

WORLD ECONOMIC FORUM



Technology
Pioneers

TOPELL ENERGY



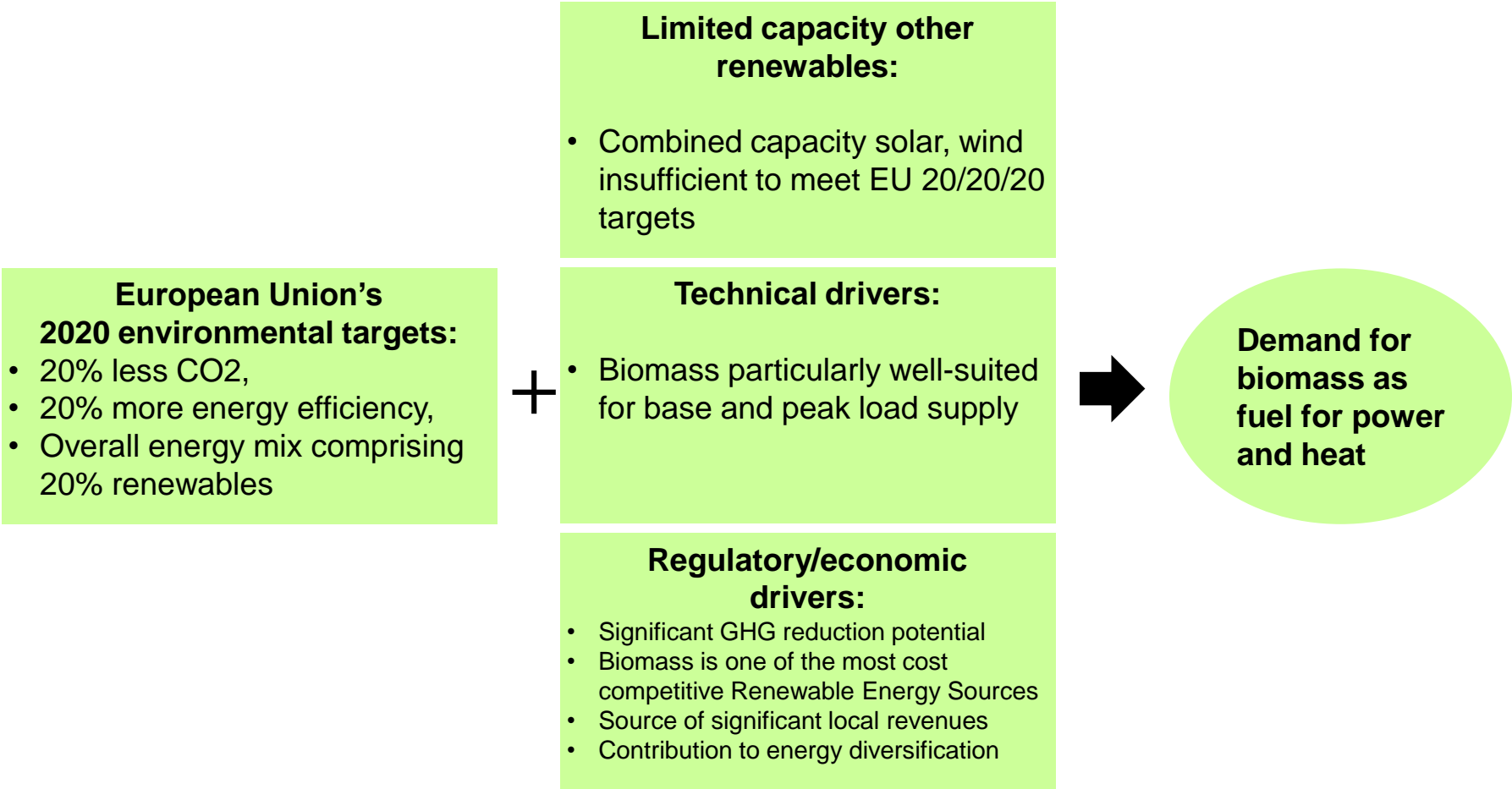
Bioenergiedag
Bio-energiecluster Oost-Nederland
Zwolle, October 14th 2010

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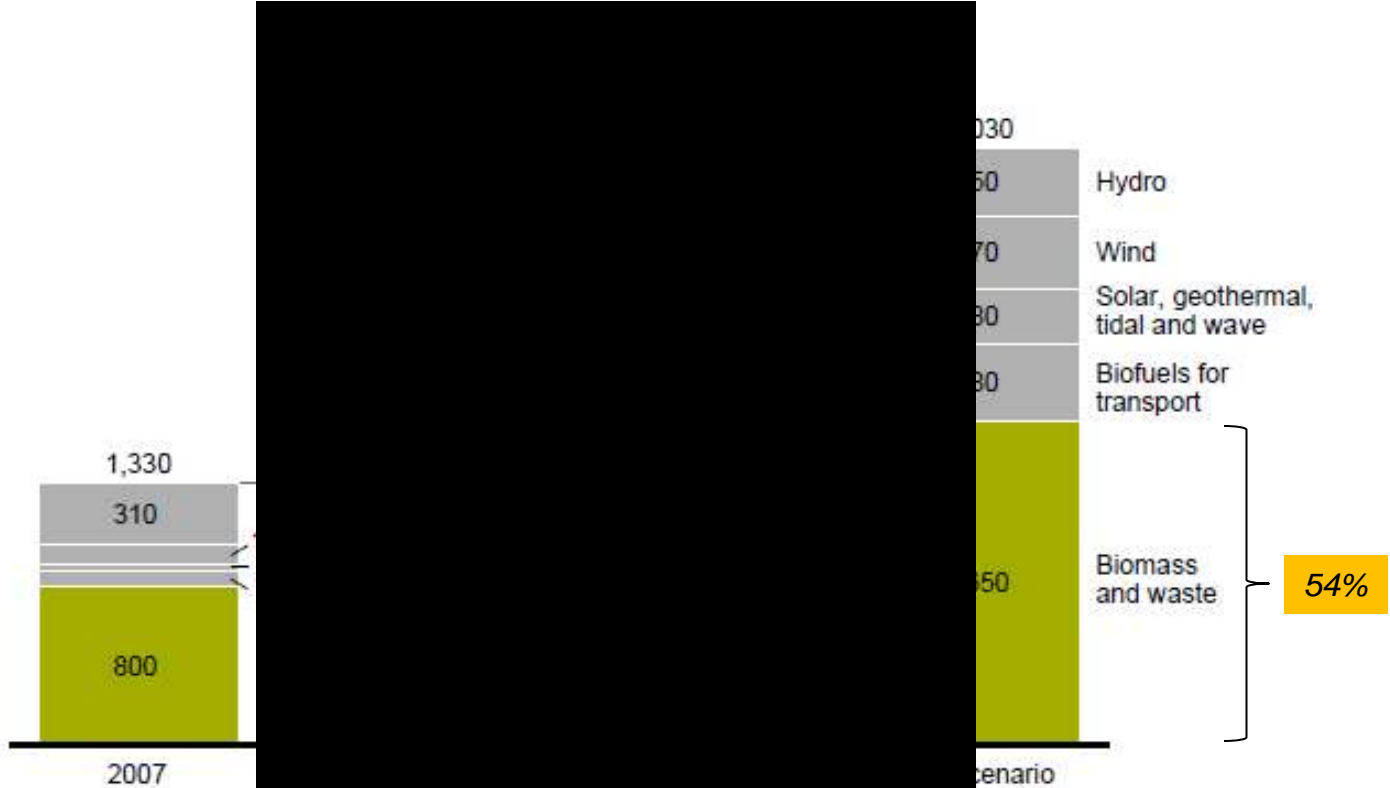
1. Drivers of biomass as sustainable fuel
2. Torrefaction – upgrade biomass to 2G solid fuel
3. Topell Energy

ENVIRONMENTAL TARGETS DRIVE DEMAND FOR BIOMASS

Major fuel for decarbonising power and heat



BIOMASS PREDICTED TO FUEL 50+% OF EU-27 FINAL ENERGY CONSUMPTION BY 2020



Sources: The Biomass for Heat and Power

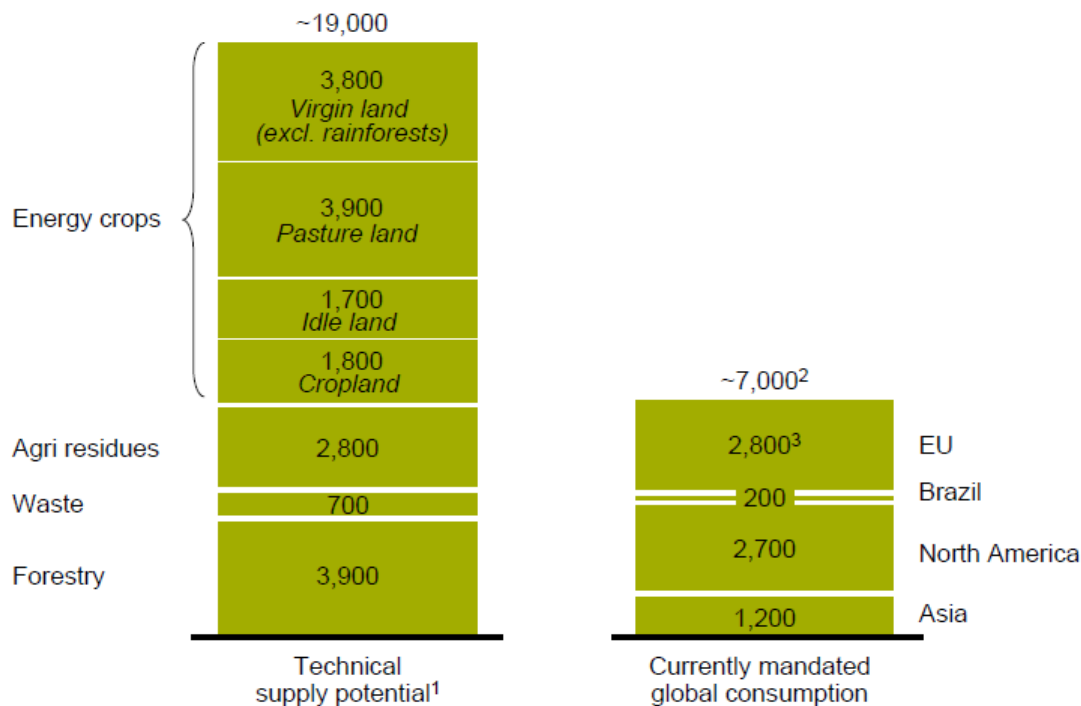
Sveaskog, Sodra, Vattenfall

SUFFICIENT LAND AND BIOMASS POTENTIAL TO MEET 2020 MANDATED GLOBAL CONSUMPTION

Energy crops important

Technical global biomass supply potential available for energy production in 2020 relative to currently mandated 2020 targets

Primary energy; TWh



¹ Includes all main supply regions in the world, but additional geographies not included. Therefore, actual potential may be higher.

² Total can vary depending on split between heat and power

³ Including 500 TWh primary energy used for biofuels to meet current European biofuels mandates

SOURCE: Food and Agriculture Organization of the United Nations; FAPRI (2007); McKinsey biomass model (2009)

Sources: *The Biomass for Heat and Power report*. Sponsored by European Climate Foundation, Sveaskog, Sodra, Vattenfall

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BIOMASS IS IMPORTANT, BUT BIOMASS NOT YET AN OPTIMAL FUEL



Low caloric density . Biodegradable . Hard to grind . Hydrophilic . Heterogeneous

UNTREATED BIOMASS PARTICULARLY HARD TO CO-FIRE IN EXISTING POWER ASSETS

1. Untreated biomass is expensive to transport and store
 - a. Low caloric value;
 - b. Biodegradable;
 - c. Hydrophylic.

2. Power plants need substantial investments to deal with biomass
 - a. Separate quay, unloading, storage, feed, mill, boiler inlet;
 - b. Because of hydrophilic nature of product, lesser milling behavior, lesser fuel/burning characteristics.

3. No matter substantial investments, boilers can only handle limited amount of biomass, increasing costs of co-firing
 - a. Refit of boiler very expensive.

If only we could make biomass coal-like..

TORREFACTION PRODUCES COAL-LIKE PRODUCT (I)

Involves thermo-chemical treatment of biomass

Torrefaction

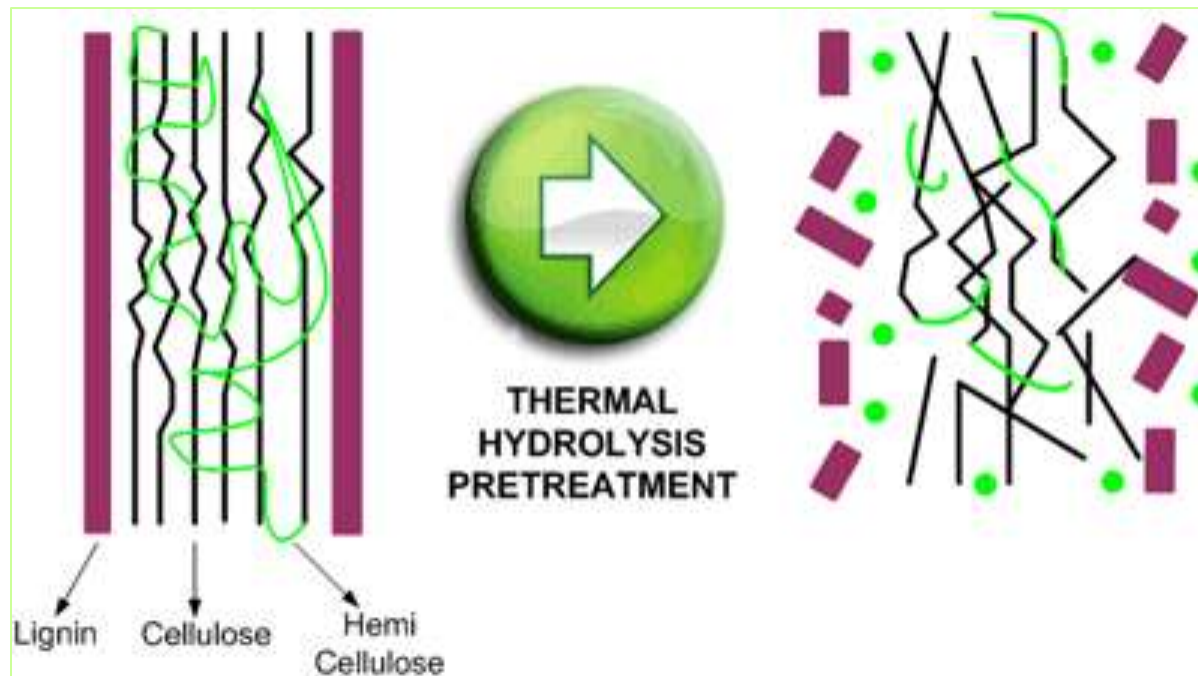
- In temperature range 200-300 C
- Under atmospheric pressure
- In absence of oxygen
- Within minutes
- Product is solid biomass
- Typical mass yield > 70%
- Typical energy yield > 85%

Not torrefied

Torrefied

TORREFACTION IMPROVES FUEL PROPERTIES BY DEPOLYMERIZATION

Which impacts caloric value and fuel characteristics



TORREFACTION PRODUCES COAL-LIKE PRODUCT (II)

Caloric value biomass increases as O and H 'leave' as CO₂, H₂O and organic acids

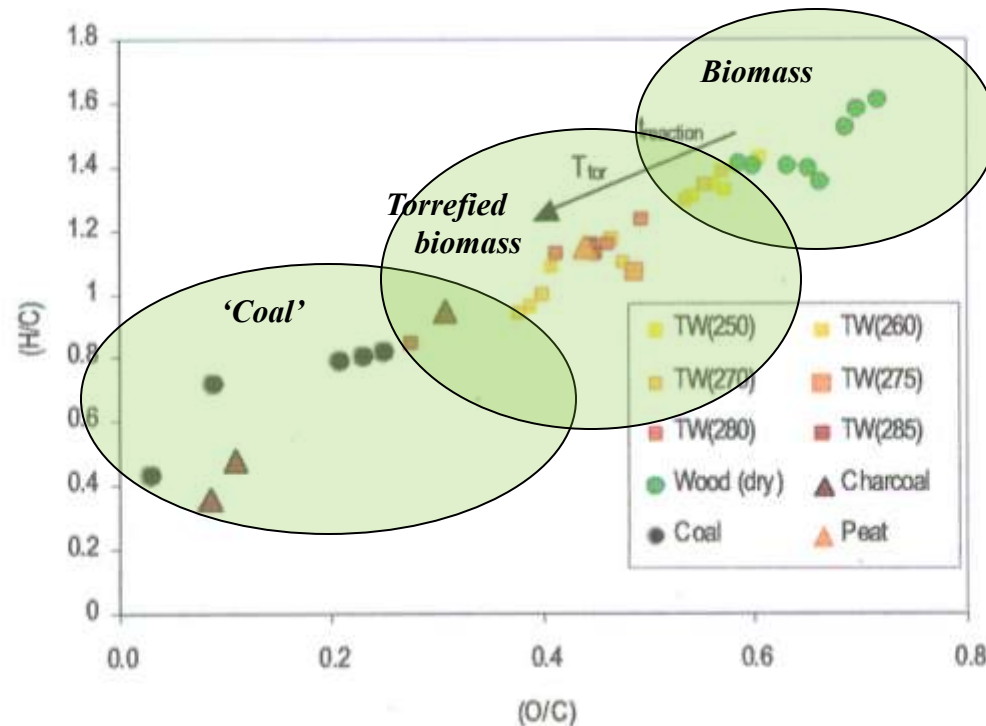





Figure 2.6 Van Krevelen diagram for torrefied wood (TW) produced at different conditions, untreated wood, coal, charcoal and peat samples. Coal and peat data is taken from Ullmann (1999). Wood and torrefied wood from Bourgois and Doat (1984), Girard and Shah (1989) and Pentananunt et al. (1990)

Source: Bergman, P.C.A.; Boersma, A.R.; Zwart, R.W.R.; Kiel, J.H.A.

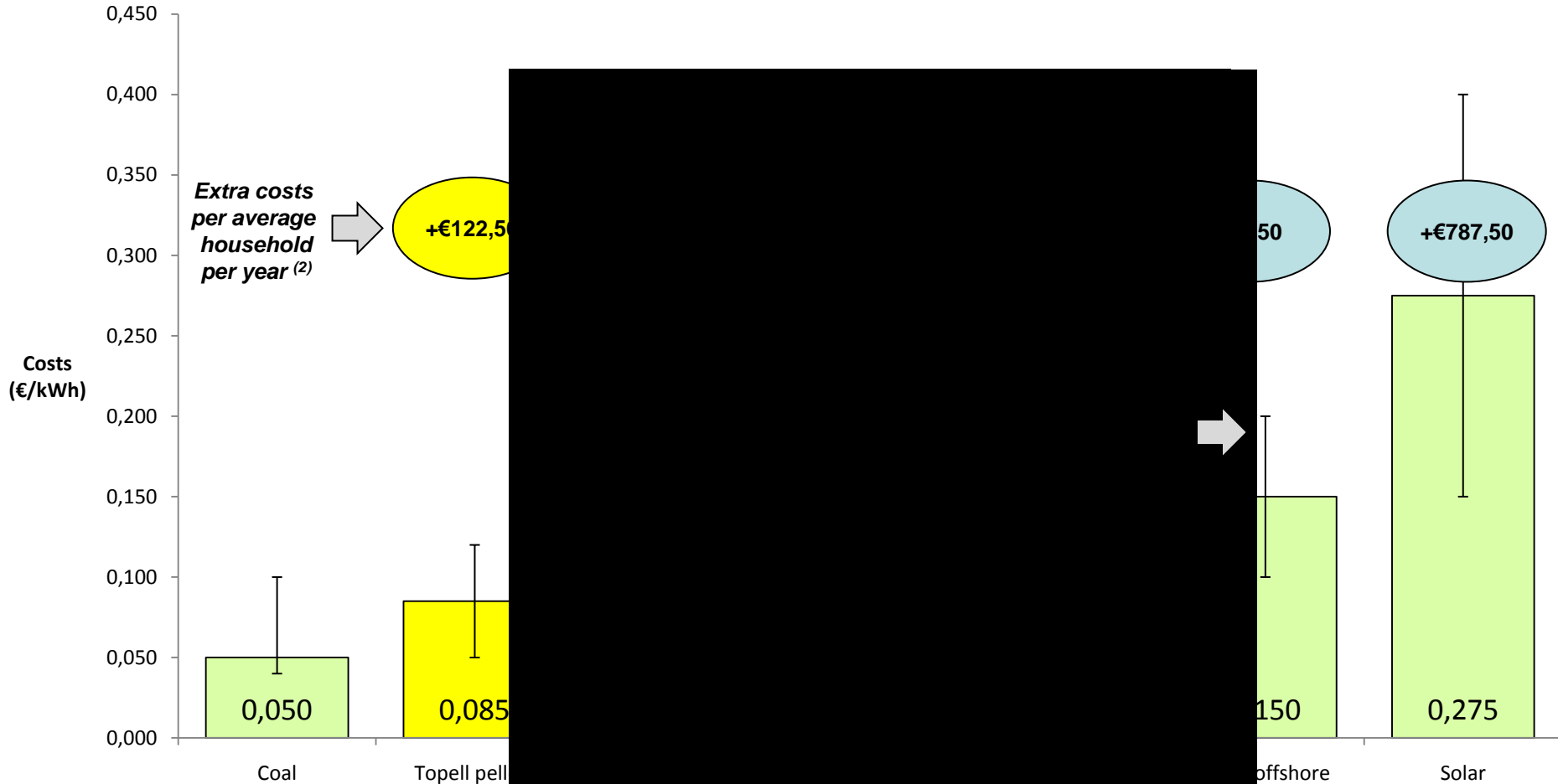
ECN-C--05-013 juli 2005; 72p.

TORREFACTION PRODUCES COAL-LIKE PRODUCT (III)

Involves thermo-chemical treatment of biomass

	<i>Biomass (pellet, chip)</i>		<i>Torrefied biomass</i>	<i>Coal</i>
		↔		
<i>Tough</i>	Yes	↔	No	No
<i>Fibrous</i>	Yes	↔	No	No
<i>Hydrophilic</i>	Yes	↔	No	No
<i>Biodegradable</i>	Yes	↔	No	No
<i>Heterogeneous</i>	Yes	↔	No	No
<i>Poor energy density</i>	Yes	↔	No	No
<i>Sustainable fuel</i>	Yes	↔	Yes	No

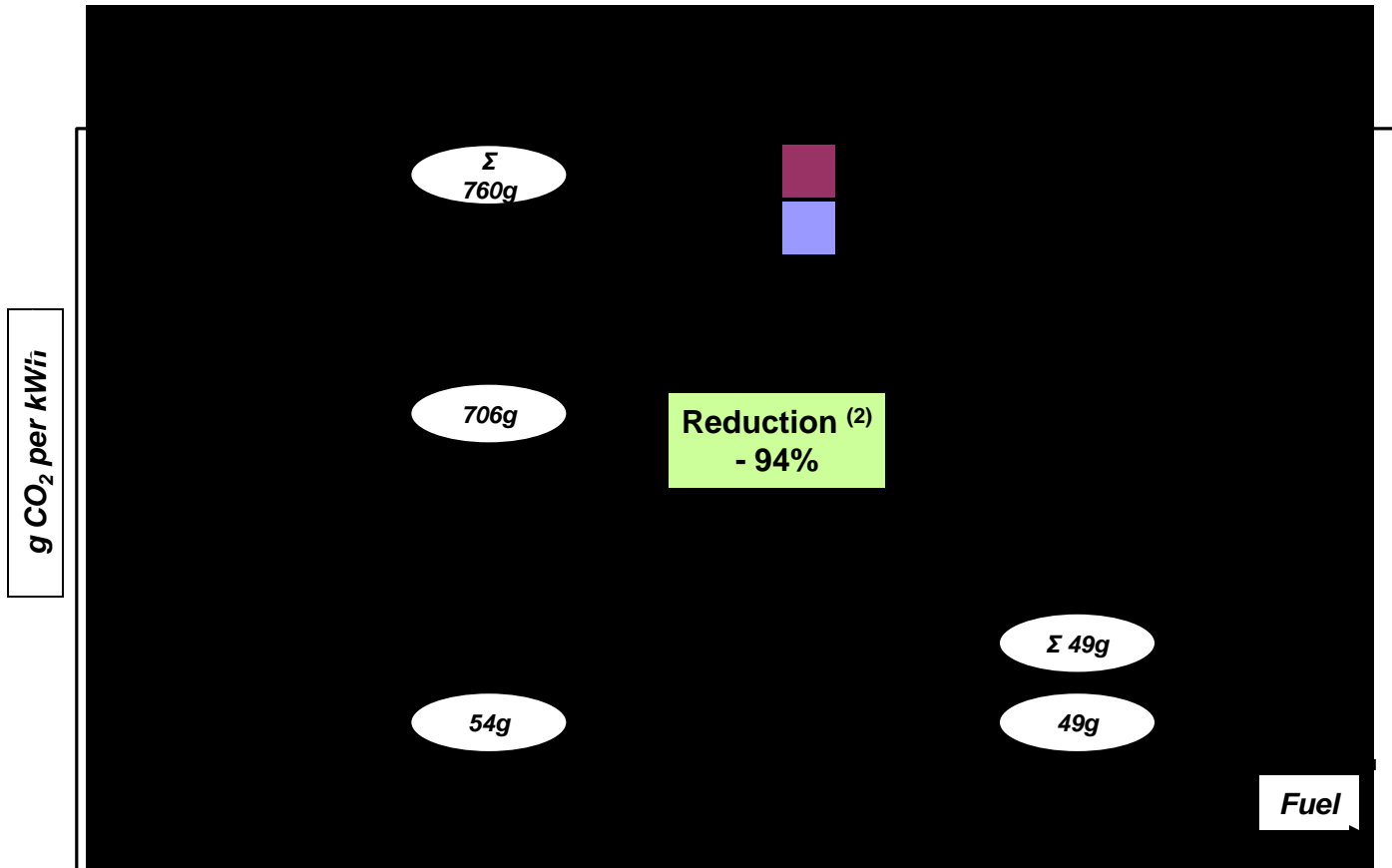
TORREFIED BIOMASS OFFERS AFFORDABLE DECARBONIZATION OF POWER PRODUCTION



(1) Source: Topell Energy analysis, F...

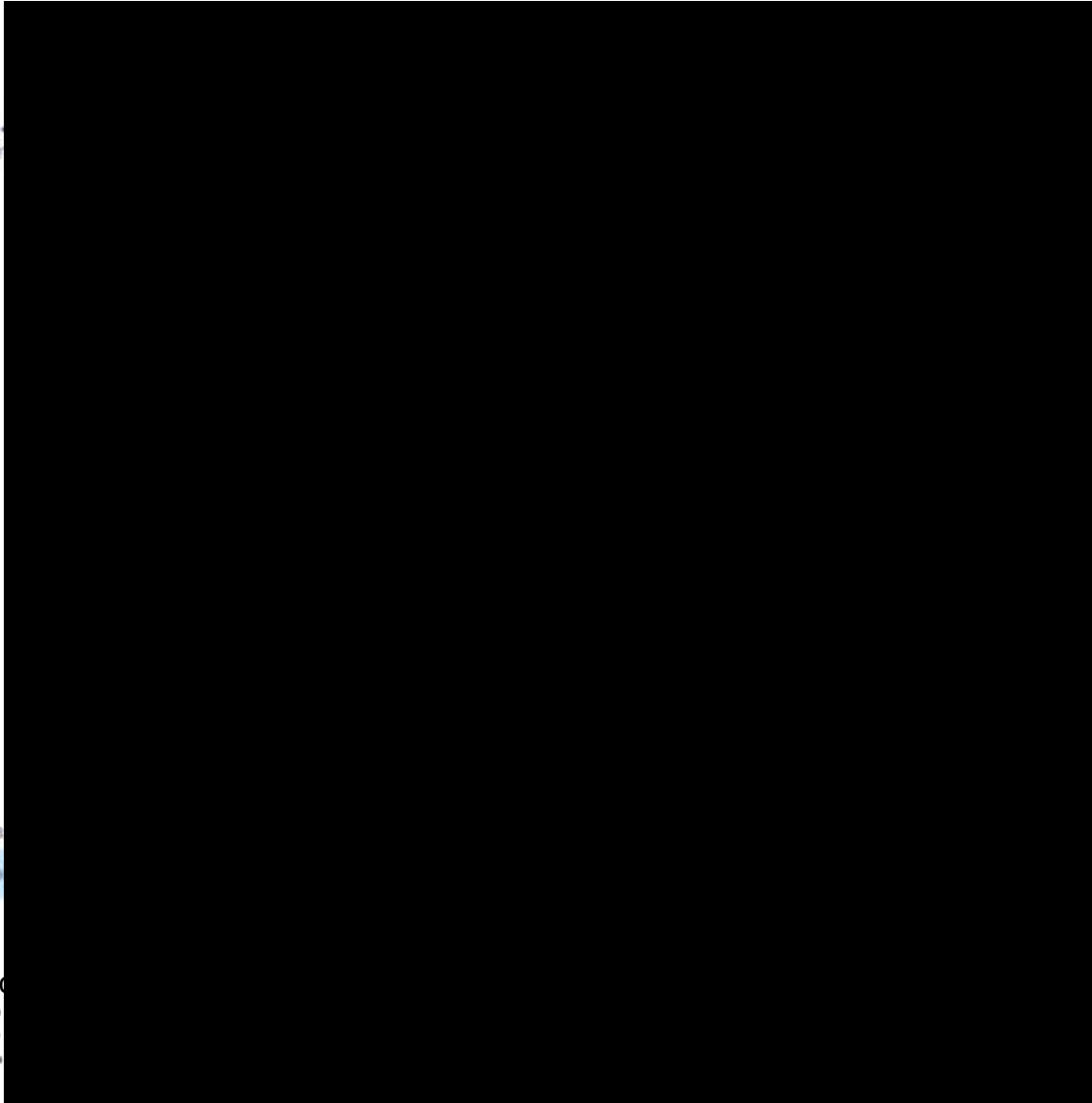
(2) Source: Topell Energy analysis. A...

TORREFIED BIOMASS REDUCES CO₂-EMISSIONS POWER PRODUCTION BY 90+%(1)



LOW HIGH CALORIC DENSITY IMPORTANT AS MOST OF BIOMASS WILL COME FROM ABROAD⁽¹⁾

North America most important supplier of forest biomass



(1) Source: IEA, Mo

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TOPELL ENERGY HAS STARTED COMMISSIONING OF FIRST COMMERCIAL SCALE TORREFACTION PLANT IN DUIVEN

First production per Q1 2011



Key (approximate) figures: 135.000 ton biomass in . 60.000 ton torrefied biomass out . 'Powers' 40,000 families