



# Energy Generation from Recovered Wood for Greenhouse Gas Reduction

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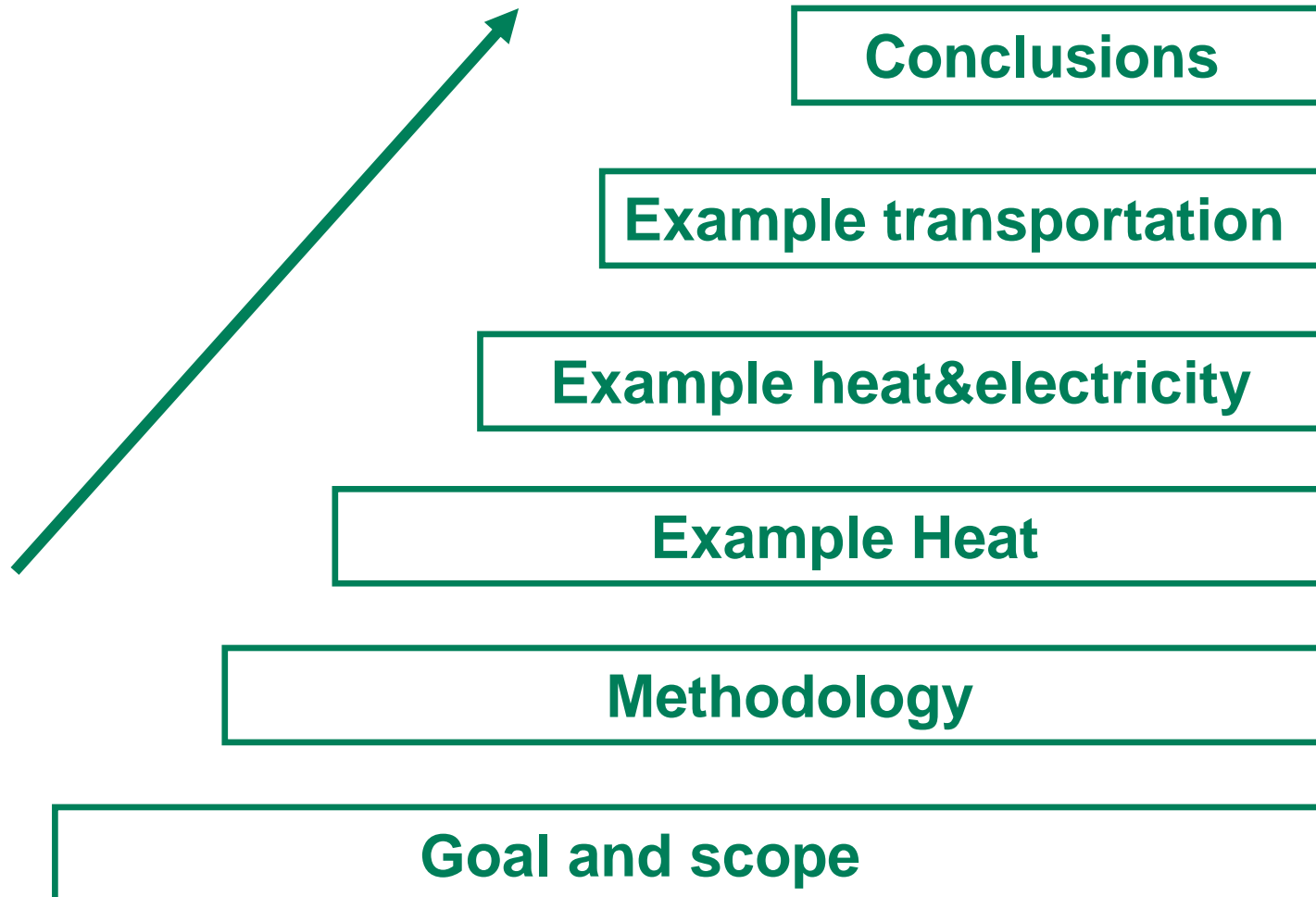
Joint Workshop COST Action E31 and IEA Bioenergy Task 38

*„Greenhouse Gas Aspects of Biomass Cascading – Reuse,  
Recycling and Energy Generation“*

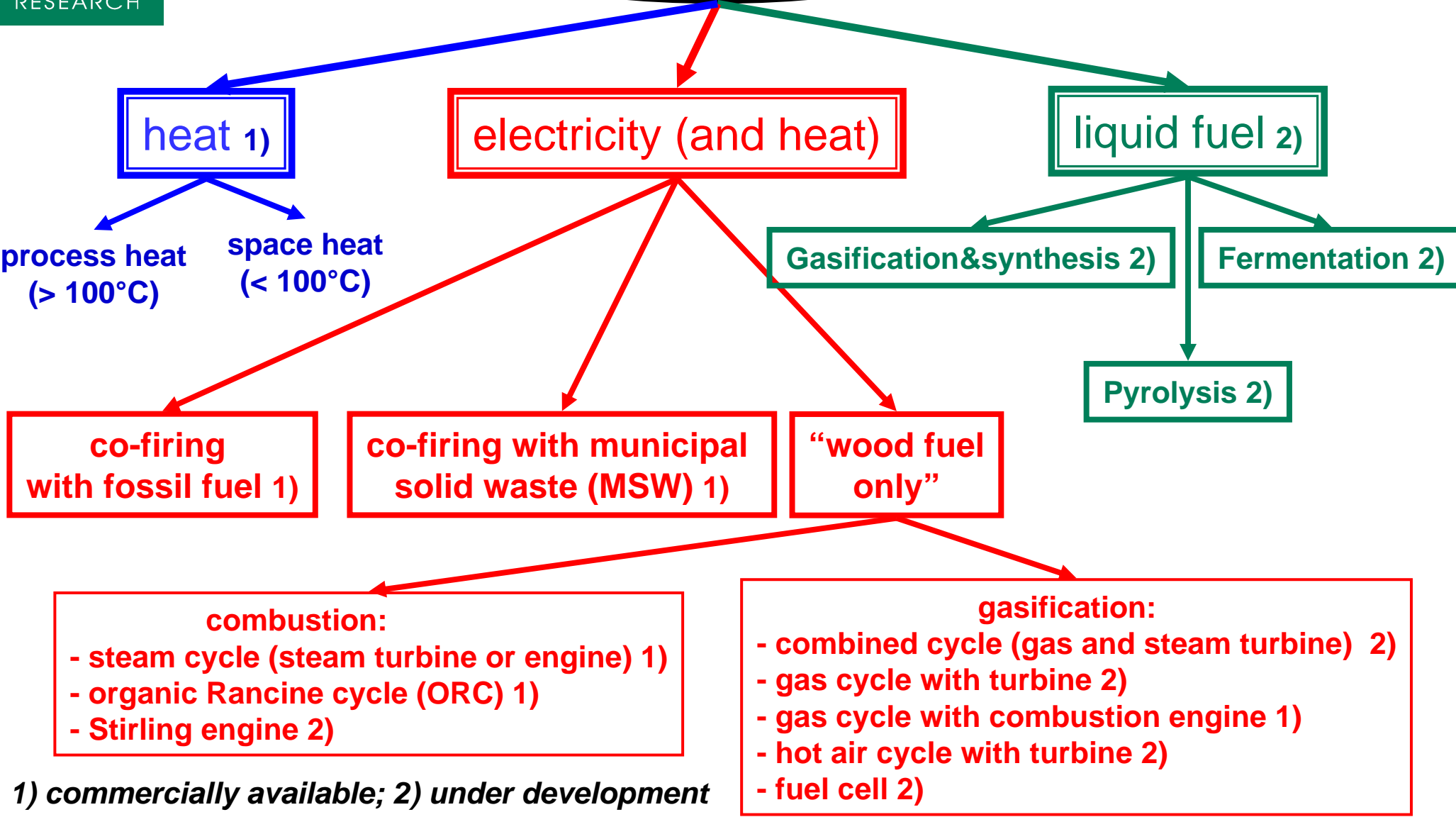
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Dublin, Ireland

# Overview



**energy generation with recovered wood**



1) commercially available; 2) under development

# Recovered Wood (example)



**recovered wood unprocessed**

# Recovered Wood (example)



**recovered wood unprocessed**



**recovered wood processed as fuel**

# Energy Systems with Recovered Wood

## Origin



## Processing



## Biofuel



## Energy generation

### Recovered wood

- packaging materials
- demolition wood
- timber from buildings
- fractions of used wood (residential, industrial, commercial)

### Mechanical

- chipping
- pelleting
- briquetting

### Thermochemical

- gasification
- pyrolysis

### Biological

- fermentation

### Solid Fuels

- wood chips
- wood pellets
- wood briquettes

### Liquid Fuels

- pyrolysis oil
- bioethanol
- Fischer-Tropsch Diesel
- liquid biohydrogen
- biomethanol

### Gaseous Fuels

- wood gas
- synthetic natural gas
- gaseous biohydrogen

### Heat

- central heating
- district heating plant

### Electricity & Heat

- steam turbine
- gas turbine
- gas & steam turbine
- stirling engine
- combustion engine
- organic Rankine cycle

### Transportation

- internal combustion engine
- fuel cell

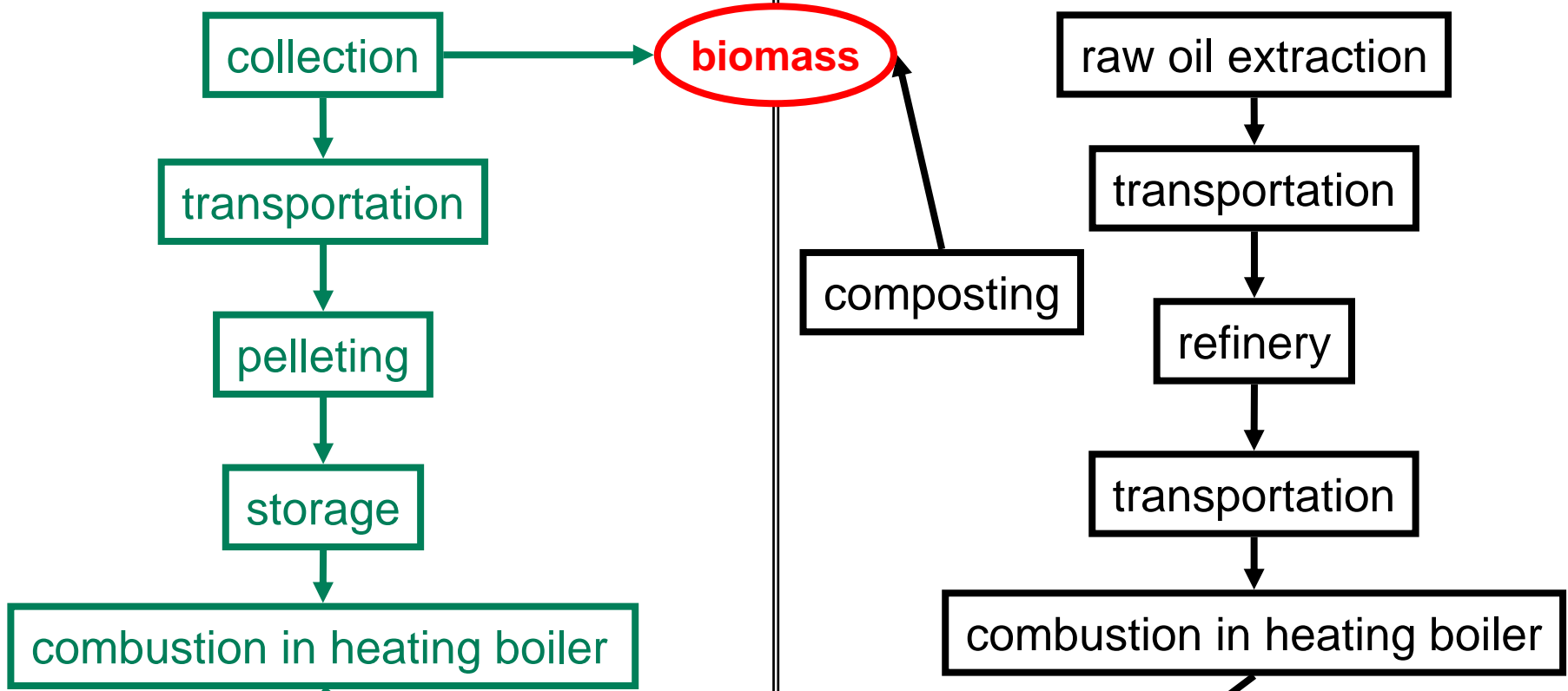
# 38 Considered Energy Systems with Recovered Wood

Type of energy generation	Current technology	Future technology	Total
Heat	4	8	12
Electricity	1	4	5
Cogeneration heat and electricity	2	9	11
Transportation service	0	10	10
Sum	7	31	38

# Example Heat from Recovered Wood

## recovered wood

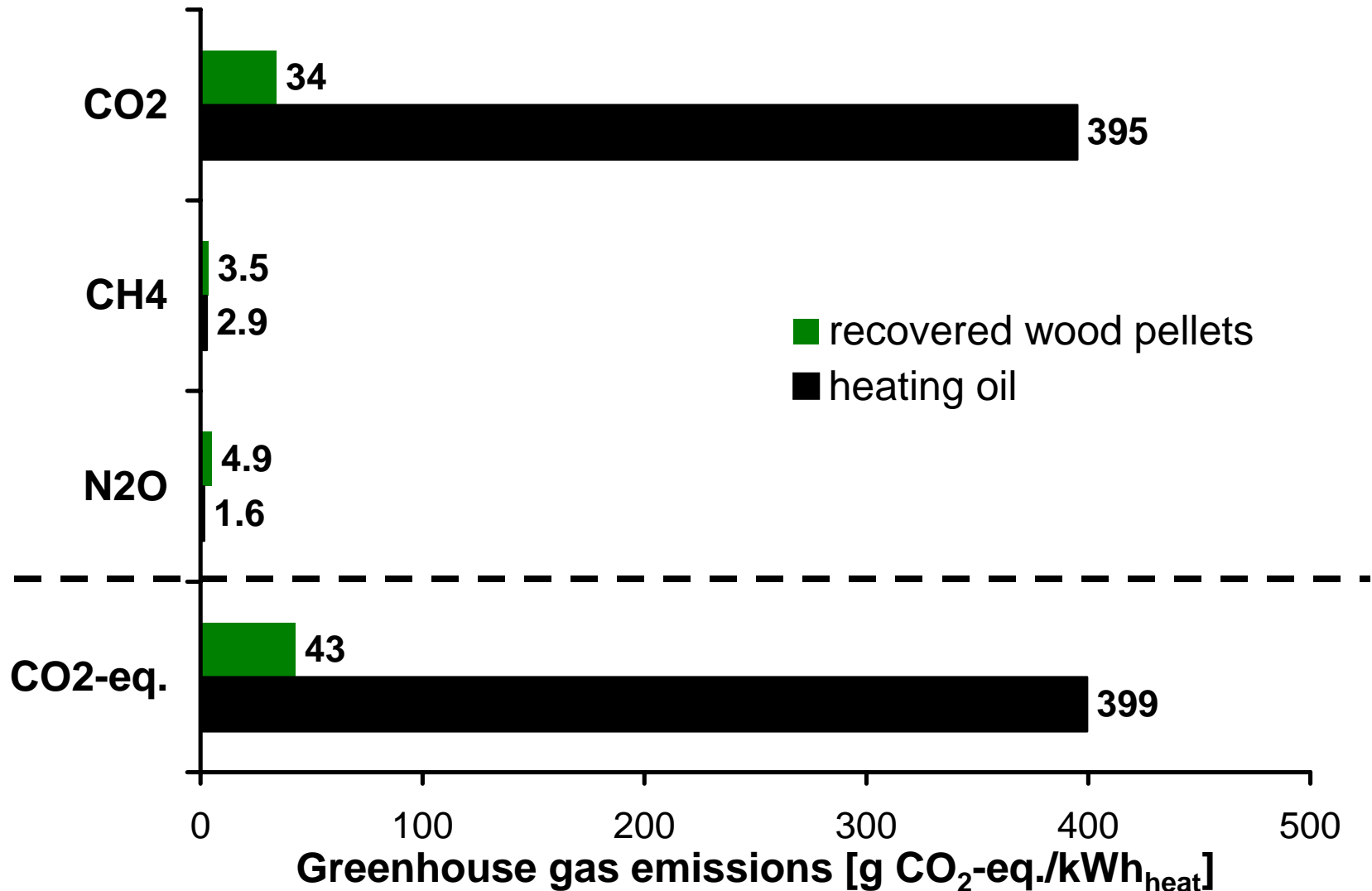
## heating oil



1 kWh heat



# Results for Heat from Recovered Wood



# Comparison Heat [g CO<sub>2</sub>-eq/kWh<sub>el</sub>]

## Fossil energy system

## Bioenergy system

		central heating system		district heating system	
		heating oil	natural gas	heating oil	natural gas
g CO <sub>2</sub> -eq./kWh <sub>heat</sub>		399	301	458	370
<b>central heating system</b>					
recovered wood briquettes	29	-93%	-90%	-94%	-92%
recovered wood pellets	43	-89%	-86%	-91%	-88%
recovered wood chips	32	-92%	-89%	-93%	-91%
<b>district heating system</b>					
recovered wood chips	53	-87%	-82%	-88%	-86%



## GHG-Reduction

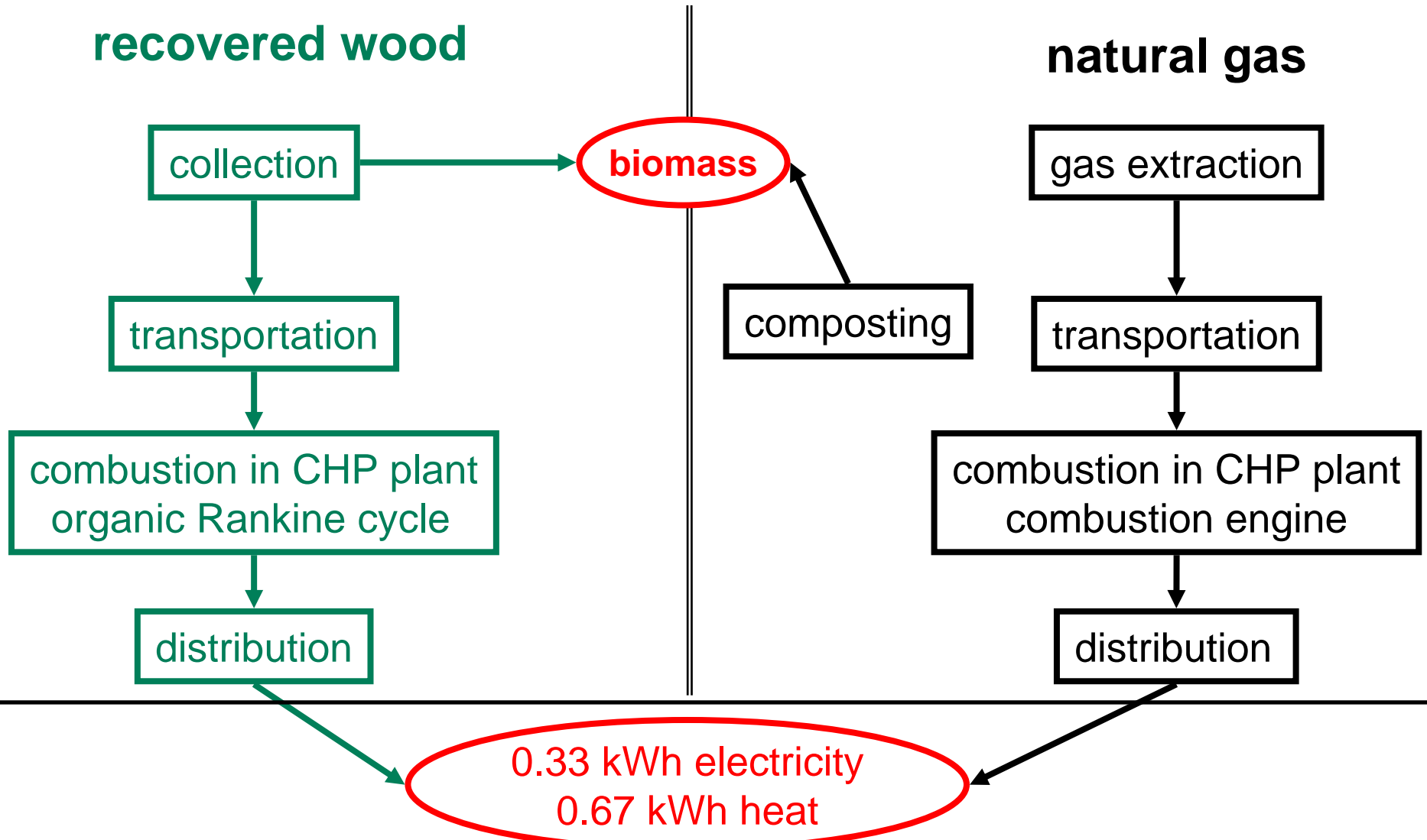
Current technology: 82 – 94%

Future technology: 70 – 94%

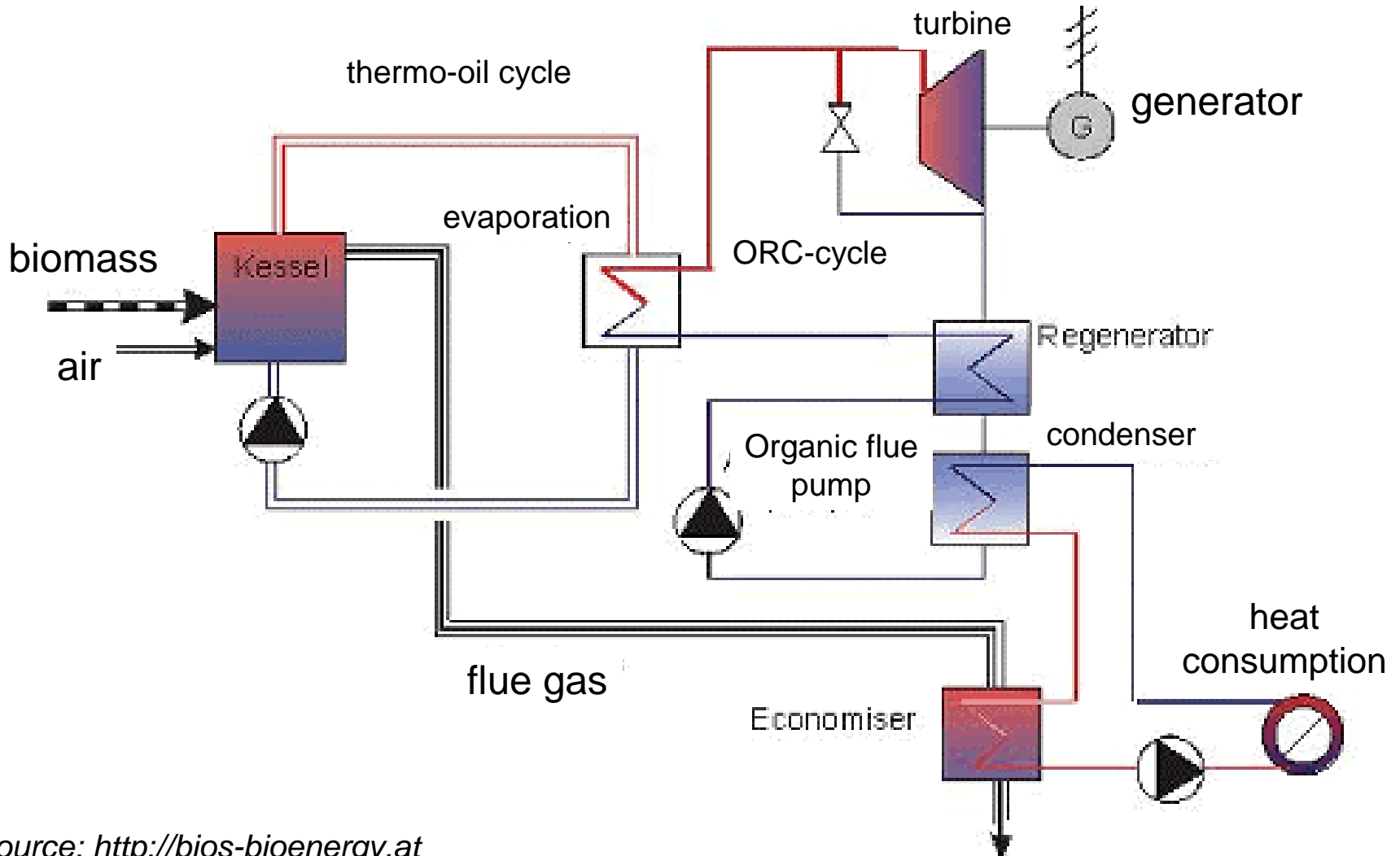
# Example Heat&Electricity from Recovered Wood

recovered wood

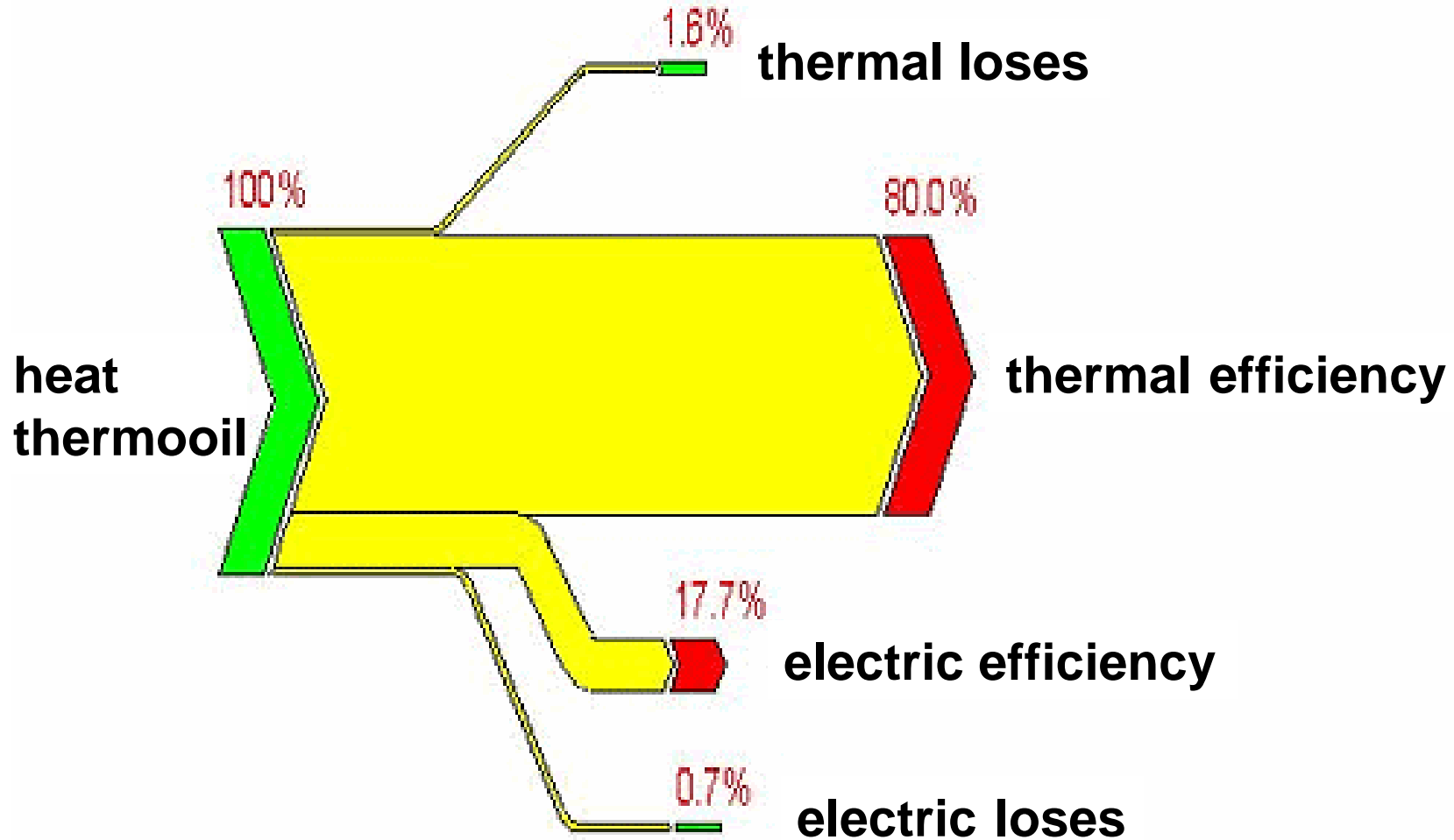
natural gas



# System of Combined Heat & Power Plant with Organic Rankine Cycle



# Energy Flow of Organic Rankine Cycle Module

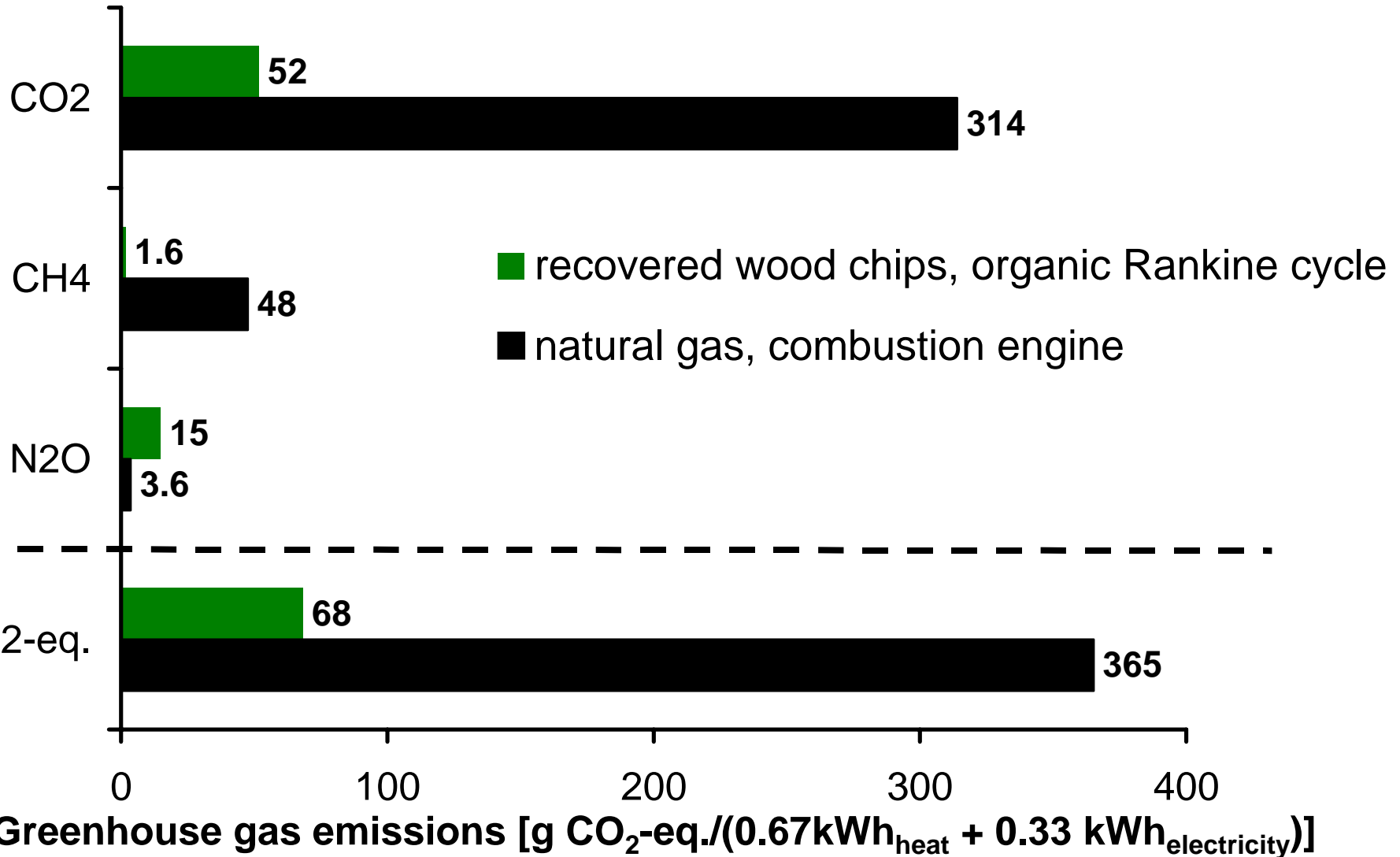


# Existing CHP Plant Admont/Austria



- Organic Rankine Cycle (ORC)
- solid biomass (chips)  
combustion + second thermo-oil  
cycle
- $2.7 \text{ MW}_{\text{heat}} / 500 \text{ kW}_{\text{el}}$
- Electricity efficiency 18%

# Results from Heat&Electricity from Recovered Wood



# Comparison Heat&Electricity [g CO<sub>2</sub>-eq/kWh<sub>e|</sub>]

## Fossil energy system

## Bioenergy system

g CO<sub>2</sub>-eq./((0.67 kWh<sub>heat</sub>+0.33 kWh<sub>electricity</sub>))

recovered wood chips, steam turbine 29  
recovered wood chips, organic Rankine cycle 68

	hard coal, steam turbine	natural gas, gas&steam turbine	natural gas, combustion engine
	517	333	365
	-94%	-91%	-92%
	-87%	-79%	-81%



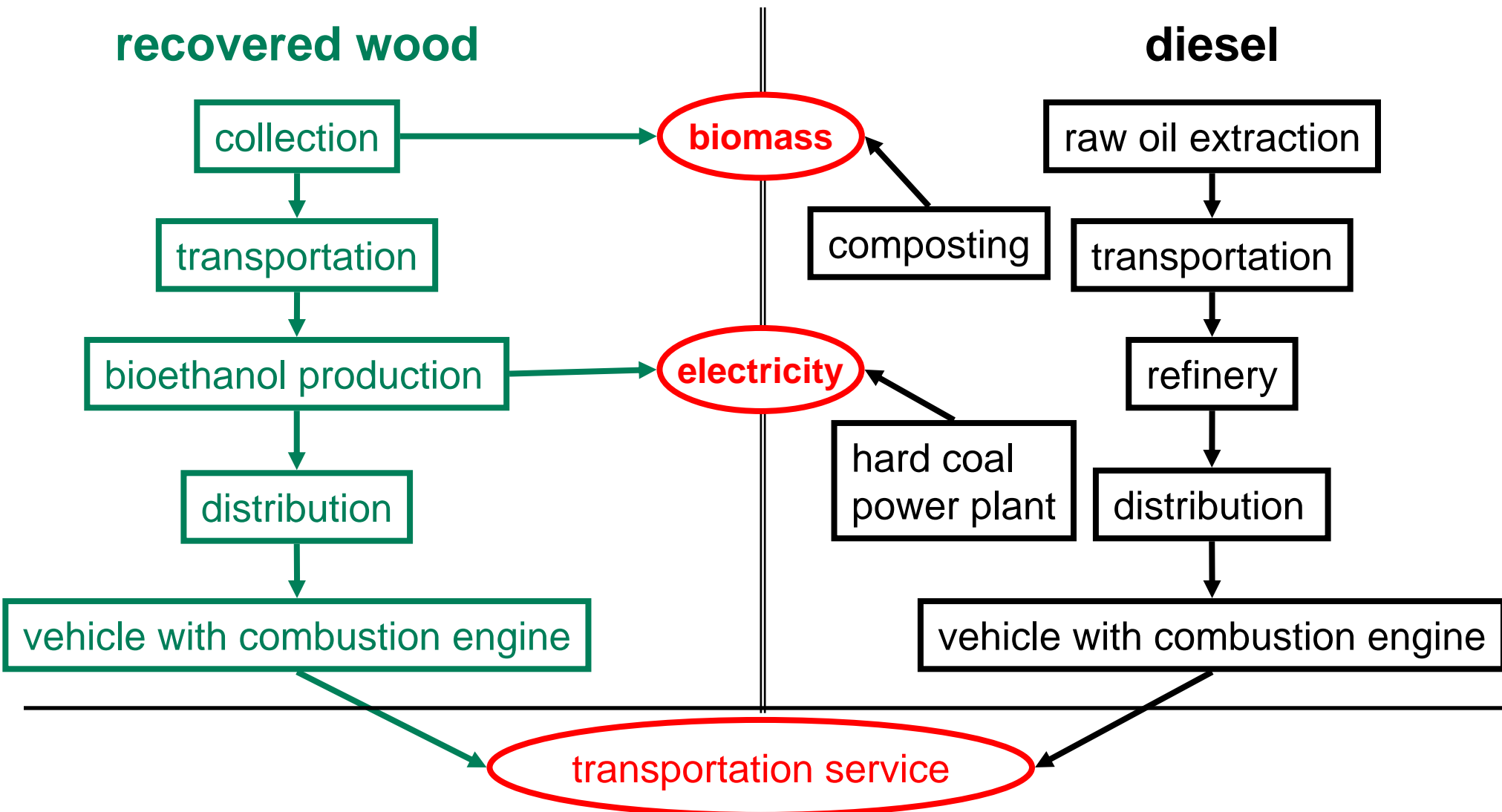
## GHG-Reduction

Current technology: 81 – 94%

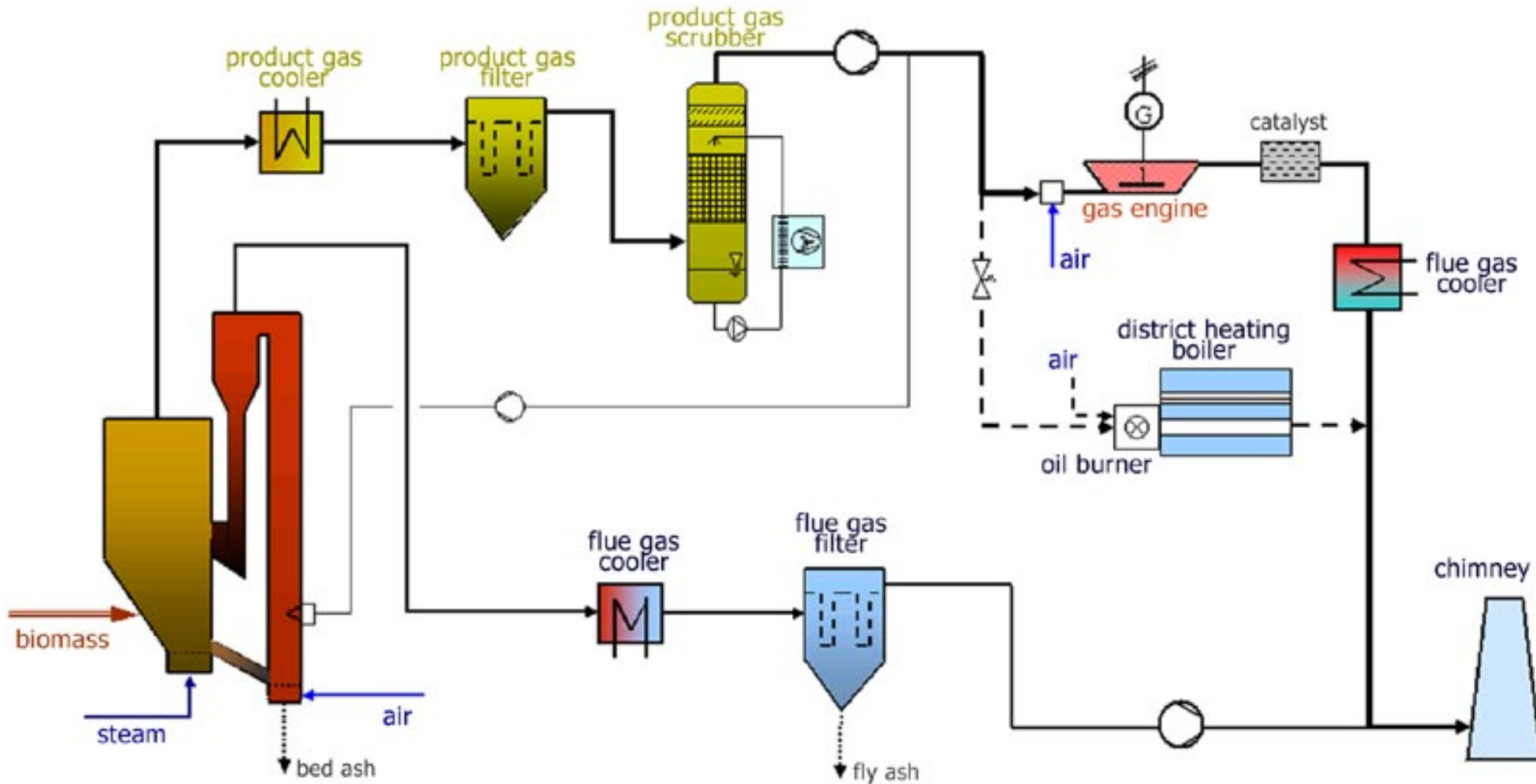
Future technology: 54 – 93%



# Example Transportation with Recovered Wood



# System of Combined Heat and Power Plant with Gas Turbine



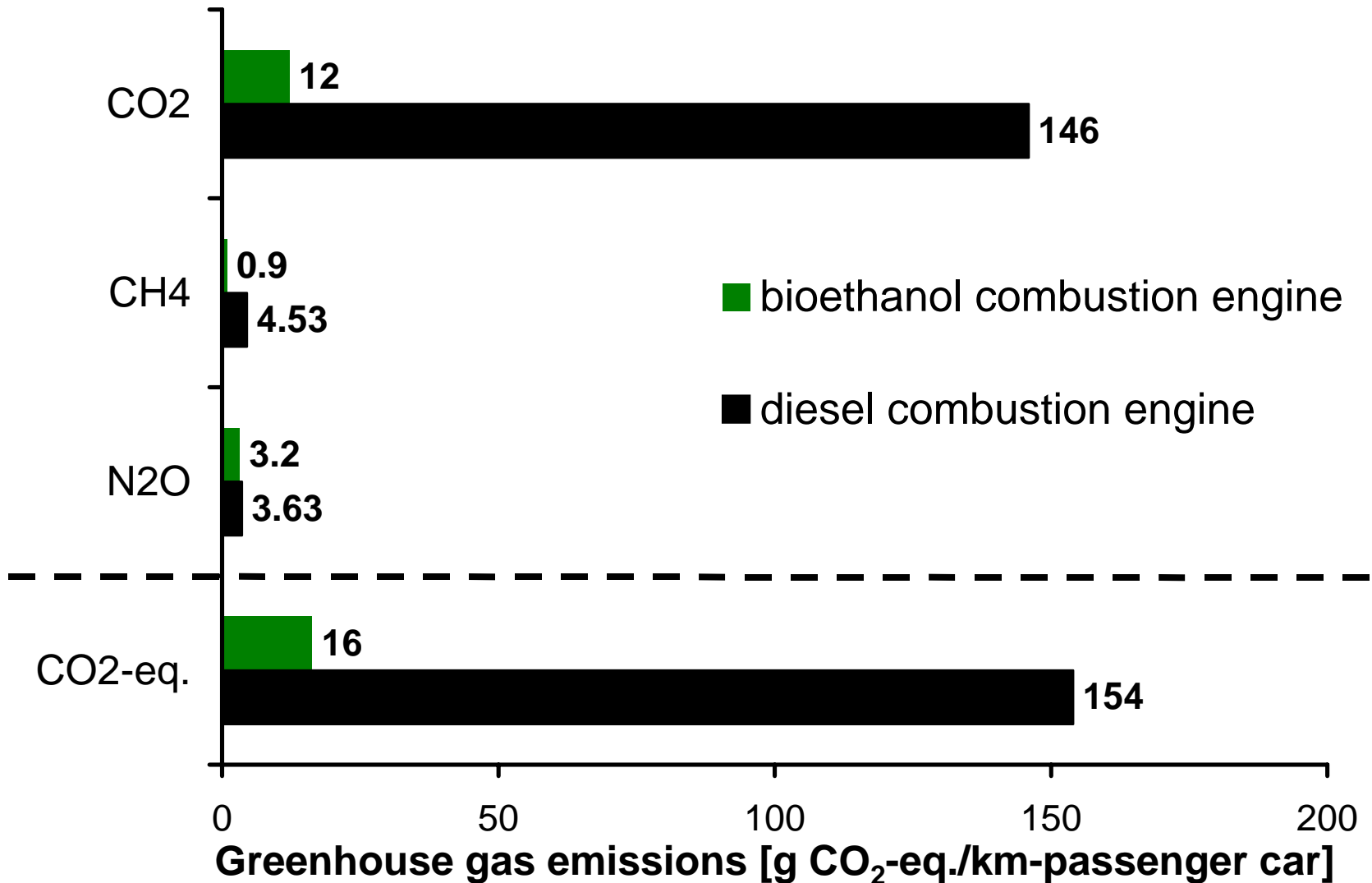


# Existing CHP Plant Güssing/Austria



- Fluidized bed gasification + gas engine
- solid biomass (chips)
- $4.5 \text{ MW}_{\text{th}} / 2 \text{ kW}_{\text{el.}}$

# Results for Transportation with Recovered Wood





# Comparison Transport [g CO<sub>2</sub>-eq/km]

## Fossil energy system

## Bioenergy system

		diesel	methanol natural gas	liquid hydrogen natural gas	gaseous hydrogen natural gas
g CO <sub>2</sub> -eq./km pc.		154	196	263	197
bioethanol	16	-89%	-92%	-94%	-92%
biomethanol with electricity	-7	-105%	-104%	-103%	-104%
biomethanol without electricity	39	-75%	-80%	-85%	-80%
liquid biohydrogen with electricity	42	-72%	-78%	-84%	-78%
liquid biohydrogen without electricity	59	-62%	-70%	-78%	-70%



**GHG-Reduction Future technology:**

**Combustion engine: 62 – 105%**

**Fuel cell: 61 - 92%**



# Conclusions

## **GHG-Reduction with recovered wood:**

- heat 70 - 90%
- electricity&heat 54 - 94%
- transportation 61 – 100%

**Significant greenhouse gas reduction with recovered wood**

**Many possibilities to produce energy from recovered wood**