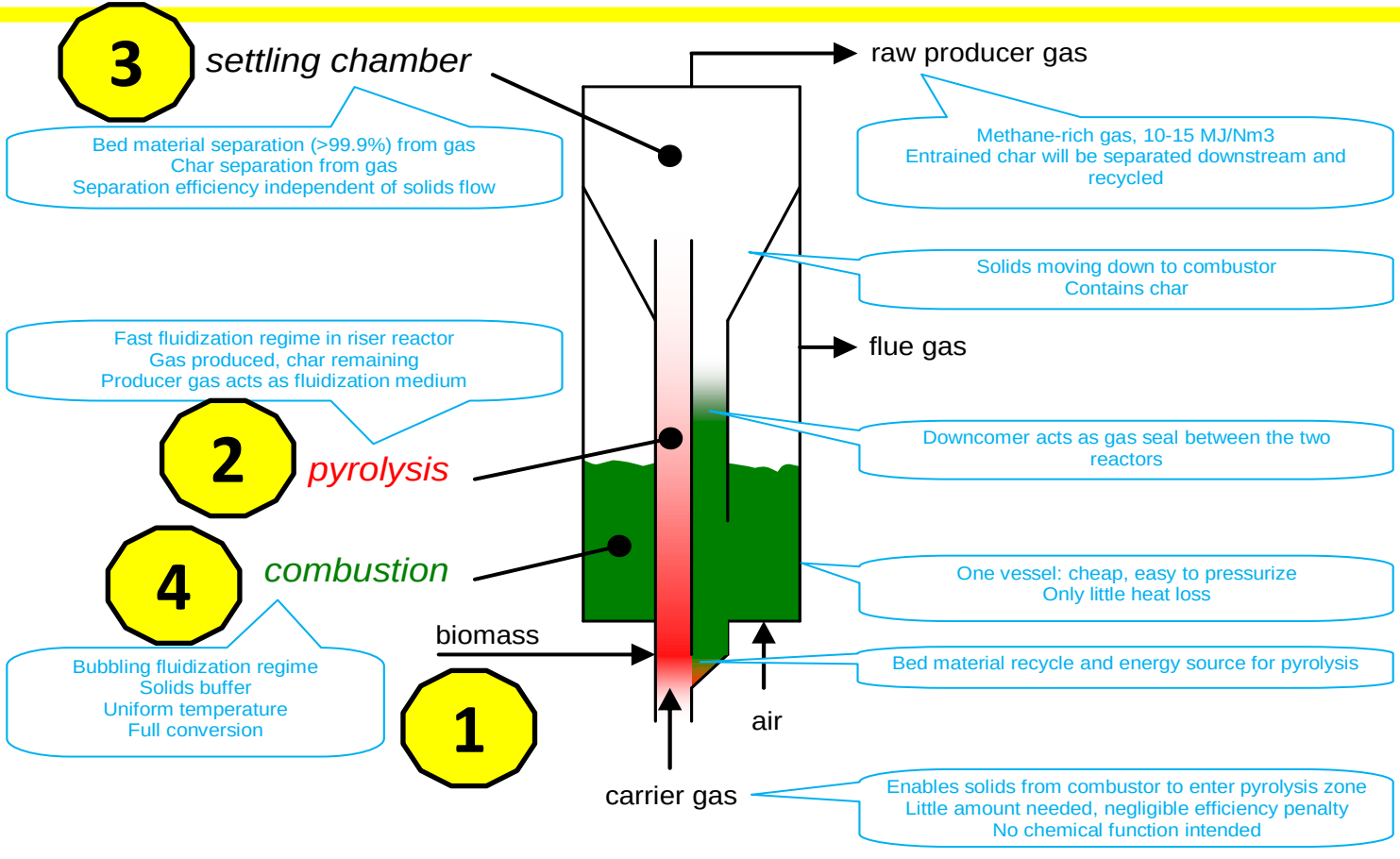


Second generation

- Two coupled reactors, two gases
- N_2-free gas without ASU
- Complete carbon conversion
- Additional degree of freedom: temperature, steam, fuel size, residence time



MILENA technology



PRODUCTS

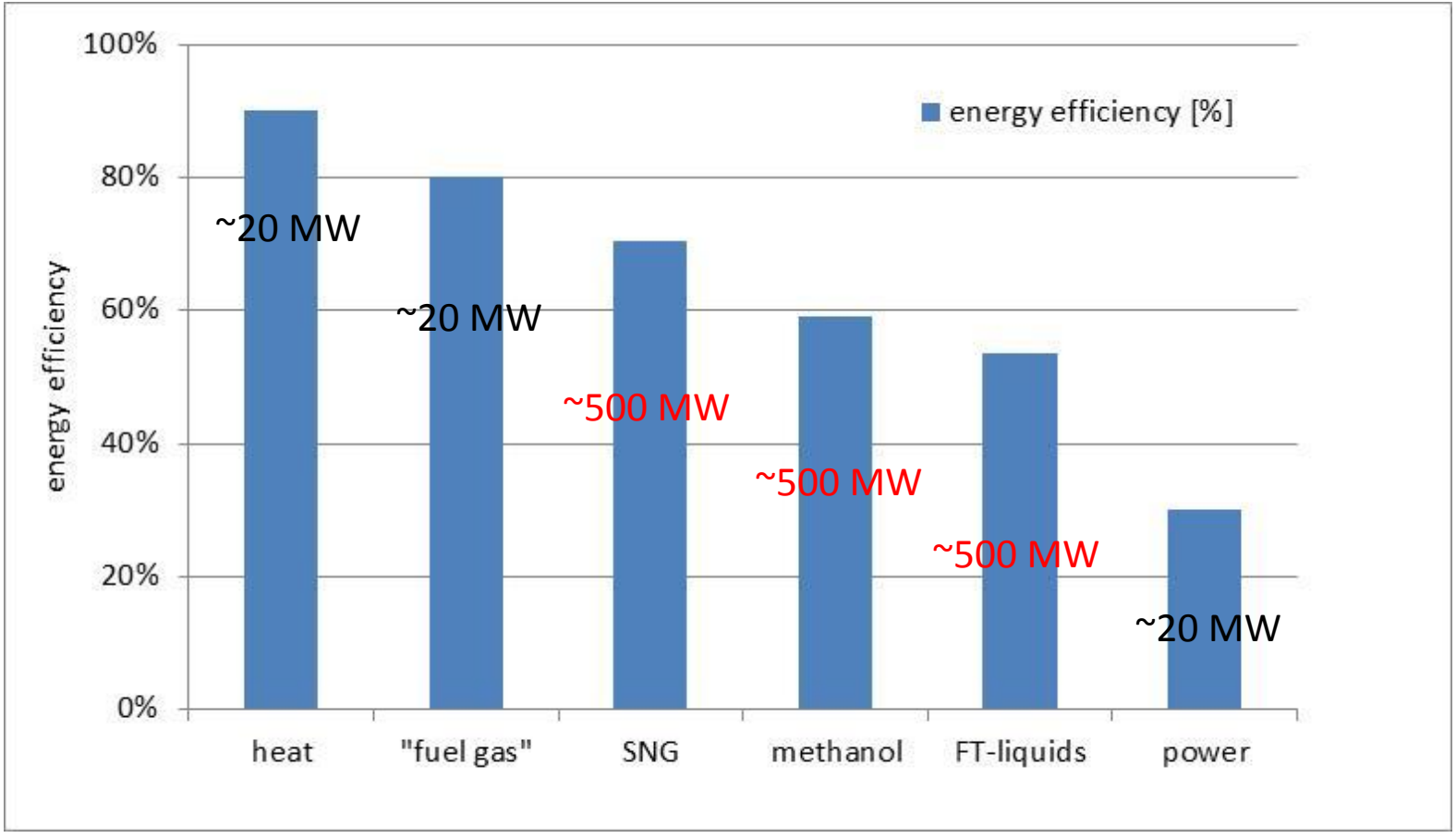
WHAT MAKES MOST SENSE?

- What products possible?
- With what efficiency?
- What does the product pay?
- What does the process cost?

- So, what makes most sense?
  - Simple approach
  - Rounded numbers
  - No subsidies

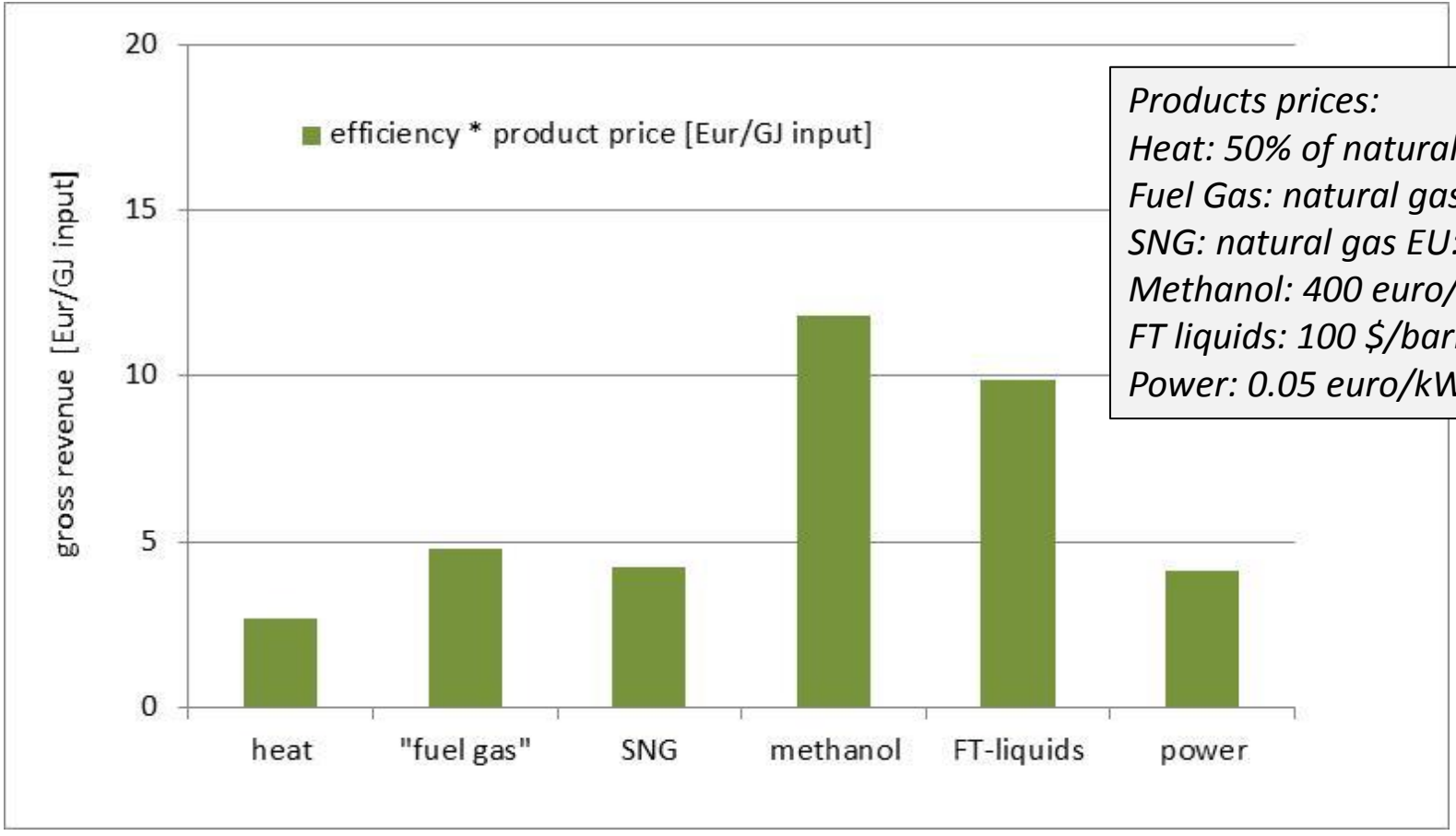
PRODUCTS and EFFICIENCY

simplified cases



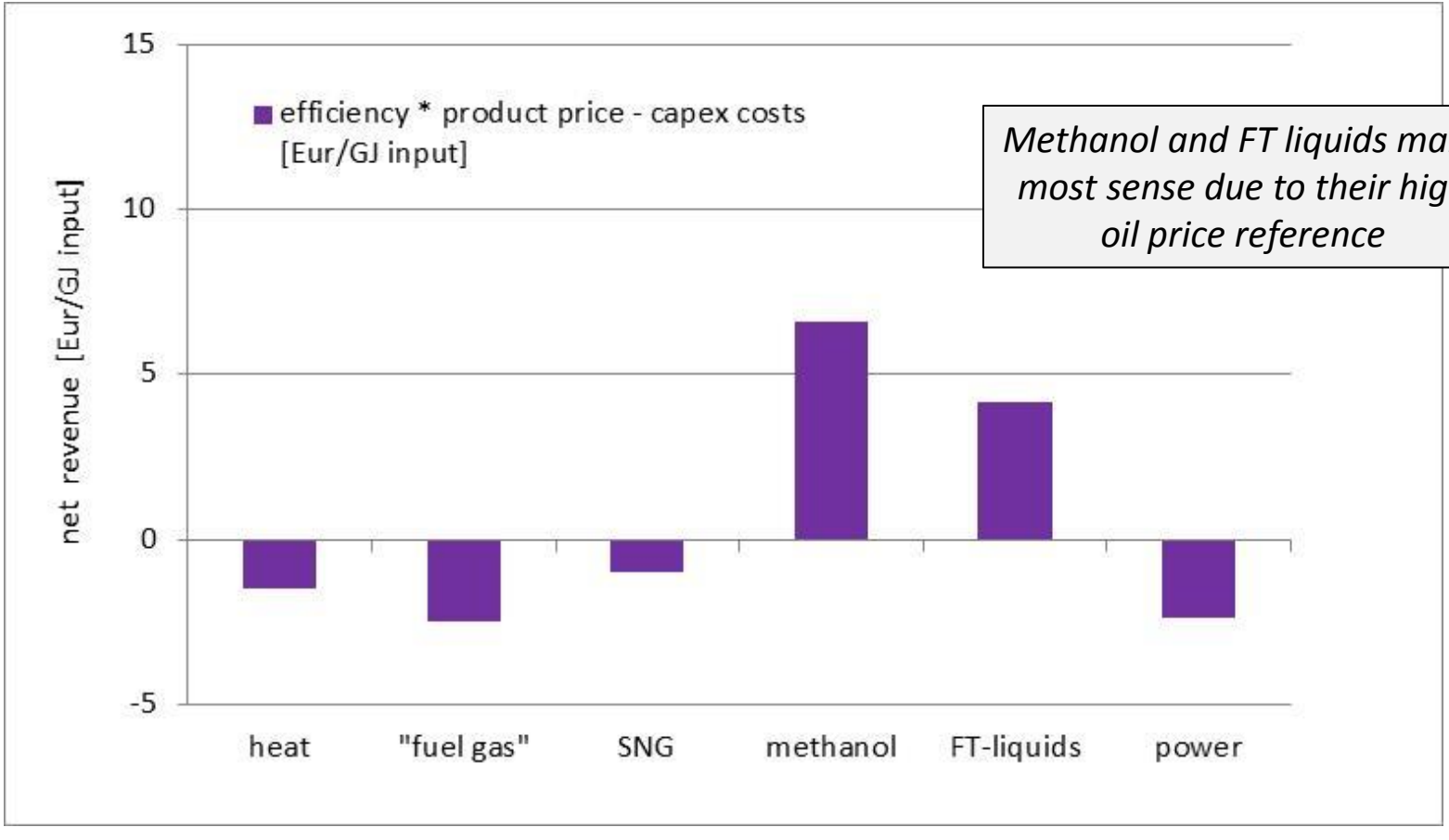
INCOME

[euro/GJ_feedstock] excluding capital costs



Products prices:
Heat: 50% of natural gas
Fuel Gas: natural gas EU
SNG: natural gas EU: 6 euro/GJ
Methanol: 400 euro/ton
FT liquids: 100 $/barrel
Power: 0.05 euro/kWh

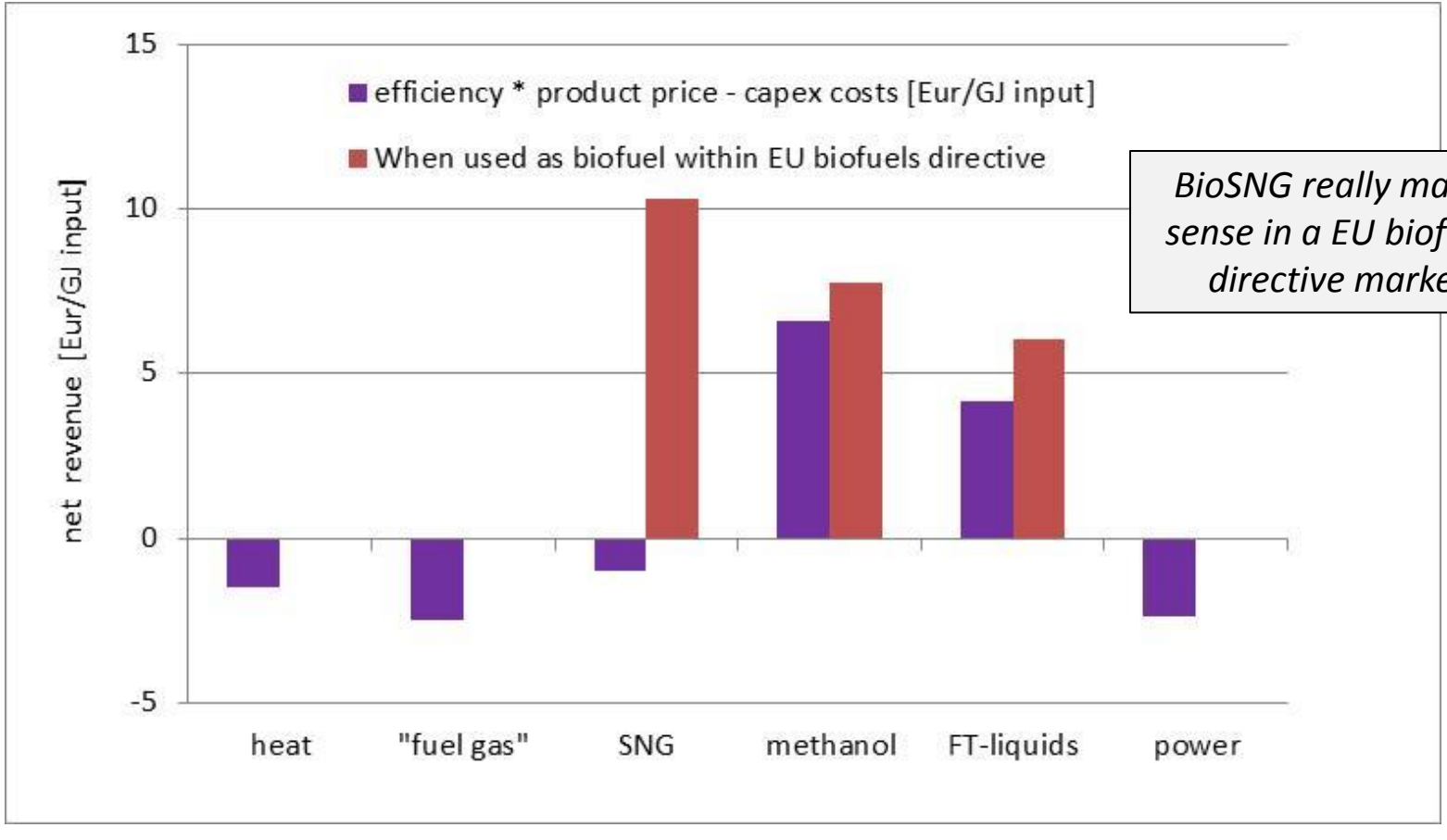
NET REVENUE
[euro/GJ_feedstock]



Methanol and FT liquids make most sense due to their high oil price reference

WHEN USED as BIOFUEL (EU)

things change significantly



BioSNG really makes sense in a EU biofuels directive market

SO…

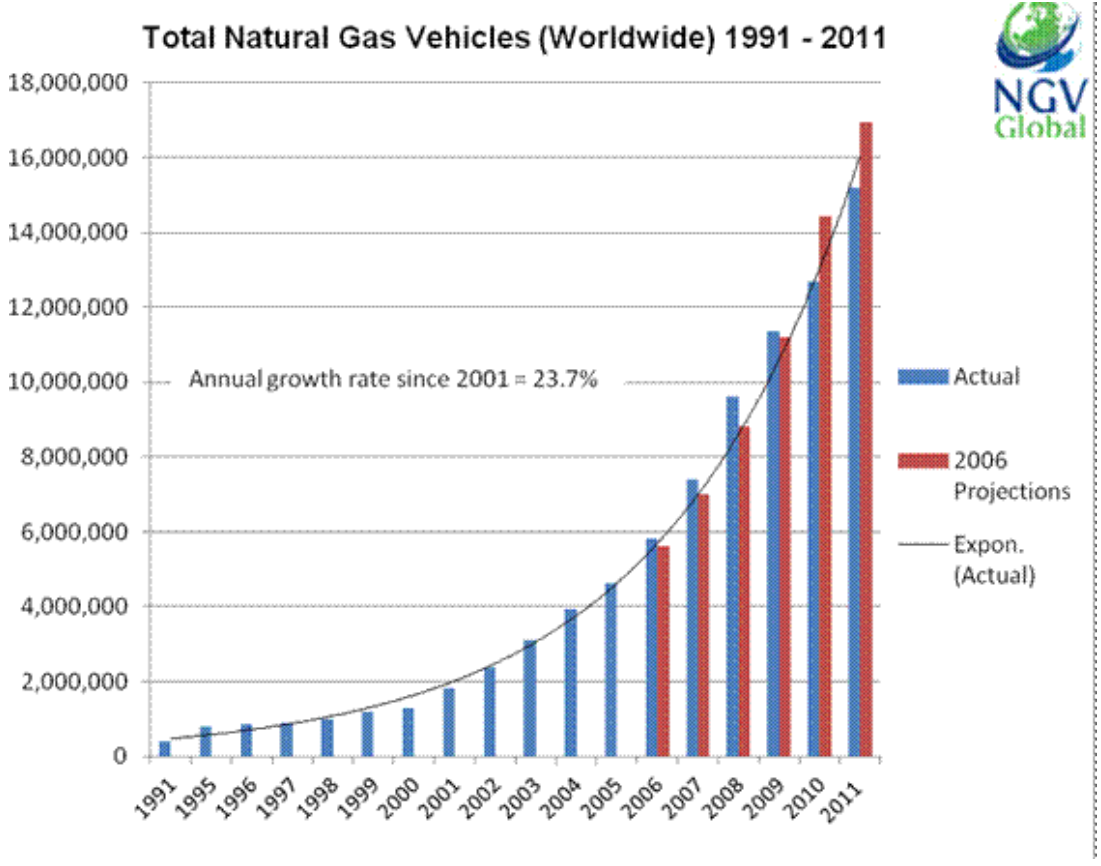
- Gasification to Methanol or FT liquids is most attractive due to the high priced oil reference
- Producing SNG seems a bad choice since natural gas is cheap (NB: not in China, Korea, Japan, …)

- But SNG can be used as vehicle fuel
- SNG from biomass then becomes a biofuel: bioSNG or bioCNG
- BioSNG then combines high value with high efficiency

- Additional: future of LNG vehicles and ships

NATURAL GAS VEHICLES

a good basis for bioSNG



24%/year growth

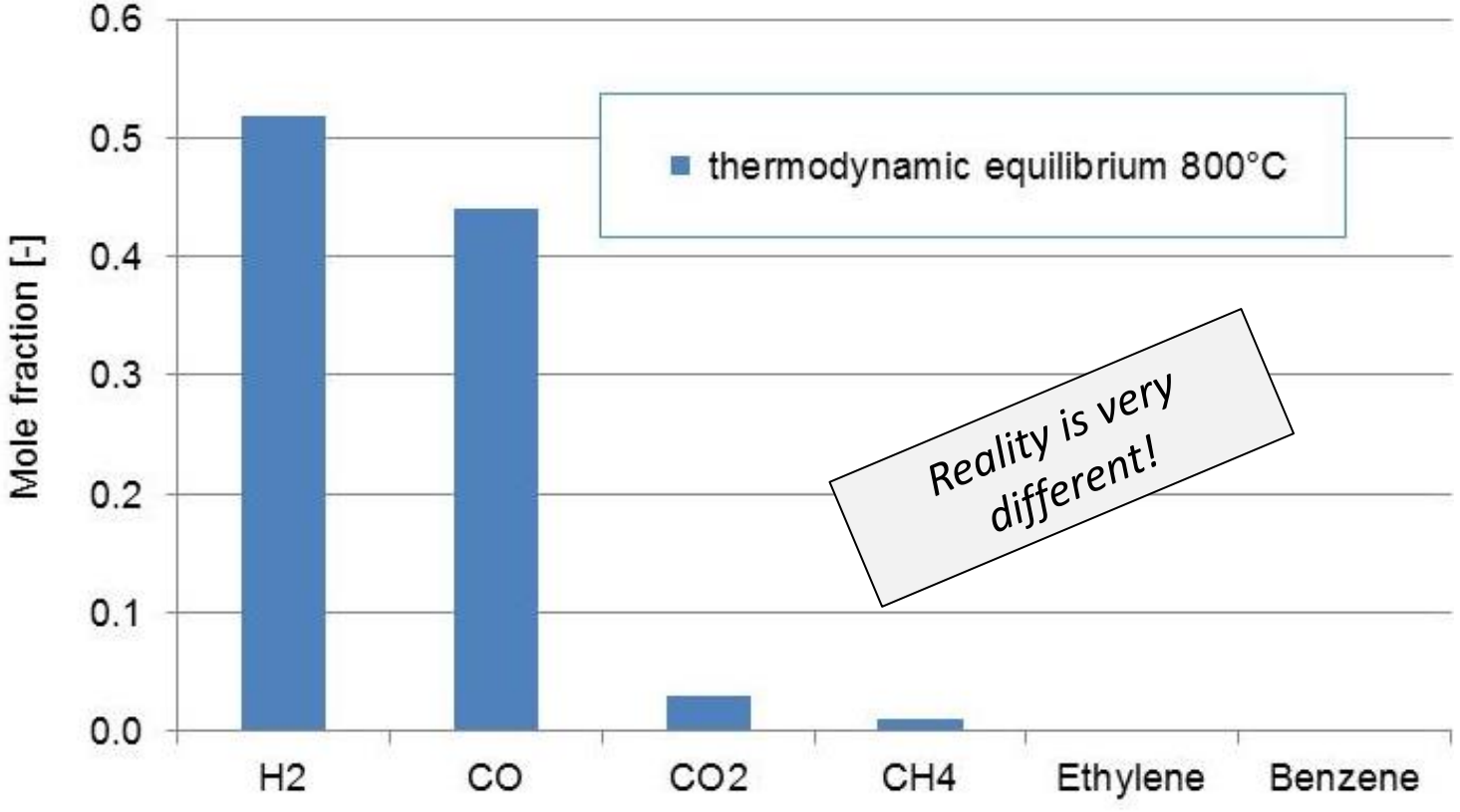
15 million cars

20 thousand fuelling stations

WHAT DOES GASIFIER ACTUALLY MAKE?

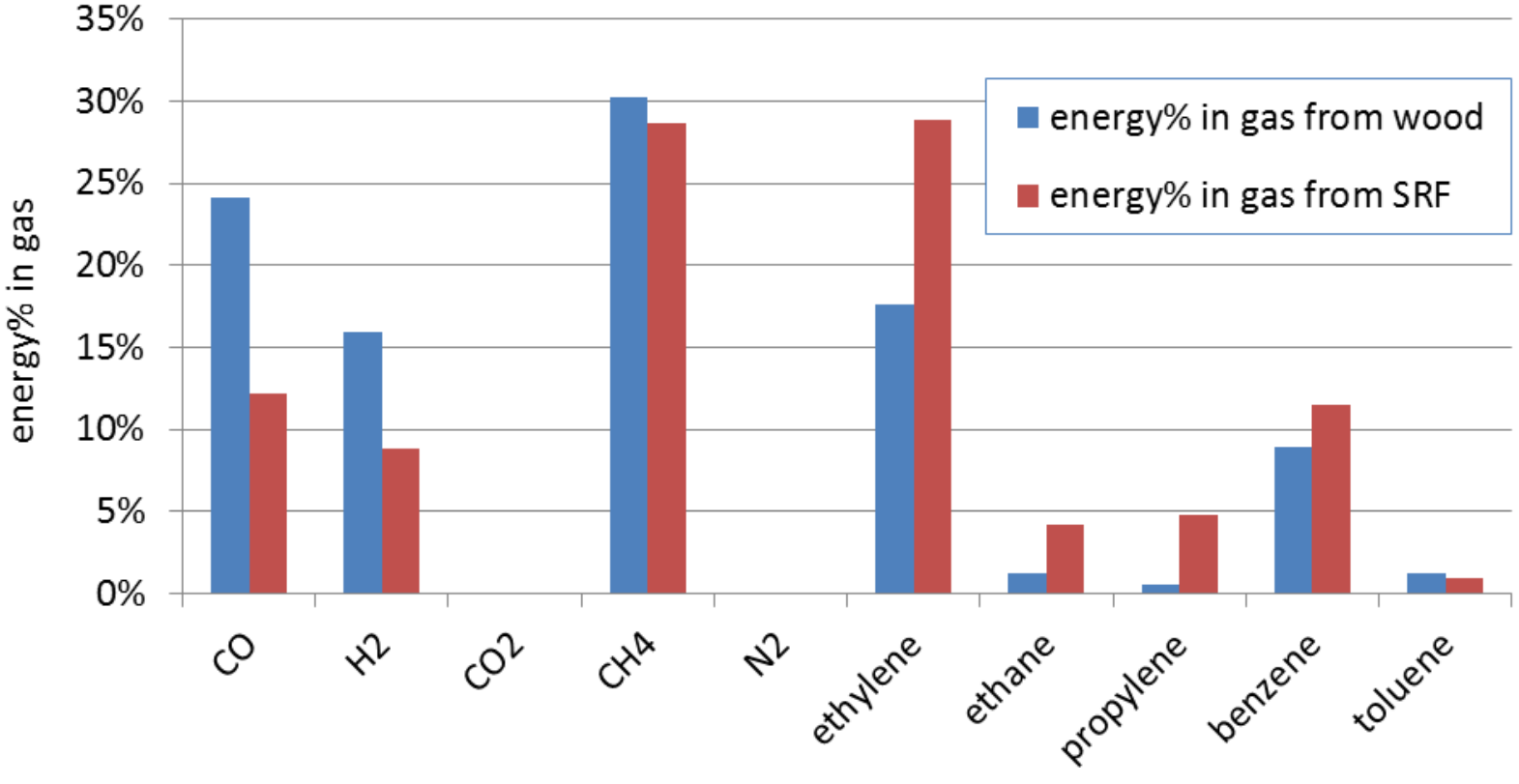
THERMODYNAMICS PREDICT…

essentially only H2 and CO containing syngas



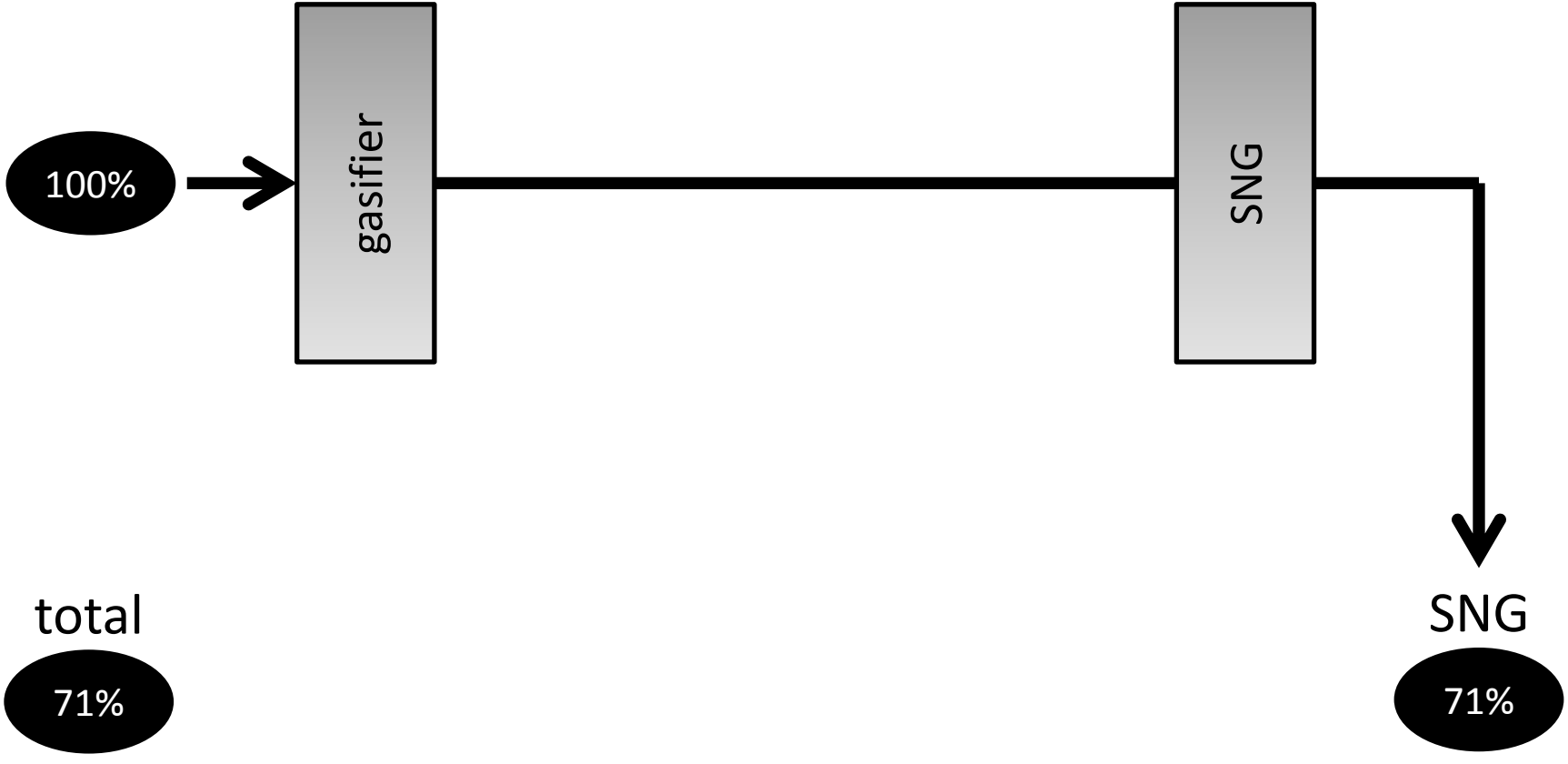
FLUIDIZED BED: REAL GAS

no wonder SNG has such high efficiency



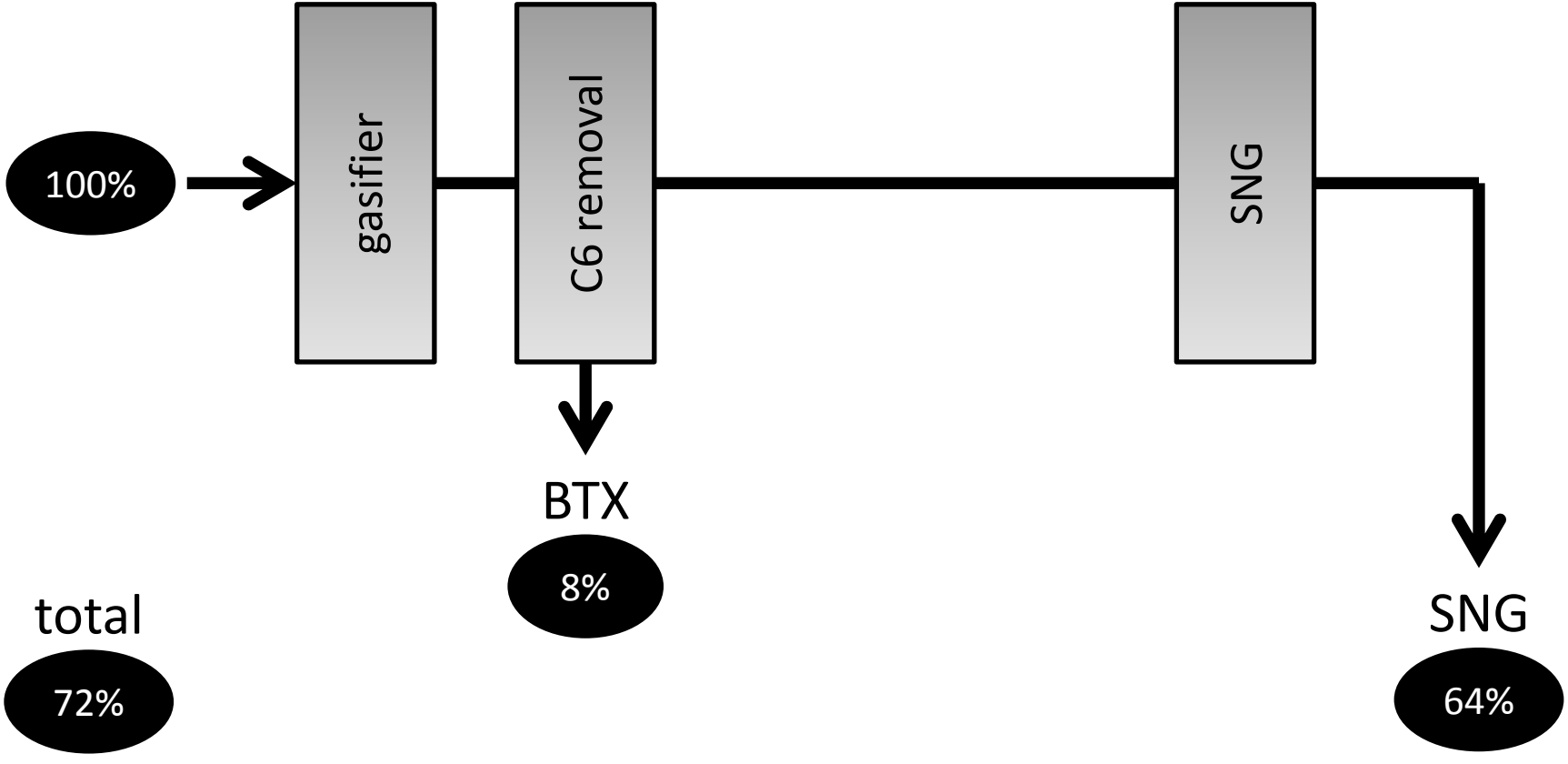
CO-PRODUCTION OPTIONS

SNG base-case



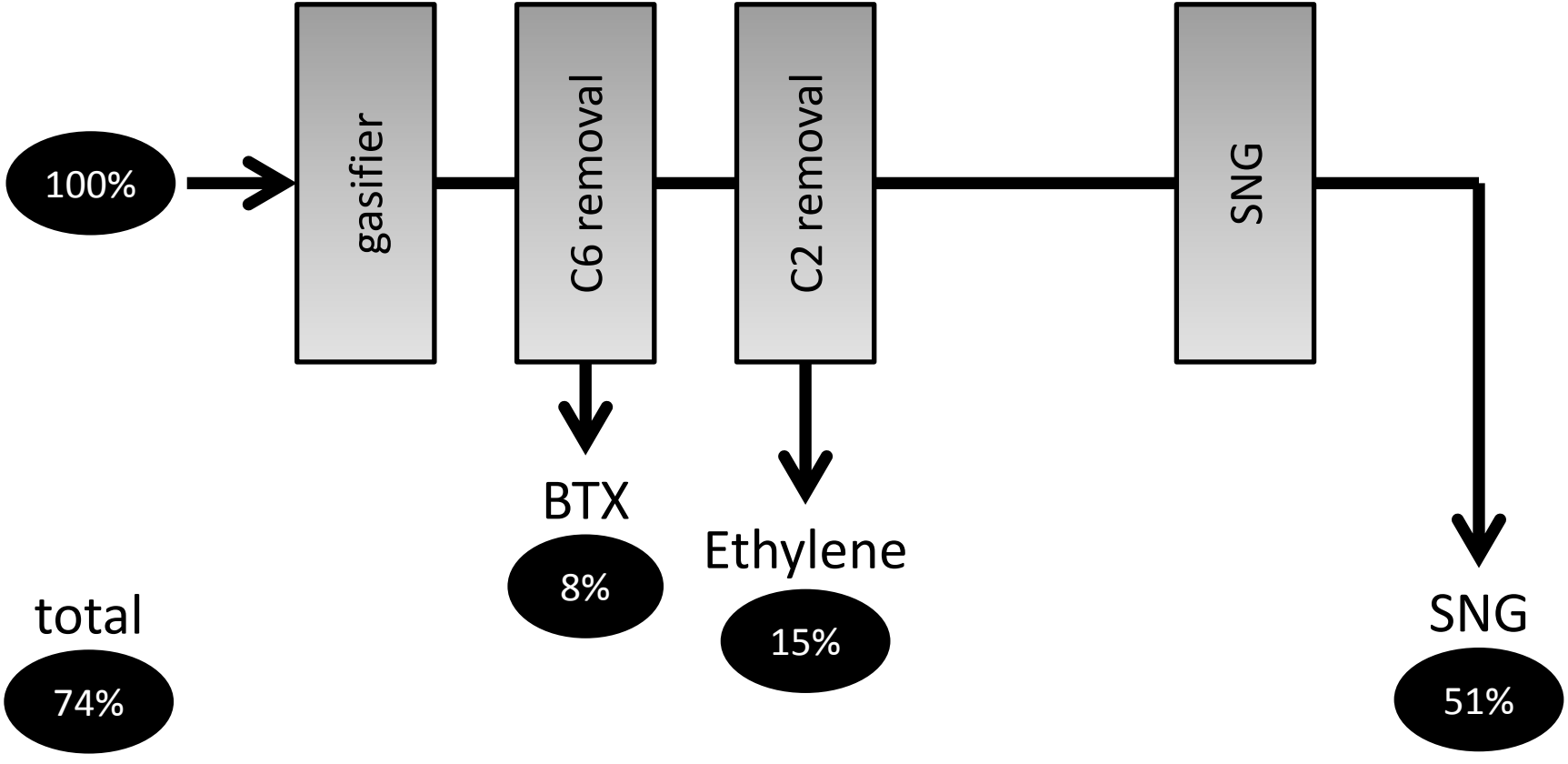
CO-PRODUCTION OPTIONS

BTX co-production



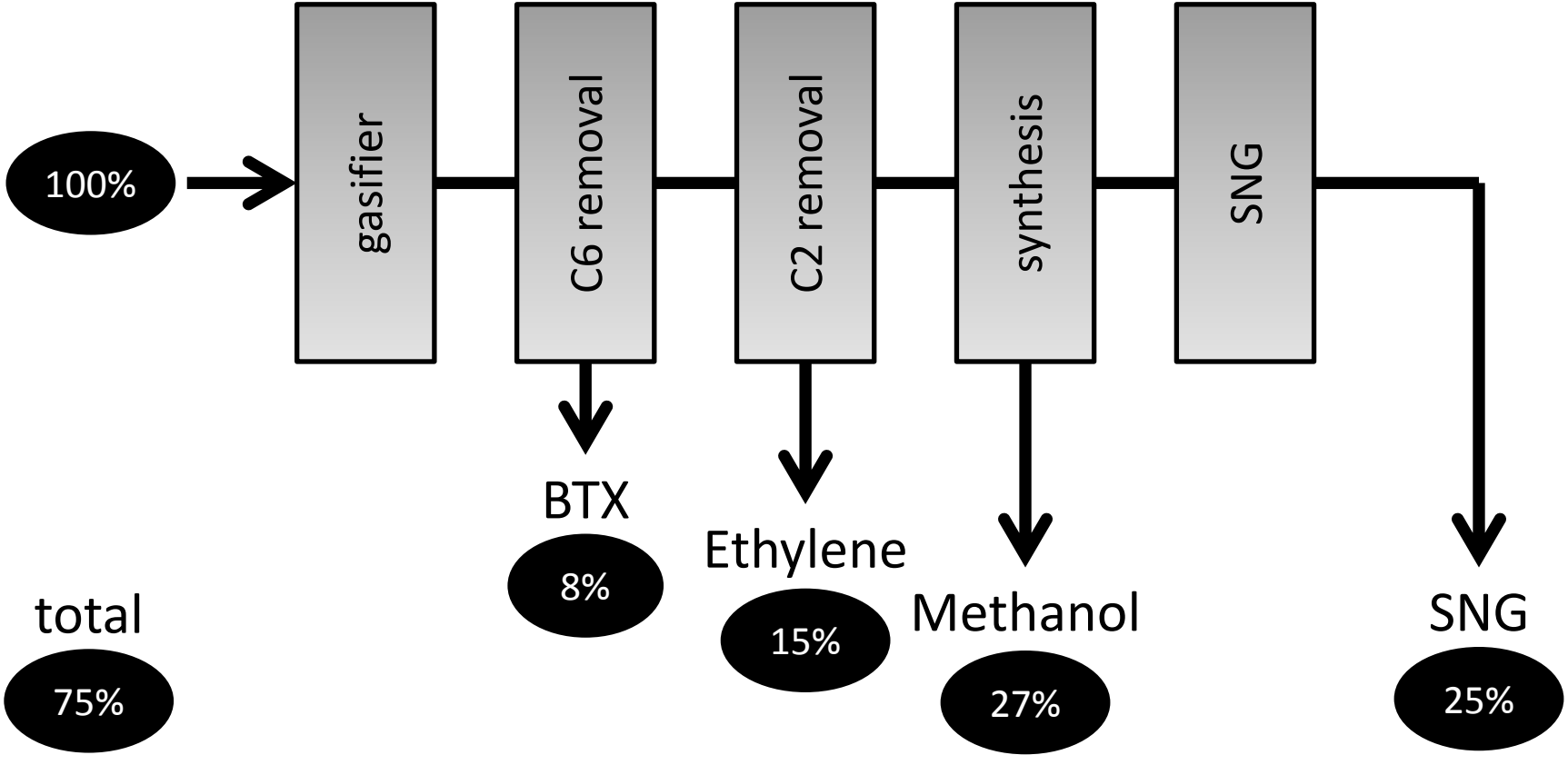
CO-PRODUCTION OPTIONS

BTX and ethylene co-production



CO-PRODUCTION OPTIONS

SNG is "what is left"



SO…

- Fluidized bed gasification (<1000°C) of biomass produces many valuable chemicals
- Harvesting these makes sense from efficiency perspective AND economic perspective

- Like a refinery…

INNOVATIONS

NEW

- Second generation gasification:
  - Higher efficiency at lower temperature
  - Additional fuel flexibility
  - N_2-free gas without ASU
  - Additional chemical looping options
- Co-production schemes: benzene, ethylene, CO_2, H_2, CH_4
- BioCCS: more than avoiding CO_2 emissions
- Power-to-Gas: an outlet for H_2 from intermittent power production
- Gasification: de-polymerisation of plastics for recycling
- Syngas fermentation: bugs downstream gasification

NEW FEEDSTOCK
NEW THINKING

What do you get if you ask an experienced EPC in petro-chemistry to design a biomass gasification plant?

What do you get if you ask an experienced car manufacturer to build a human-powered two-wheel car?

It certainly works, but may not be the best choice

THANKS FOR THE ATTENTION

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