Nya idéer för drivmedel från skogsindustrins restprodukter för ökad potential och ökad flexibilitet

Rikard Gebart, LTU och Anders Östman, Cellulose Fuels

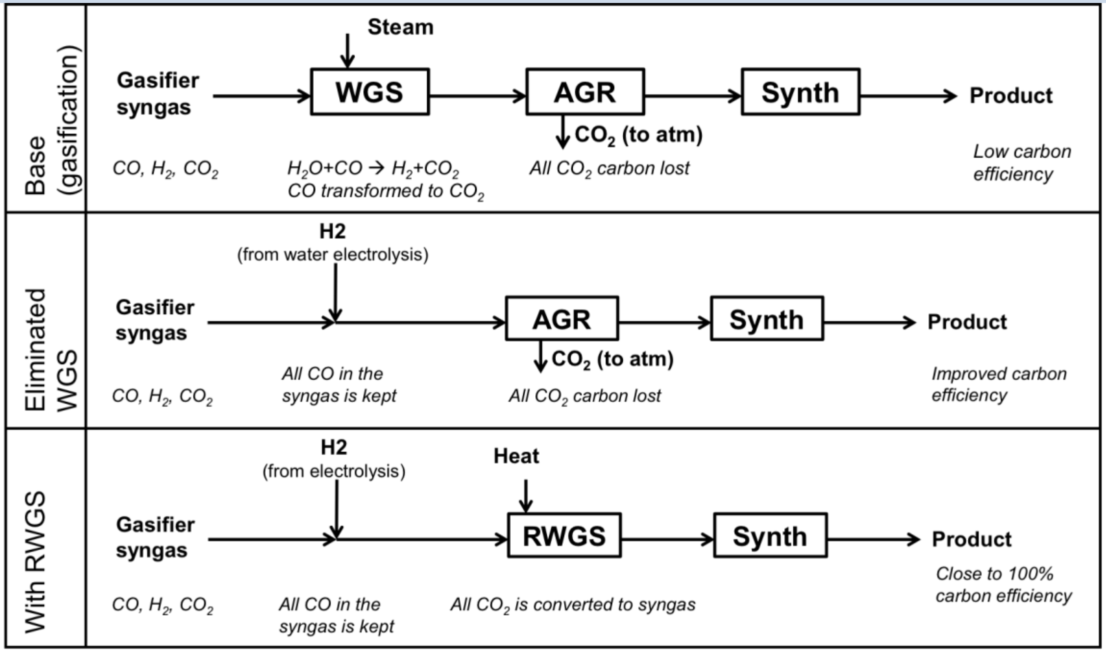
Agenda

- Power-to-liquids genom kombination av ett förgasningsbaserat bioraffinaderi och förnybar el (Rikard Gebart)
- Ny process för kombinerad biokemisk och termokemisk omvandling av skogsrester (Anders Östman)

Fundamental problem with syngas from biomass and how it can be removed

- Generic wood "molecule" $CH_{1.4}O_{0.6}N_{0.02}$
  - H/C ratio of wood is 1.4
  - H/C ratio of typical end products are 2 – 4
- Hydrogen content in syngas must be increased before synthesis
  - Water-gas shift reactor (WGS) uses chemical energy and increases venting of CO_2
  - Addition of hydrogen from an external source makes it possible to use all chemical energy in the syngas and to add more renewable energy

Power-to-liquids in a biorefinery



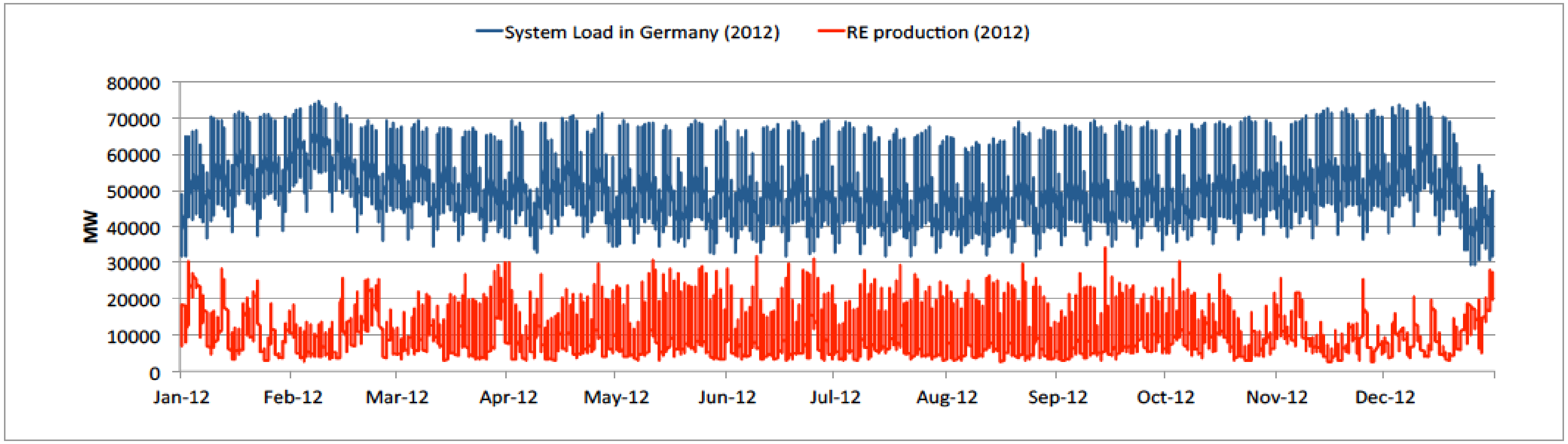
Base case

Hydrogen addition
60% improvement

Reverse shift
150% improvement

- **In a conventional process 60% of the carbon is vented to the atmosphere as CO2**
- **The process yield increases 150% if all CO2 is converted to CO with RWGS**
- **The process yield in the demonstration increases by 76% (once-through RWGS that shifts about 50% of the CO2 to CO)**
- **The concept works with all gasification based BtX processes, e.g. BioDME, Bioliq and Gobigas**

Electric Energy Load in Germany



$\Phi_{L\ 2012} = \int L_{2012}(t) = \mathbf{469}$ TWh (1687 Pj)

$\Phi_{WP\ 2012} = \int WP_{2012}(t) = 73.4$ TWh (264.2 Pj)

$\Phi_{WP\ 2012} / \Phi_{L\ 2012} = 16\ \%$

If we also includes the hydropower production – 21.8 TWh produced in 2012 – the percentage of renewable electricity produced – and introduced into the electric grid – is:

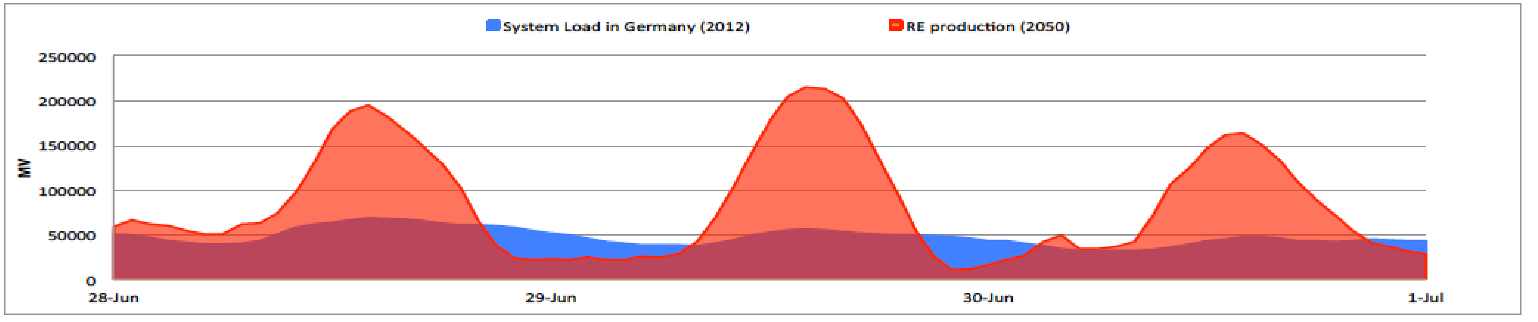
$\Phi_{RE\ 2012} / \Phi_{L\ 2012} = 20\ \%$

Total installed power of renewables sources in Germany 2012		
	Installed power (GW)	Energy production TWh
Wind	31.3	46.0
Hydro	4.4	21.2
Photovoltaic	32.6	28.0

Zahlen un Fackten Energiedaten BMWi

Scaling up the installed RES

f = 20

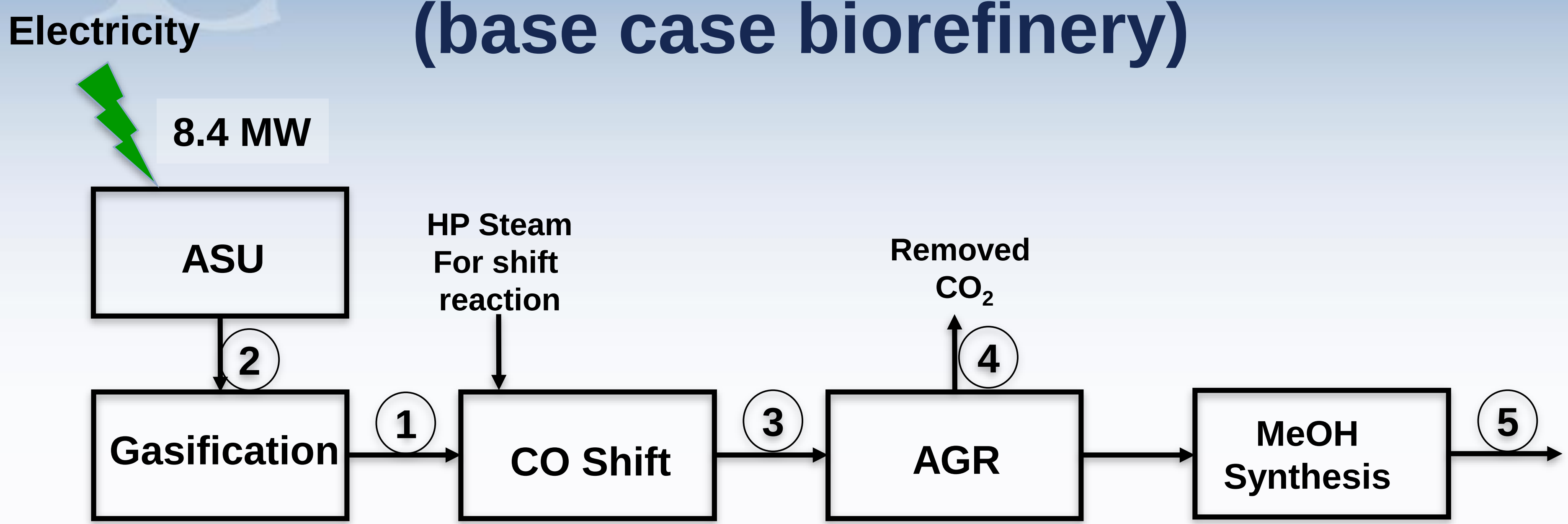


In this scenario the total amount of load electricity not covered from the renewable electricity production corresponds to circa 6% of the annual load $F_{L\ 2050}$

$$\Phi_{out\ 2050} = \int [L_{2050}(t) - RE_{2050}(t)]\, dt \quad when \quad RE_{2050}(t) < L_{2050}(t) = 0.06 \cdot \Phi_L$$

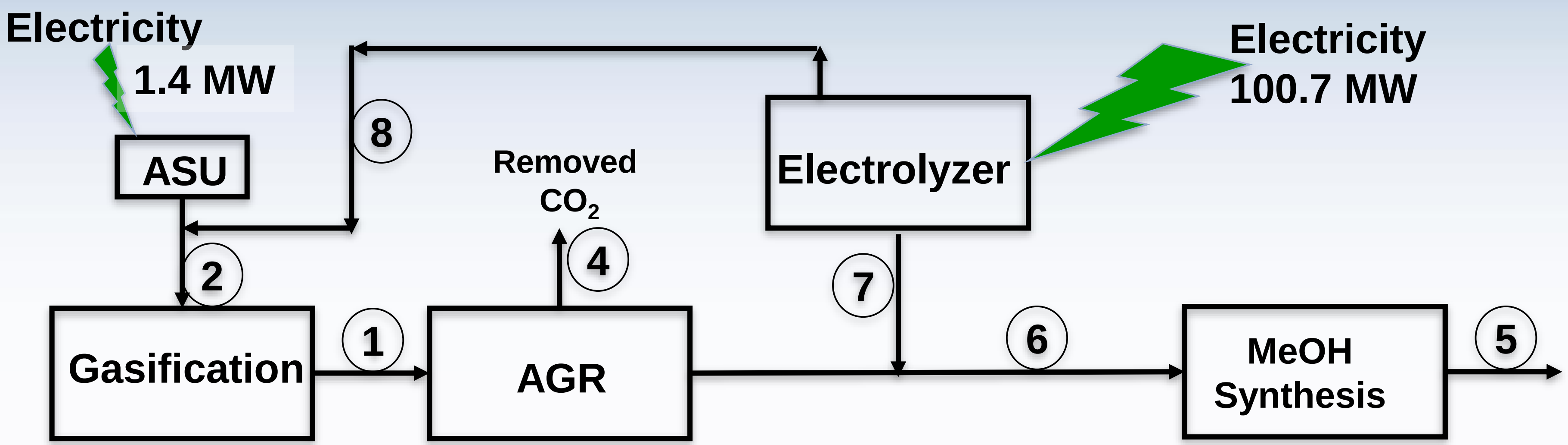
Scaling 20 times (f = 20) the installed renewable power – only wind and PV - and consequently the produced electricity, the production must fulfill the 94% of the total electric demand (load).

Main Process Blocks (base case biorefinery)



Kompo-nent	(1) Rågas, Nm3/h	(2) Oxygen	(3) Shifted Gas MW	(4)Removed CO_2 Nm3/h	(5) MeOH, MW / Ton/h			
H_2	22351 (67MW)		128,1 MW	CO_2 16819	102.5 / 18.6			
CO	19416 (67,9 MW)							
O_2		12874						

Main Process Blocks (Power to Liquid Case)



Kompo-nent	(1) Rågas, Nm3/h	(2) Oxygen	(3) Shifted Gas MW	(4)Removed CO_2 Nm3/h	(5) MeOH, MW / Ton/h	(6) Gas after H_2 injektion, Nm3/h	(7) Added H_2, Nm3/h	(8) Added O_2, Nm3/h
H_2	22351 (67MW)		----	CO_2 11412	159.3 / 28.9	43775 (131,2 MW)	21424 (64,2 MW)	
CO	19416 (67,9 MW)					19416 (67,9MW)		
O_2		12874						10712

Some key conclusions - 1

- Methanol from raw gas via shift:

(67 + 67.9) x 0.95 x 0.8 = 102.5 MW

- Methanol from raw gas with H_2 addition:

(67 + 67,9 + 64,2) x 0,8 = 159,3 MW

- Increased production from a given amount of feedstock: 159.3 / 102.5 x 100 = **55%**
- Conversion efficiency of hydrogen energy to methanol energy:

100 x (159.3 – 102,5) / 64,2 = **88%**

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Some key conclusions - 2

<u>Power price 60 €/MWh</u>

- If Power price is 60€ / MWh then the cost of power in the hydrogen production cost is 60 / 0.64 = 94€ / MWh.
- Savings on power needs for oxygen production corresponds to 7 MW. If this is credited the power consumption for hydrogen the conversion efficiency becomes 64.2 / (100.7-7) = 68.5%
- *Cost of power in the hydrogen production* cost then becomes 60 / 0.685 = 88€ / MWh.

<u>Power price 45 €/MWh</u>

- *If average power price is 45€ / MWh the corresponding cost element is 66 €/MWh*

Some key conclusions - 3

- If Power price average is 45€ / MWh then the cost of power in the methanol production cost is 45 / 0.685 / 0.8 = 82 € / MWh.
- This concept is economically at least as good as adding capacity via pyrolysis oil addition to black liquor
- To meet the requirement of H_2 for the calculated case there would be a need of about 40 units each producing 600 Nm3/h
- Area required to hose the plants would be about 5000 m
- If stand-alone “power to gas / liquids” concepts are “real concepts” worth going for then the described process principle is clearly more efficient.

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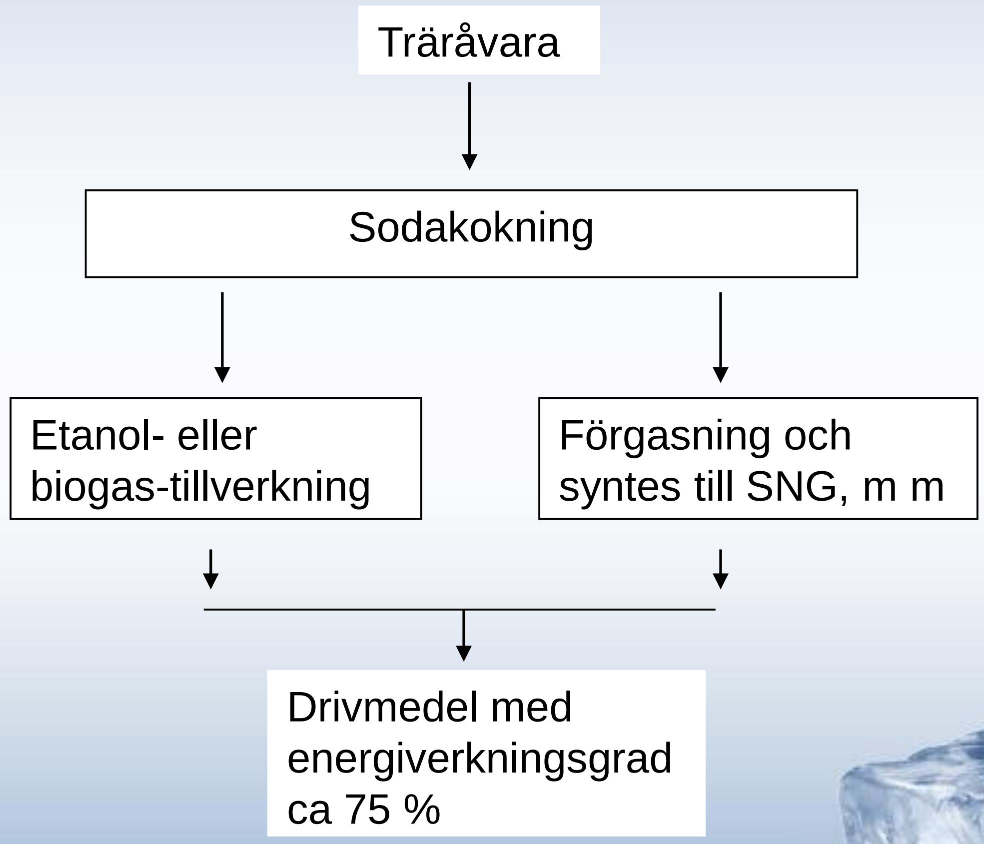
Other impact when going from shifting of gas to hydrogen injection

- Less investment: WGS unit and air separation (ASU) unit
- No HP steam consumption in WGS unit
- Lower investment in AGR unit if no or less CO_2 is to be removed (smaller Rectisol)
- The ratio between H_2S / CO_2 for feed gas to the Rectisol will be higher which improves the performance

Allmänt processkoncept



Etanol ur träråvara respektive cellulosa

”konventionell” (utvecklad) teknik för etanol ur lignocellulosa (träråvara)

Träråvara

↓

Förbehandling; 150-200 grader C, H_2SO_4 el. SO_2

↓

Etanoltillverkning; hydrolys och jäsning → Rest-produkter

↓

Etanol

Etanol ur cellulosa

Cellulosa

↓

↓

Etanoltillverkning; hydrolys och jäsning → Rest-produkter

↓

Etanol

Ingen förbehandling
Förhöjd verkningsgrad med ren cellulosa
Mindre reaktorvolymer
Mindre restprodukter att ta hand om
Lägre enzymkostnad

Fastbränsleförgasning respektive svartlutsförgasning

”konventionell” (utvecklad) teknik för fastbränsleförgasning och syntes

Träråvara

↓

Förbehandling; flisning torkning, inmatning

↓

Förgasning och syntes till MeOH, SNG, FT, etc → Rest-produkter (Värme)

↓

Drivmedel

svartlutsförgasning

Träråvara

↓

↓

Förgasning och syntes till MeOH, SNG, FT, etc → Rest-produkter (Värme)

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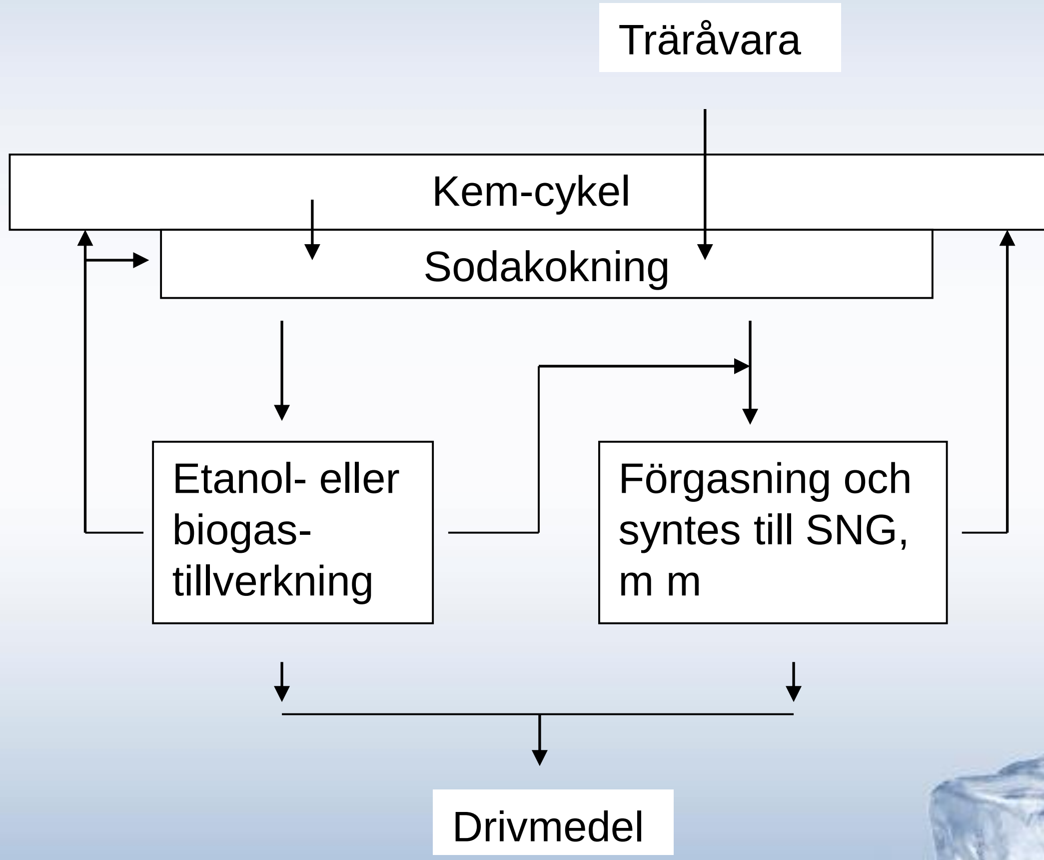
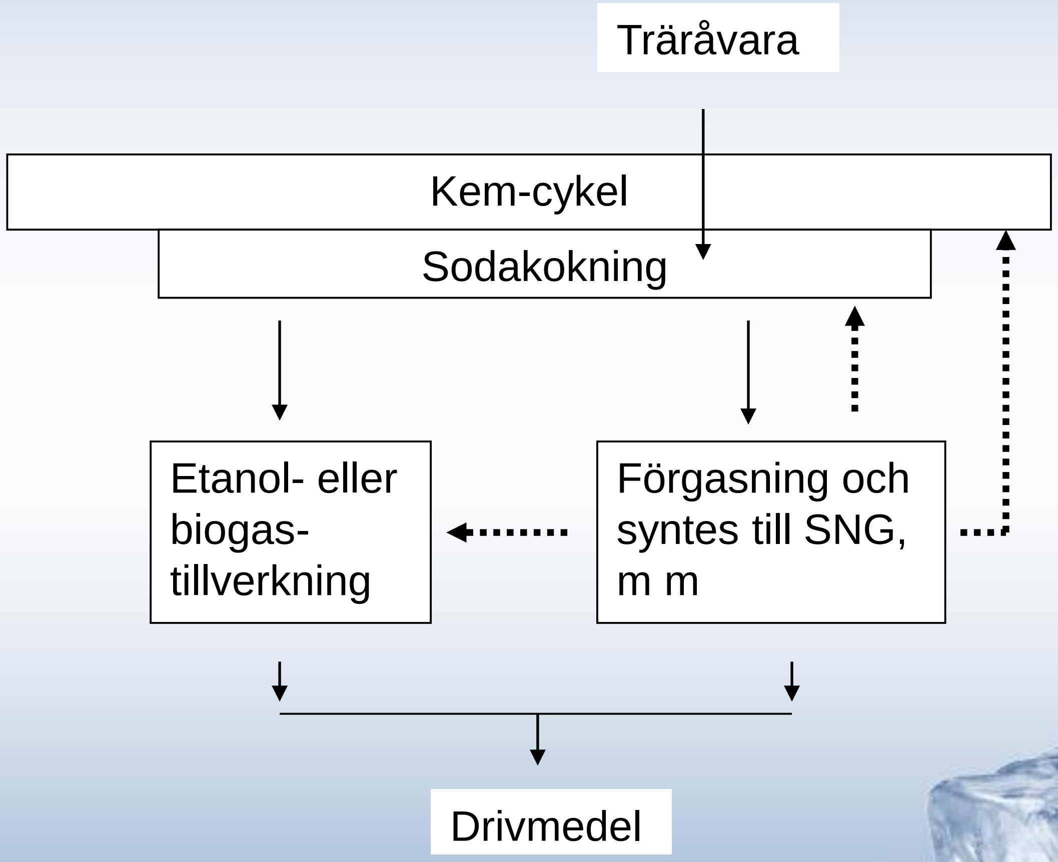
Drivmedel

Ingen förbehandling
Enklare inmatning

Processtekniska fördelar - Material



Processtekniska fördelar – Ånga och bränsle



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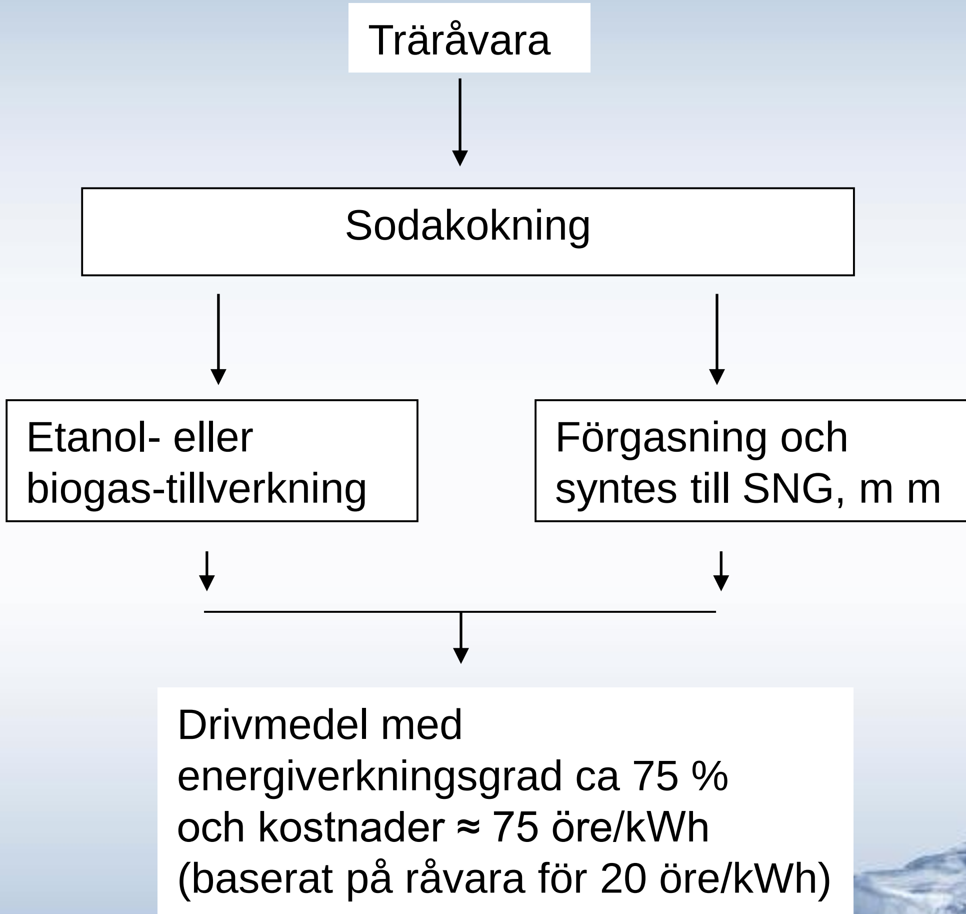
Utvärderingar av sammanlagda verkningsgradseffekter och kostnader



Samtliga delprocesser = befintlig teknik ger: trovärdighet, konkurrensutsatt upphandling, förenklad inkörning, m m