Energy research Centre of the Netherlands

Synthetic Natural Gas (SNG)

Large-scale introduction of green natural gas in existing gas grids

Robin Zwart

Contents

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Introduction on ECN

- Independent energy research institute
- Founded in 1955
- 650 staff
- Annual turnover: 80 million EURO
- Activities:
  - Biomass
  - Solar
  - Wind
  - Fuel Cell Technology
  - Clean Fossil Fuels
  - Energy Efficiency
  - Policy Studies

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Introduction on ECN

Mission

- ECN focuses on the knowledge and information required by the government to develop and evaluate policies and to achieve policy objectives in the field of energy, the environment and technological innovation.
- ECN partners with industry in the development and implementation of products, processes and technologies important for the transition to a sustainable energy system.
- ECN closely works together with Dutch and foreign universities and research institutes and performs a bridging function towards implementation by carrying out technological research.

ECN develops high-quality knowledge and technology for the transition to a sustainable energy supply

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Definitions

Biogas and SNG

Biogas	- produced by digestion, contains mainly CH_4 and CO_2
Landfill gas	- product of landfills, composition similar to biogas
SNG	- "Synthetic Natural Gas", contains mainly CH_4 produced via gasification of coal and or biomass followed by methanation
bio-SNG	- SNG from biomass

"***green natural gas***"	- comprising both bio-SNG and upgraded biogas/landfill gas
(or "***green gas***")	- complies with specifications for injection to natural gas grid
(or "***bio-methane***")	- has same properties as natural gas
	- can be used in all existing equipment

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Definitions

Green gas is biogas as well as SNG

Green Gas = **Upgraded Biogas** + **Synthetic Natural Gas (SNG)**

	Upgraded Biogas	Synthetic Natural Gas (SNG)
• **Technology**:	digestion / landfill	gasification & methanation
• **Status**:	commercially available	in development
• **Implementation**:	today	after 2010
• **Production scale**:	small *(~300 kW)*	large *(~1,000 MW)*
• **Potential**:	limited *(< 60 PJ in Netherlands)*	unlimited *(> 240 PJ in Netherlands)*
• **Feedstock**:	wet biomass *(available)*	dry biomass *(import required)*

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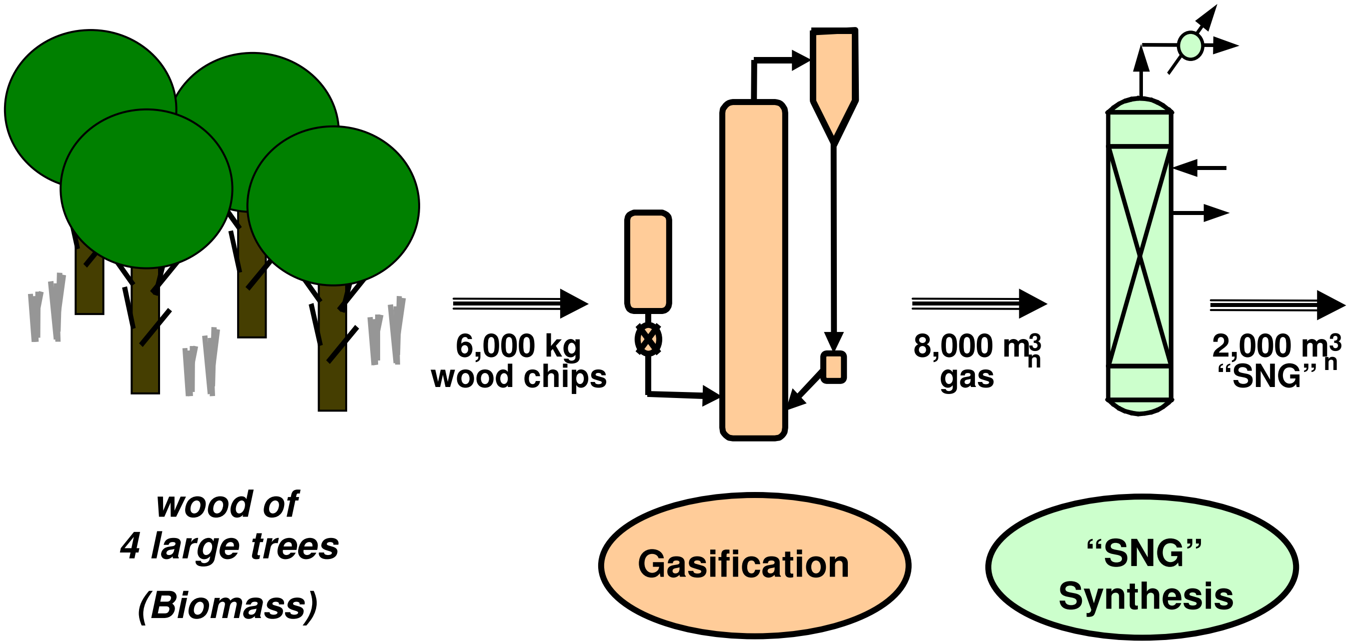
SNG production technology

SNG production via biomass gasification

Plus additionally as transport fuel ???



Spatial heating

Warm tap water

Cooking

2,000 m_n^3/a "Green Gas" required for one household

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SNG production technology

The ECN approach

- Use conventional technology (Great Plains Synfuels Plant, ND/USA)
- Adapt for biomass
- Focus on high efficiency (>70%)

3 GW lignite-to-SNG plant, Beulah, ND, USA

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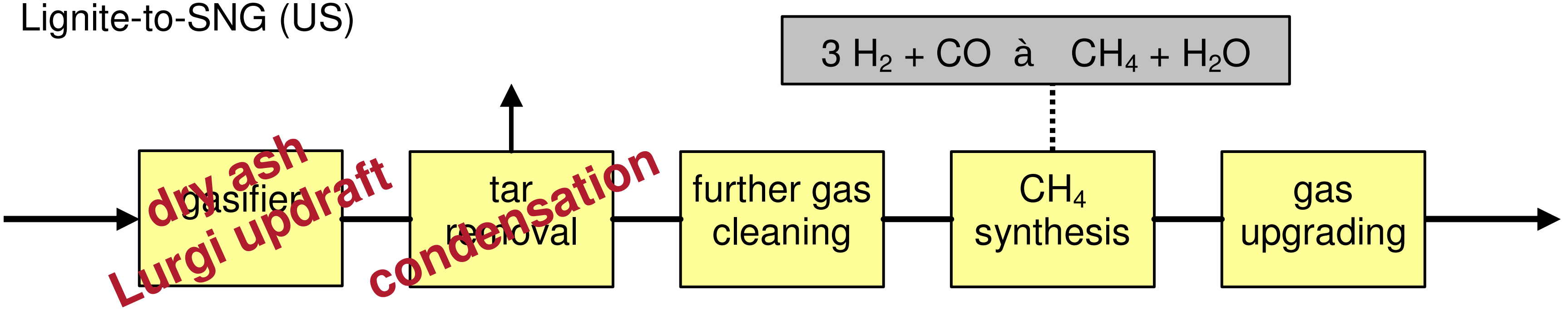
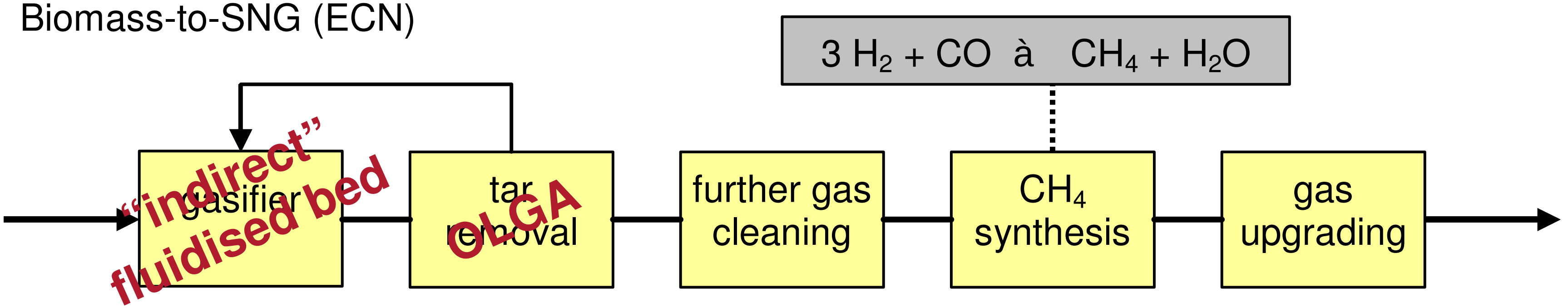
SNG production technology

Difference between lignite and biomass

Lignite-to-SNG (US)



Biomass-to-SNG (ECN)



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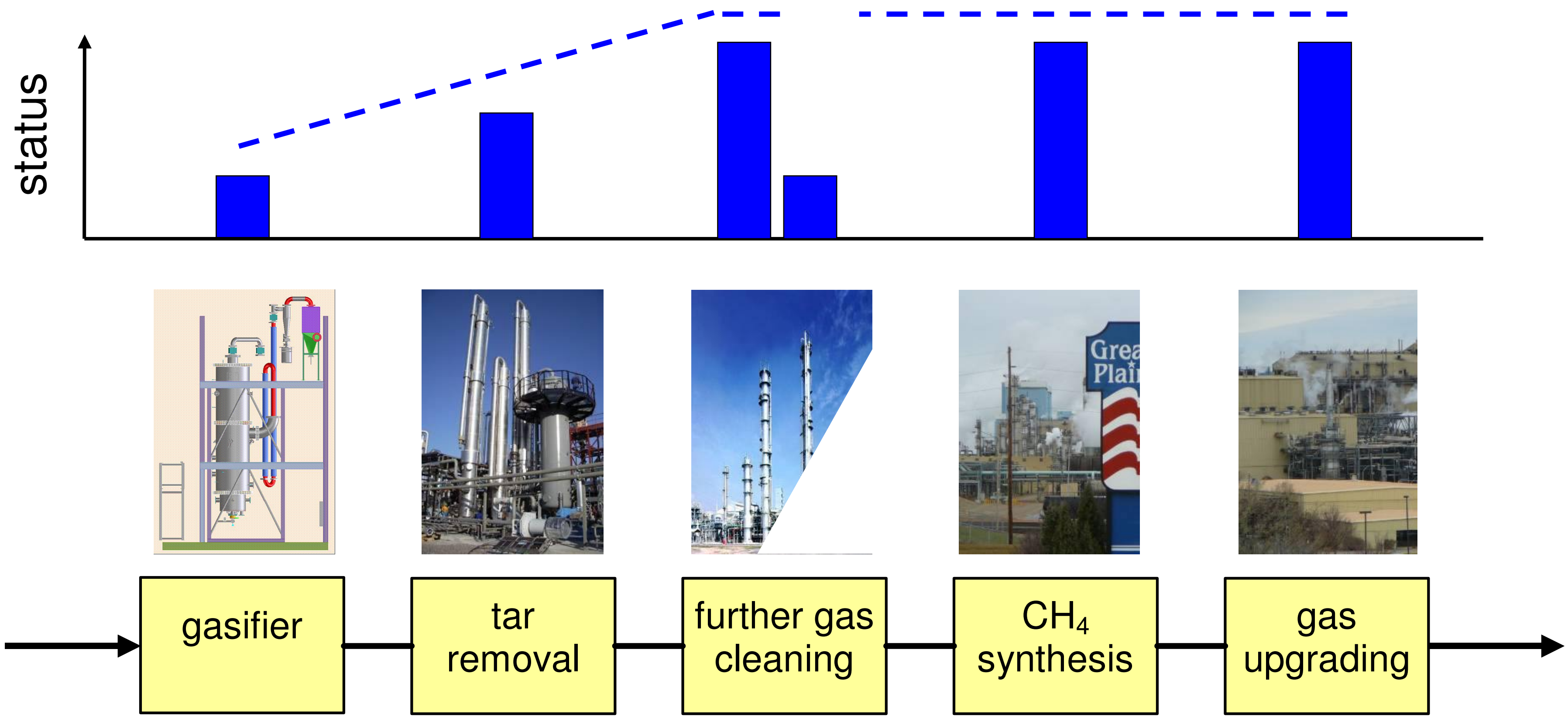
SNG production technology

Status



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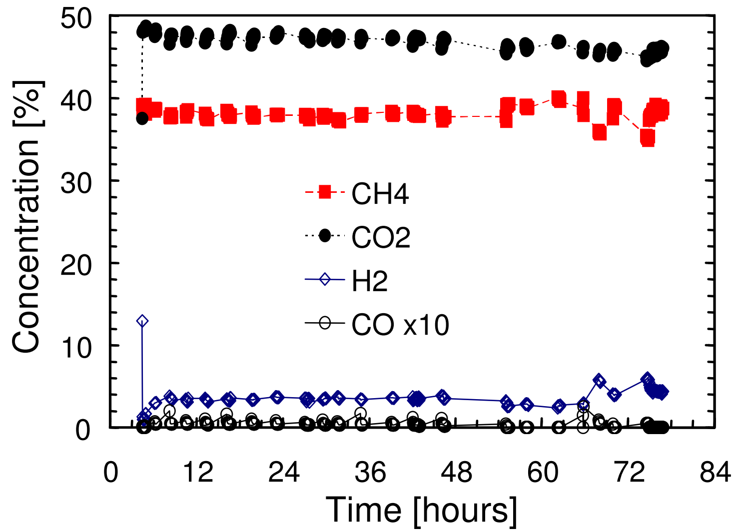
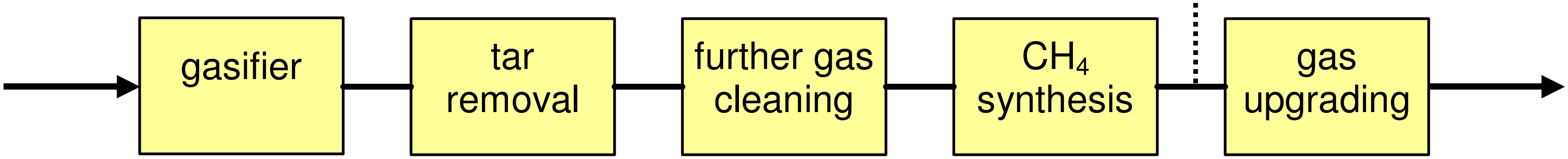
SNG production technology

Lab scale testing





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Motivation for green gas

Environmental considerations

- Reduction of Greenhouse Gas (GHG) emissions
  - Kyoto protocol (CO_2)
  - EU regulations (20% CO_2 reduction in 2020, 60-80% in 2050)

- Local emissions
  - gas is a clean fuel
  - reduce local emissions from transport
  - EU targets for natural gas as transport fuel

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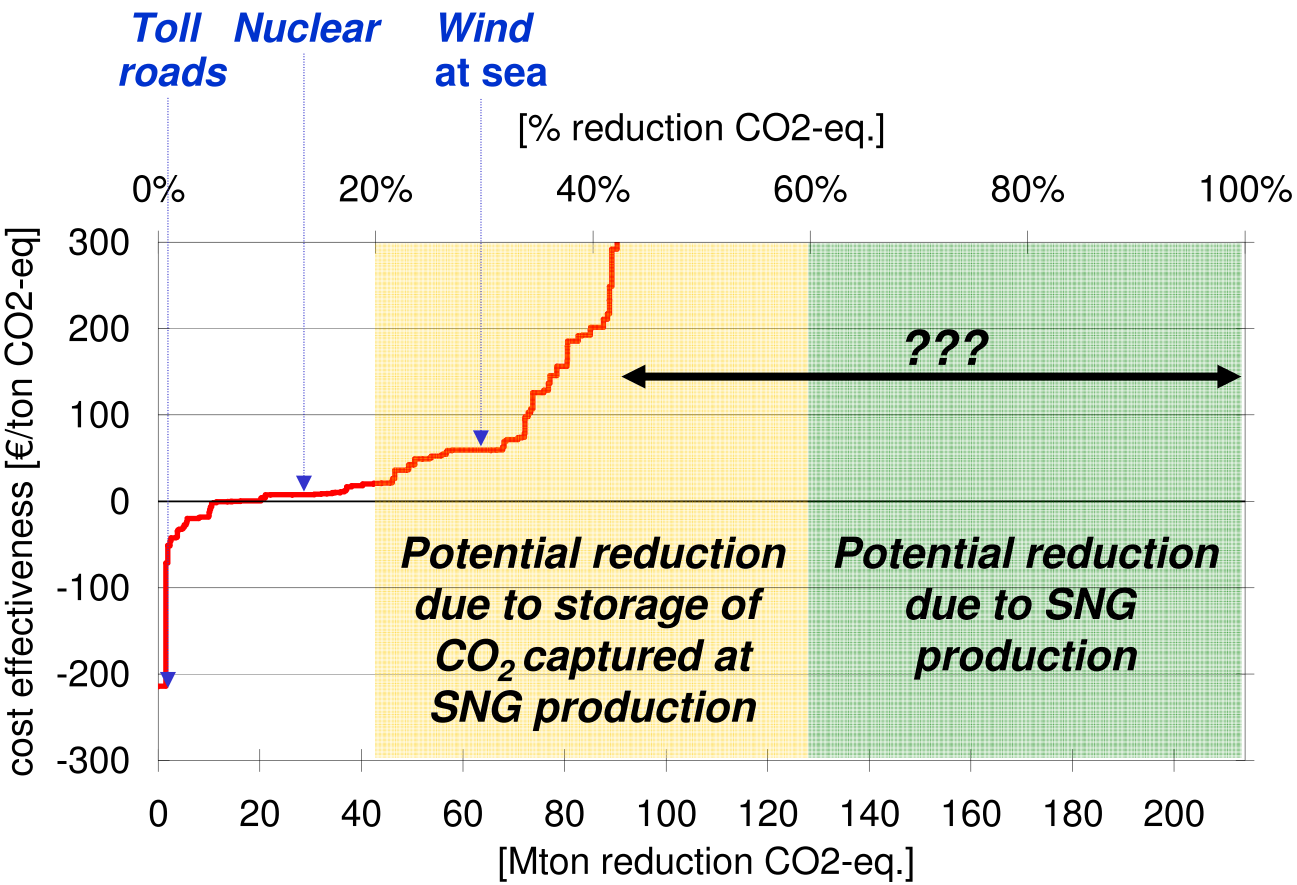
Motivation for green gas

Environmental alternatives (Dutch situation)



<u>EU targets</u>

- 20% in 2020

- 60-80% in 2050

<u>Reduction costs</u>

- 25 €/ton in 2020

(includes nuclear, …)

- ? €/ton in 2050

(targets not reached?)

<u>Natural gas substitution</u>

- 40% of total emissions

- CO_2 storage possible

<u>Green gas potential</u>

- 40% by SNG

- 40% by CO_2 storage

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Motivation for green gas

International energy developments

- Security of supply
  - decrease dependency on one politically unstable region (crude oil)
  - energy as political 'pressure tool', i.e. Russia (for natural gas)
- Increasing prices of fossil fuels
  - fast growing economies China & India
- Fuel diversification
  - decrease dependency on oil
  - use coal, biomass, and natural gas (LNG)
- Depleting resources of fossil fuels
  - crude oil (20-40 years)
  - natural gas (40-60 years)
  - coal (~200 years)
- Natural gas is solution for medium-long term

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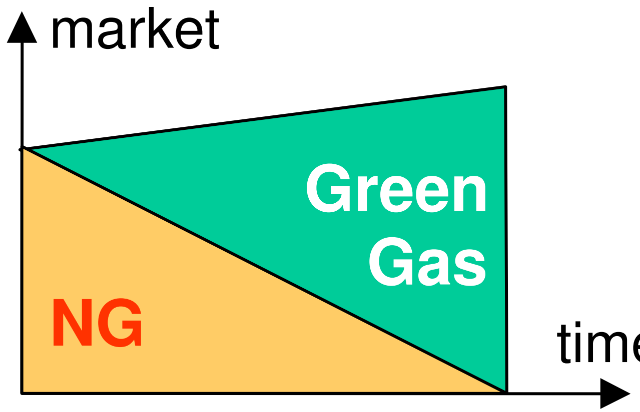
Motivation for green gas

Social considerations

- Agricultural development
  - production of biomass in EU-25
  - job creation & rural development

- Implementation
  - natural gas market is growing
  - Green Gas is additional to natural gas
  - in time Green Gas can compensate for decrease in natural gas
  - natural gas is well accepted, hence green natural gas as well
  - introduction similar to green electricity



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Potential and application

Dutch situation

- In the Netherlands, in total 3,300 PJ primary energy is consumed:

[PJ/y]	Coal	Crude oil	Natural Gas	Other	Total
Electricity	200	10	350	300	860
Transport	.	480	.	10	490
Heat	40	240	1,100	20	1,400
Chemistry	70	370	90	20	550
Total	*310*	*1,100*	*1,540*	*350*	*3,300*

- **At least 20% natural gas substitution required for 2050 EU targets = 300 PJ “Green Gas”**

- Large potential for Green Natural Gas = **HEAT**
  - 40% of heat is used by distributed small consumers (i.e. households)
  - 96% of this heat is from natural gas combustion

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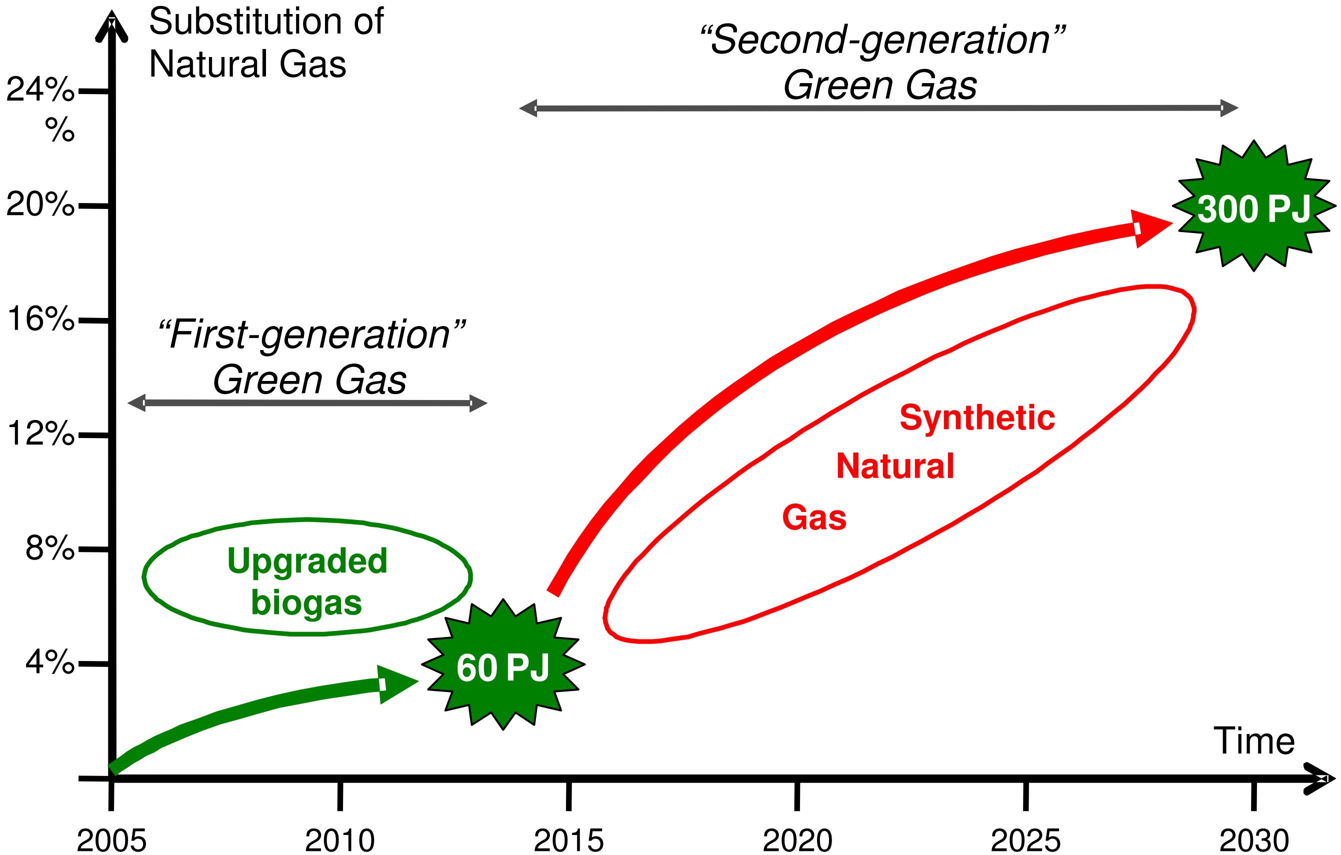
Potential and application

Initially biogas, ultimately SNG



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Potential and application

Advantages of SNG for distributed renewable heat

- large-scale production / small-scale utilization
- no new infrastructure needed

- gas storage: production all year
- efficient distribution: 1% (S)NG loss vs. typically 15% energy loss in heat distribution systems
- SNG combustion: easy-to-meet local emission limits
- Same gas quality: high social acceptance
- Natural gas back-up: security of supply!
- Ease of introduction: only few industrial partners, but many end-users
- Free market possibility: similar to green electricity

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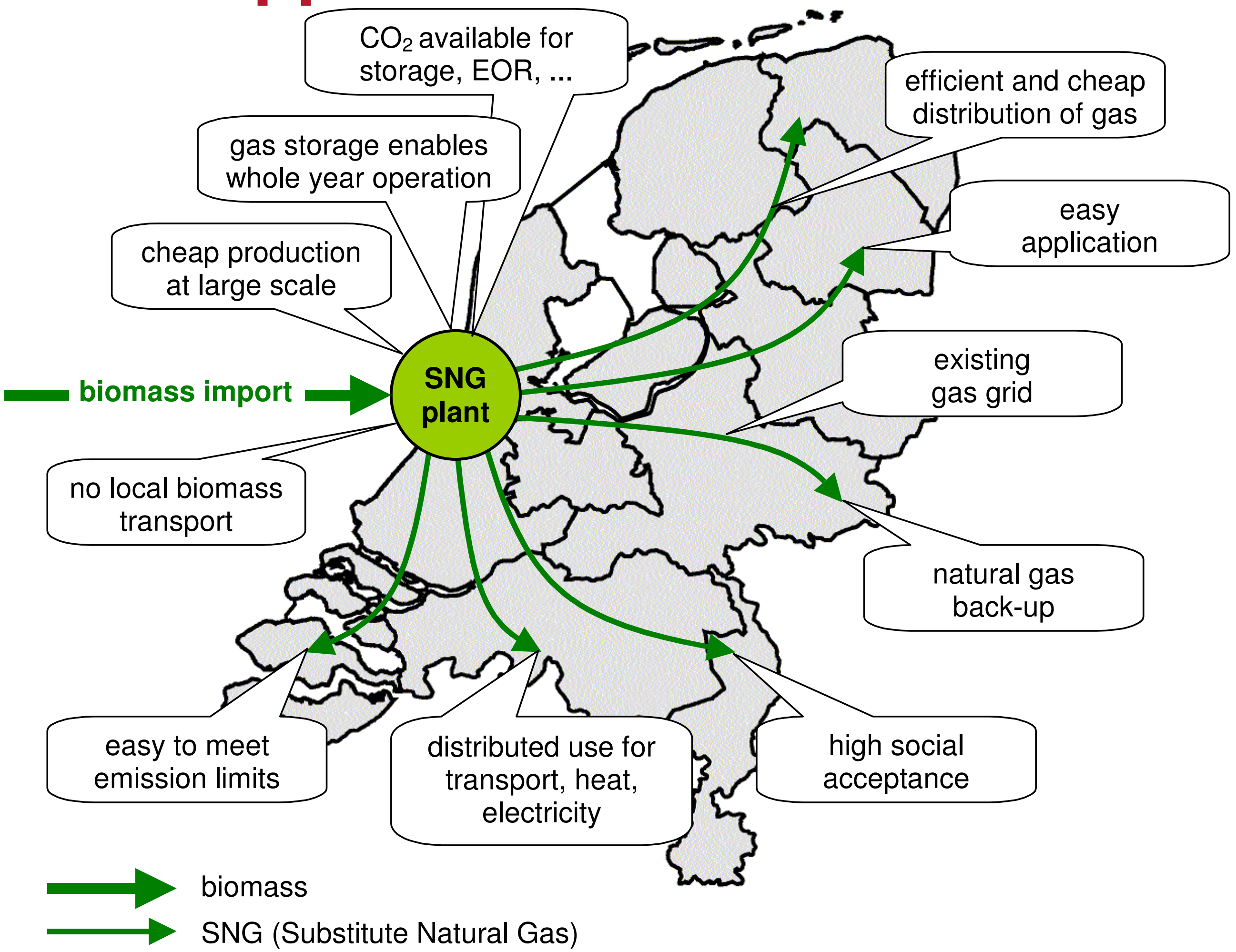
Potential and application



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Potential and application

Alternatives for distributed renewable heat

- Local biomass combustion
  Disadvantages: large number of small-scale plants in populated areas, relative expensive due to small scale
- Combined Heat & Power (CHP) plants
  Disadvantages: large number of small-scale plants, relative expensively due to small scale, electricity and heat demand not in balance
- All electric heating
  Disadvantages: new equipment, new power capacity and network expansion required, only high efficiency combined with (expensive!) heat pumps

=> **SNG is the best route for the large-scale production of renewable heat**
large-scale centralized production plants, transport via gas grid, local consumption, clean conversion

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Implementation

Required SNG production capacity

- Biomass feedstock is imported in the Netherlands
- Biomass available in large amounts in few harbours
- Typical SNG production plant = 1,000 MW_{th}
- Total 12 plants required
- Total annual biomass consumption:
  - *20 million tonnes per year*
  - *1.7 million tonnes per plant*

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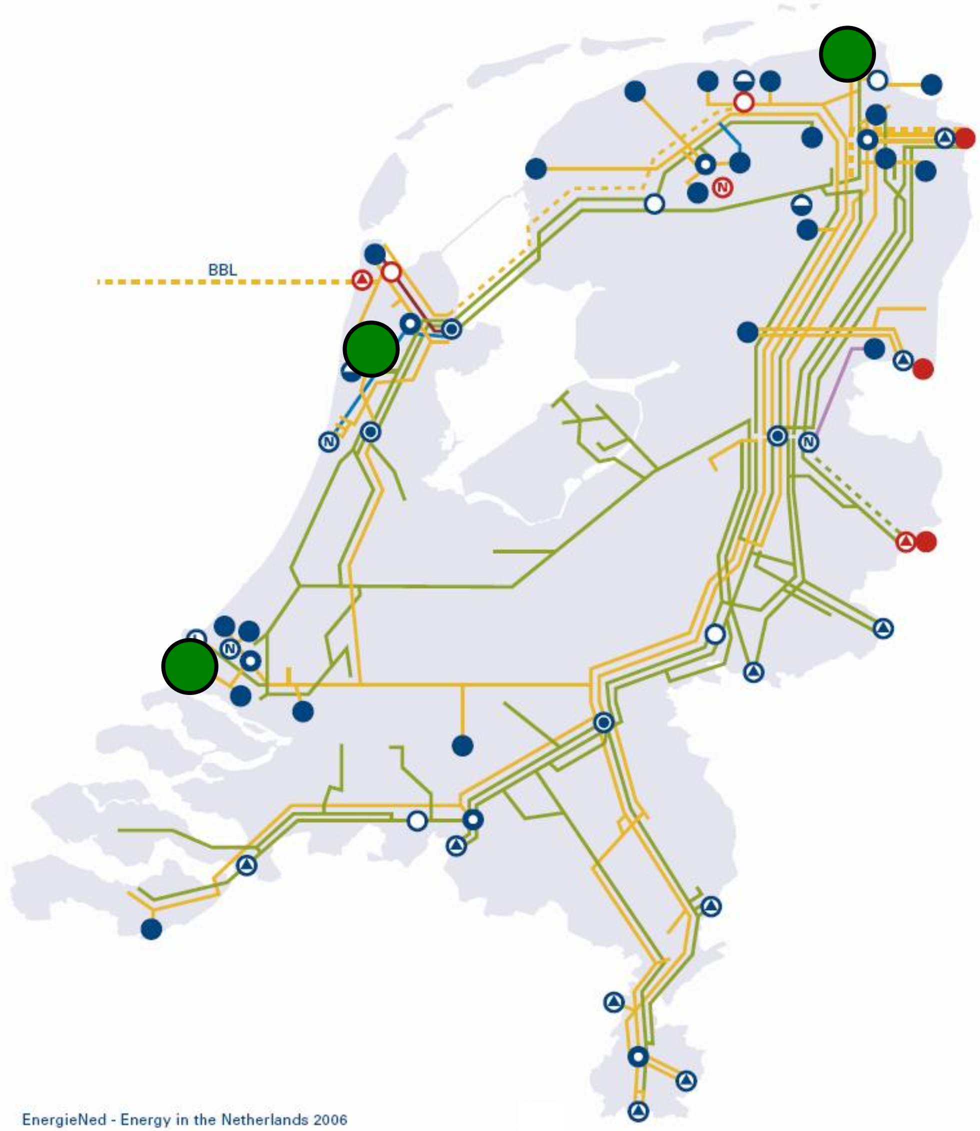
Implementation

Integrating SNG production into existing infrastructure

- pipeline – Groningen gas
- pipeline – high-caloric gas
- pipeline – low-caloric gas
- pipeline – desulphurized gas
- pipeline – nitrogen
- feeder station(s)
- compressor and blending station
- compressor station
- blending station
- underground gas storage
- export station
- LNG facility
- nitrogen injection



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Implementation

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- Typical SNG production plant = 1,000 MW_{th}
- Total 12 plants required
- Total annual biomass consumption:
  - *20 million tonnes per year*
  - *1.7 million tonnes per plant*

- Is that a lot? **YES!**
- Is that unrealistic? **NO!**

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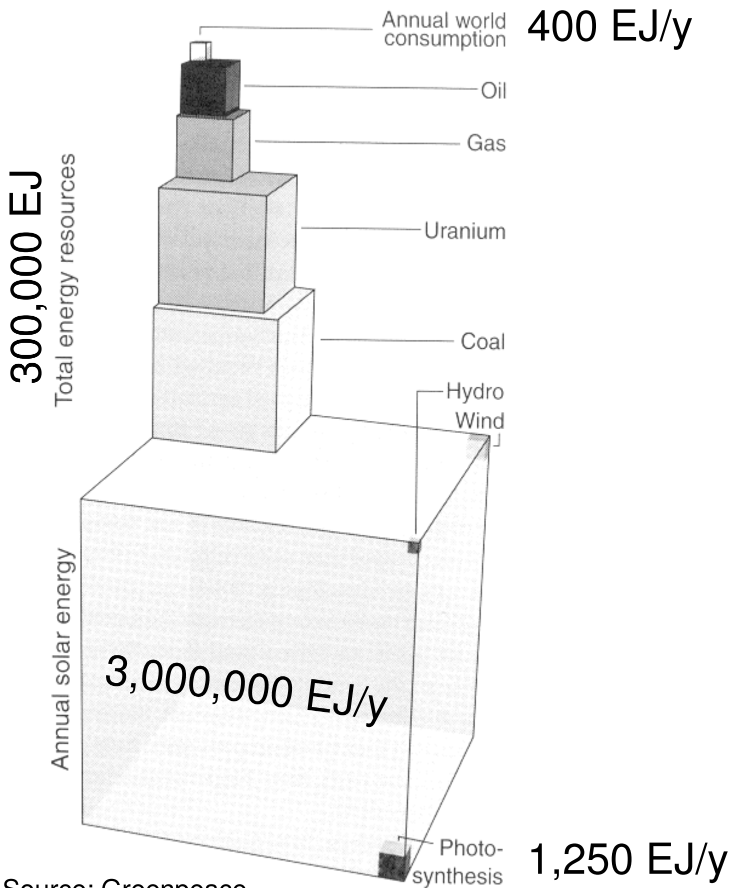
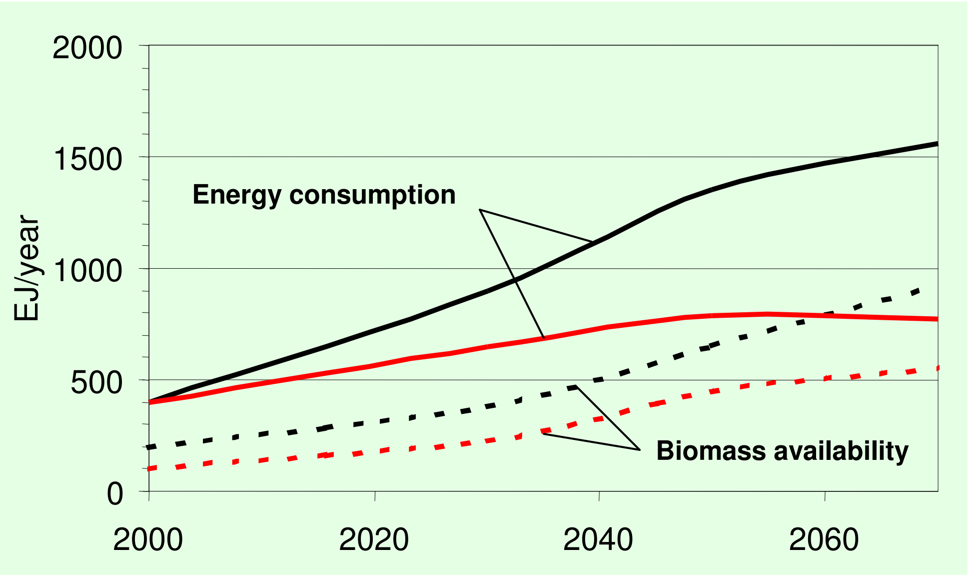
Biomass availability and import

2 approaches



Source: Greenpeace

Economic & Biomass scenario's



Source: thesis Hoogwijk.www.mnp.nl/images/thesisMHoogwijk_tcm61-28001.pdf

Yes, there is enough biomass…

to be a serious option for renewable energy generation and SNG production

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Biomass availability and import

Current general import & export statistics

Import & Export by sea shipping (2004)			Transhipment [million tonnes per year]			
Harbour	Position	Share	Total	Coal	Crude oil & Oil products	Ores & Minerals
Netherlands	-	100%	463.8	46.7	160.7	71.0
Rotterdam	1	76%	352.0	25.3	136.0	50.0
Amsterdam	2	11%	50.0	12.7	16.0	6.4
IJmuiden	3	4%	18.0	5.8	0.3	9.0
Delfzijl & Eemshaven	7	0.5%	2.3	0.008	0.013	1.2

- Total biomass requirement for SNG
  - same range as today's coal transhipment in Rotterdam
  - 4.3% increase for total Netherlands transhipment (in 2030)
- Biomass for one plant
  - would double transhipment in Delfzijl

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Biomass availability and import

Current biomass import & export statistics

Organic materials (2000) [kton/year]	Import	Export	Transhipment
Wood & Pulp	7,010	3,462	10,472
Oil seeds	7,133	1,845	8,978
Meat, Fish & Dairy	2,995	5,028	8,023
Cereals	6,413	630	7,043
Sugar & Cacao	1,926	1,856	3,782

- Total biomass requirement for SNG
  - double of today's would & pulp transhipment
- Biomass for one plant
  - same order as today's import of sugar & cacao
  - today's cereals transhipment equals biomass import for three SNG plants

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Economy of SNG production

Can SNG become competitive?

Assumptions

- Large-scale (~1 GW)
- Situated in Dutch harbor
- Imported biomass
- IRR 12%/10 years

Targets

- Making SNG costs competitive
- Making SNG CO_2 competitive

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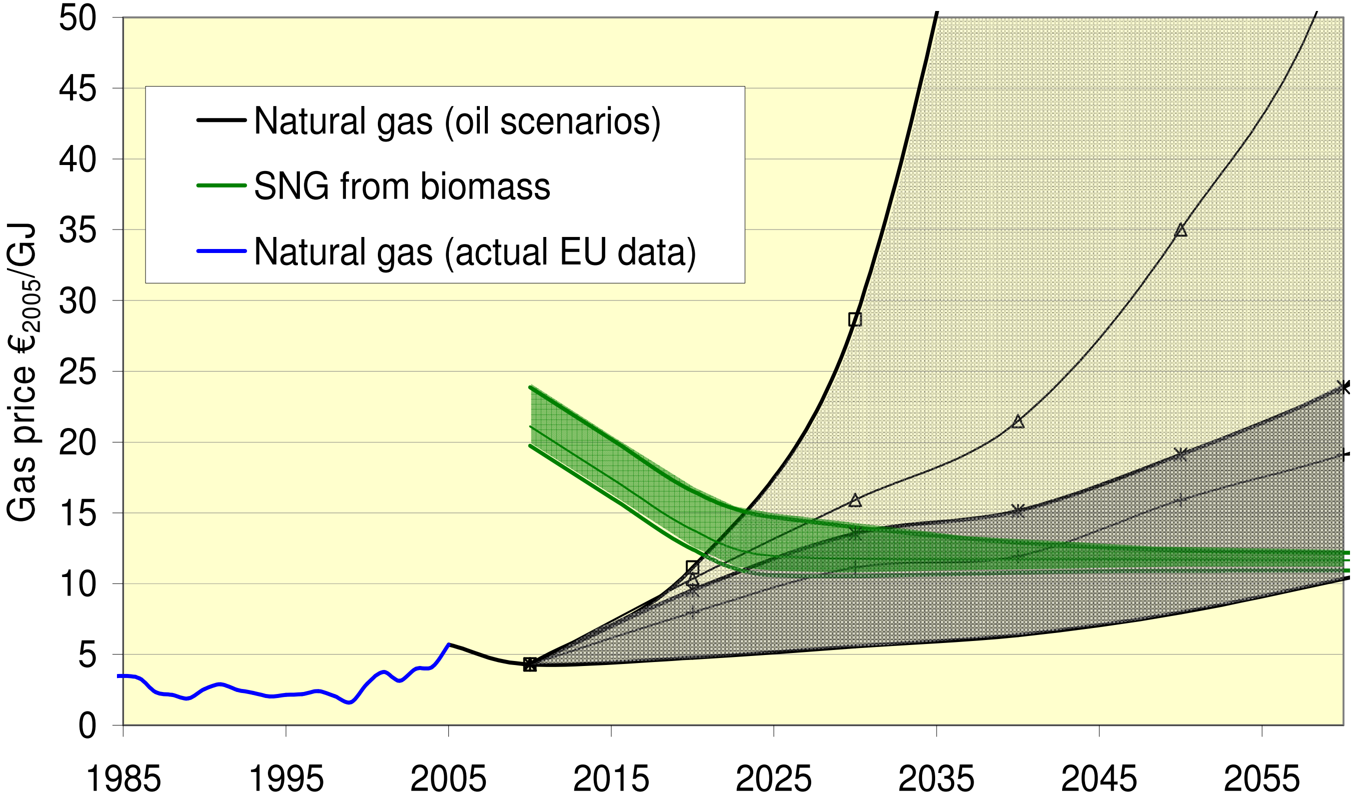
Economy of SNG production

SNG and natural gas in same cost range



Biomass

Imported as TOP pellet

1.0 - 4.0 €/$GJ_{overseas}$ now

1.3 - 2.5 €/$GJ_{overseas}$ 2050

Oil / gas

Business as usual vs. ASPO

Gas related to oil price

Plant scale

Initially 100 $MW_{th,input}$

Ultimately 1 $GW_{th,input}$

Learning curves included

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Scenario	Description	Assessment
BGR	According to the German **B**undesanstalt für **G**eowissenschaften und **R**ohstoffe (***BGR***), the unconventional oil reserves amount to 2,760 EJ compared to 6,350 EJ for conventional oil. On top of that, the unconventional oil resources are estimated at 10,460 EJ compared to conventional oil resources of 3,525 EJ. The BGR figures contain big amounts of unconventional oil. Unconventional oil encompasses extra heavy oil, tar sand, and oil shale.	*Realistic*
ASPO	The **A**ssociation for the **S**tudy of **P**eak **O**il and Gas (***ASPO***) suggests that the global production of conventional oil peaked in the spring of 2004. The peak in world oil production, from both conventional and non-conventional sources, is predicted in the year 2010. The ASPO scenario doesn't take into account continually increasing reserve estimates in older accumulations. As such, big varieties are among estimates of remaining OPEC oil and unconventional oil, where ASPO is much more pessimistic than BGR.	*Extremely Pessimistic*
No Shale	Shale oil is often presumed to play at best a marginal role in future oil supply, because its energy return on energy invested is rather low. A rising oil price, supposition for shale oil production, could make shale oil more expensive at the same time. The "***No Shale***" scenario is based on the BGR figures without any available shale oil resources considered.	*Pessimistic*
IR	This optimistic so-called "**I**ncreased **R**ecovery" (***IR***) scenario is based on the assumption that there is a further increase of the overall mean recovery factor from today's 35% up to 45% and applies it to all remaining conventional reserves and resources from the BGR data.	*Optimistic*
Reference	In the reference scenario oil prices in the past are extrapolated towards a future of impressive technological improvements and high economic growth (2% in the OECD countries and almos twice as high in developing countries, according to the Sauner project). This growth, and associated high levels of capital investment facilitate the assumed rapid rates of technical progress. This scenario assumes that oil and gas remain dominant during the 21st century.	*Rather Optimistic*

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Economy of SNG production

- The projected long-term production costs of **SNG = 11.7 €/GJ_{SNG}**
- Additional costs:
  - *5.7 €/GJ, with a **natural gas price = 6 €/GJ***
  - *equivalent to 2.7 €ct/kWh_{SNG} (or relating to electricity ~ 5.5 €ct/kWh_e)*
  - *carbon costs: 100 € per ton CO_2 (with CO_2 storage 55 € per ton CO_2)*
- Support options:
  - *subsidy (e.g. "Gas MEP") of 5.7 €/GJ*
  - *establishment of CO_2 trading market*
  - *additional cost of ~3.6 €ct for each m_n^3 gas consumed (when substituting 20%)*
- But what happens to the natural gas price in 2030?
  - *increase to level of SNG production costs*
- Financial support required for Development and Demonstration
  - *new technology*
  - *first plants are small scale*

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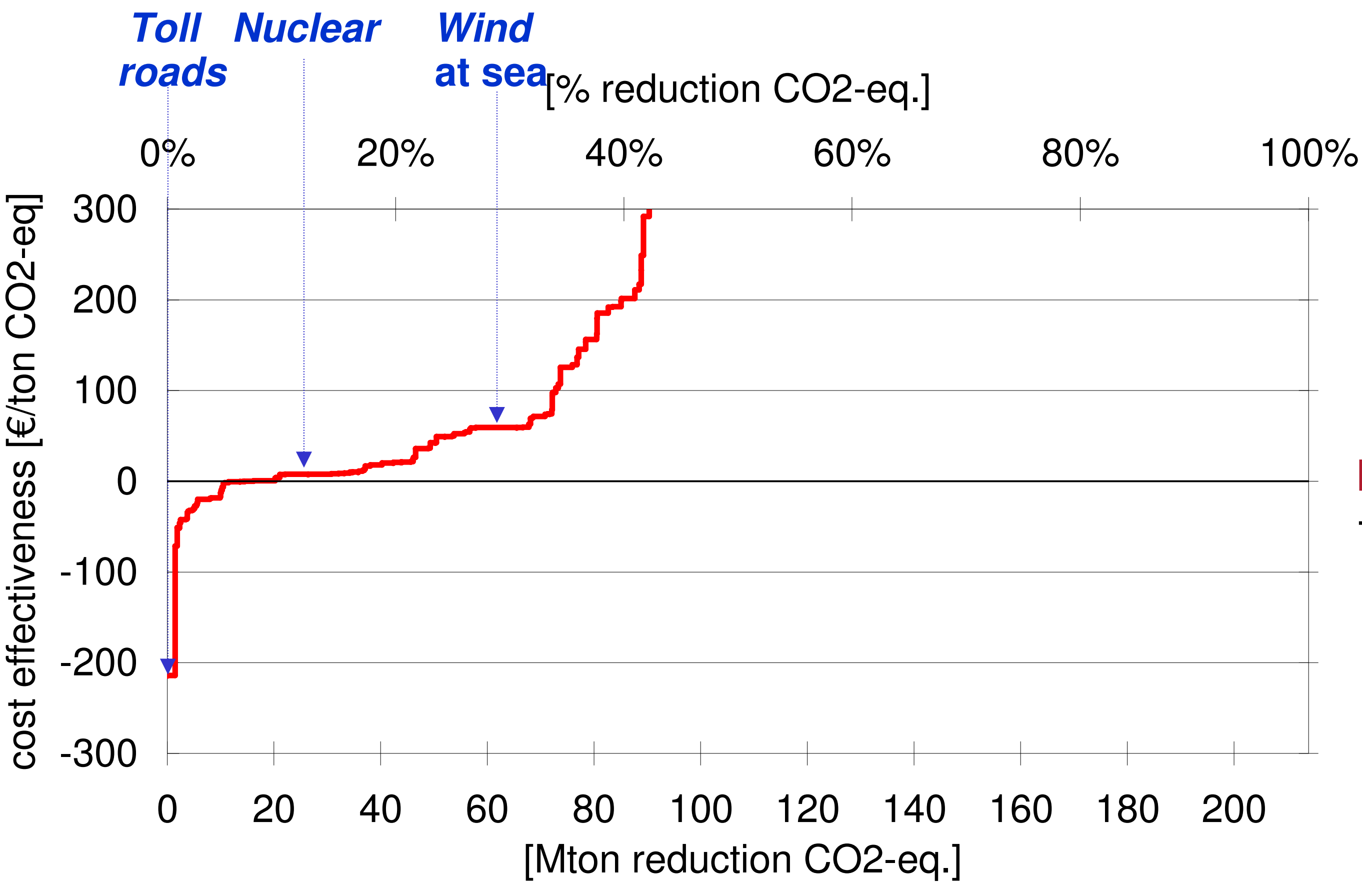
Economy of SNG production

Costs of CO_2 emission reduction



Reference

"Optiedocument"

ECN – policy studies

Oil: 25$/bbl

Natural gas: 4.1€/GJ

20% capital (IRR = 15%)

80% loan (ir = 5%)

Biomass costs 4€/GJ$_{\text{at gate}}$

Total emissions 215 Mton/a

Conclusions

Reduction potential limited

Exponential cost increase at 35% CO_2 reduction

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Economy of SNG production

Based on assumptions ECN policy studies ("optiedocument")

- The projected long-term production costs of **SNG = 10.5 €/GJ$_{SNG}$**
- Additional costs:
  - 6.4 €/GJ, with a ***natural gas price = 4.1 €/GJ***
  - equivalent to 2.3 €ct/kWh$_{SNG}$ (or relating to electricity ~ 4.5 €ct/kWh$_e$)
  - carbon costs: 115 € per ton CO_2 (with CO_2 storage 61 € per ton CO_2)
- Support options:
  - subsidy (e.g. "Gas MEP") of 6.4 €/GJ
  - establishment of CO_2 trading market
  - additional cost of ~4.1 €ct for each m_n^3 gas consumed (when substituting 20%)

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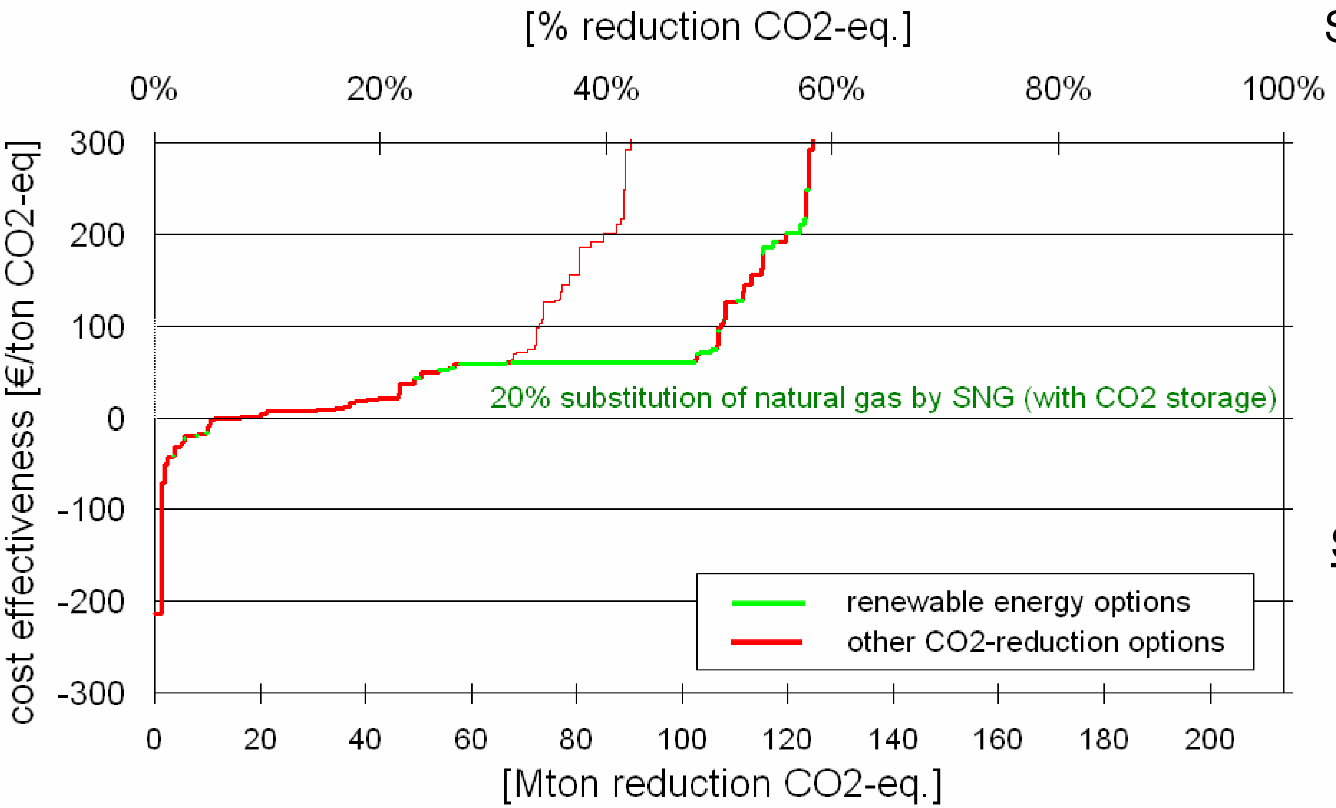
Based on assumptions ECN policy studies (“optiedocument”)

Economy of SNG production

SNG costs competitive and with huge potential



Reference

Same as in “Optiedocument”

ECN – policy studies

Oil: 25$/bbl

Natural gas: 4.1€/GJ

20% capital (IRR = 15%)

80% loan (ir = 5%)

Biomass costs 4€/GJ$_{\text{at gate}}$

SNG without CO2 storage:

115 €/ton$_{CO2}$ / 85 Mton$_{CO2}$

SNG with CO2 storage:

61 €/ton$_{CO2}$ / 170 Mton$_{CO2}$

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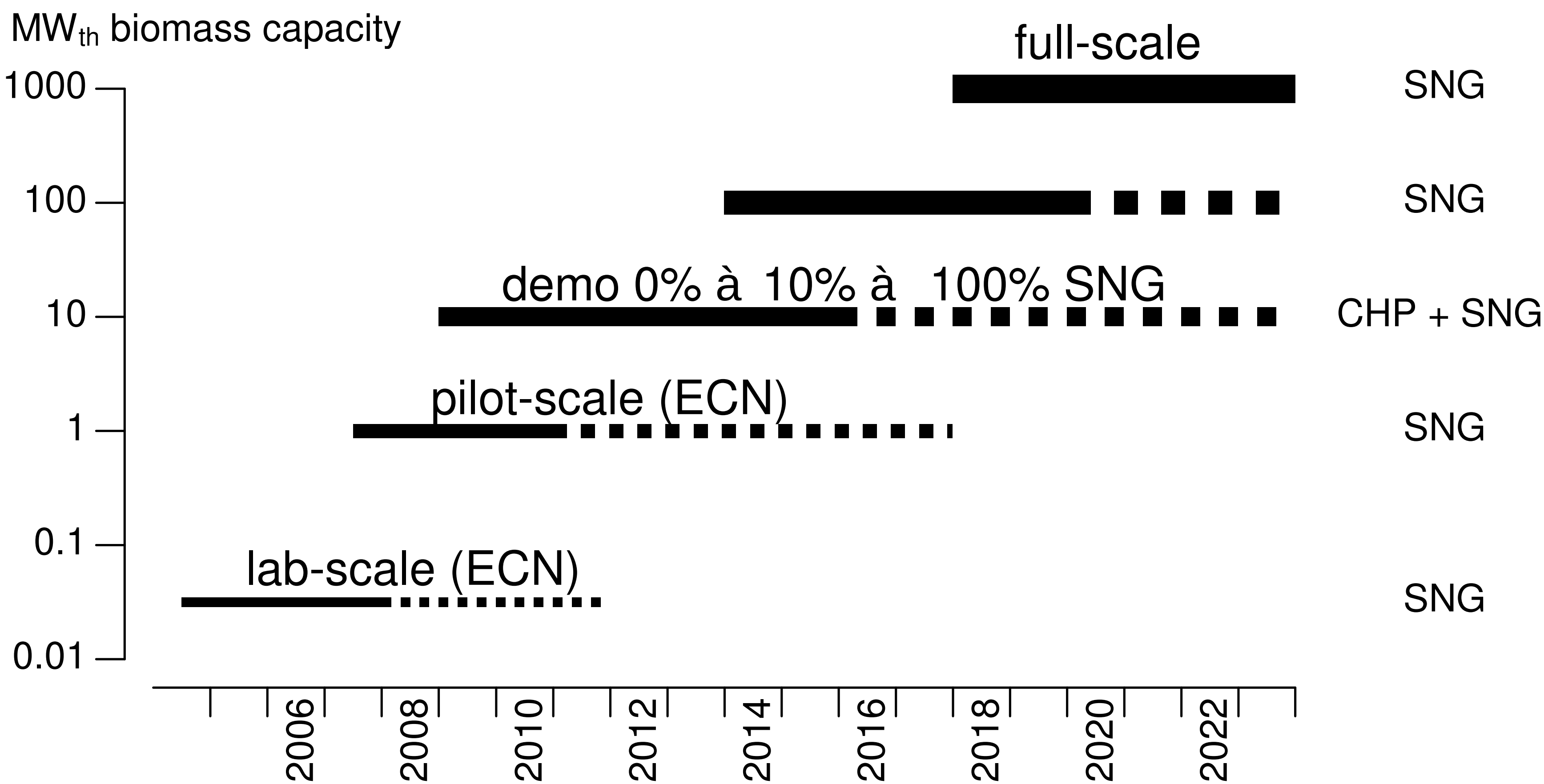
SNG development trajectory

Phased approach



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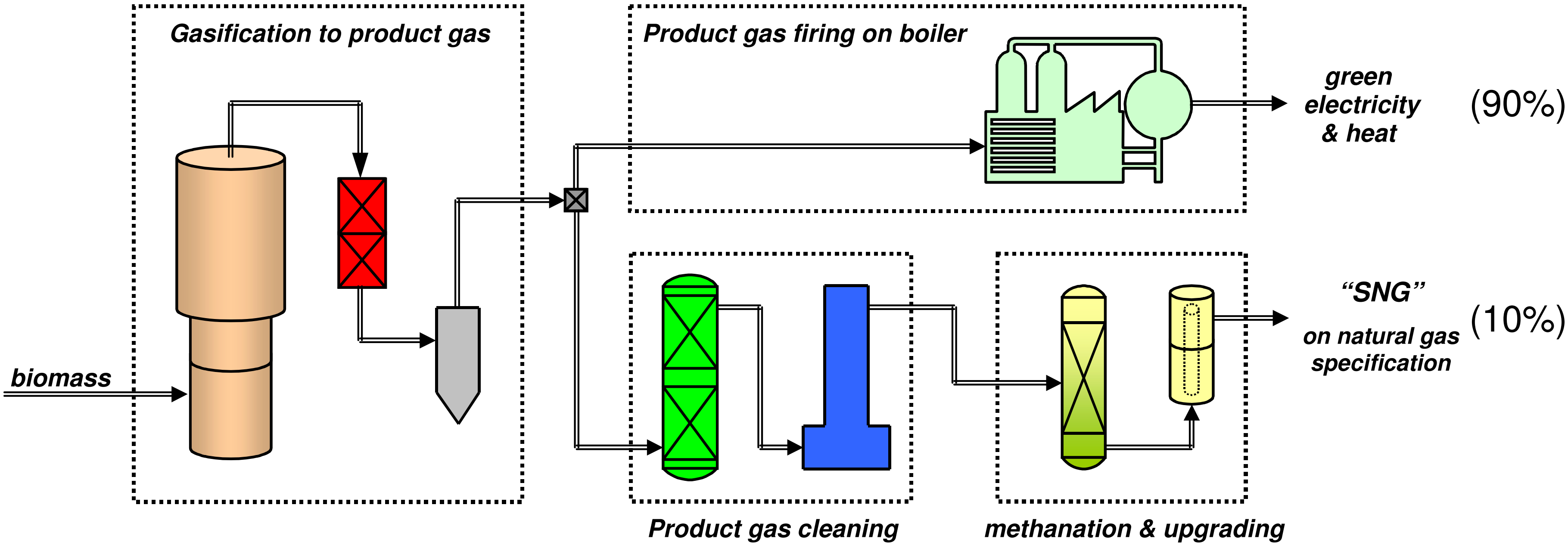
SNG development trajectory

Slipstream demonstration



Possible line-up of demonstration project

- 10 MW_{th} biomass gasifier (~15 kton/jr)
- Production of green electricity with boiler-firing *(low risk, direct profit)*

- Slipstream gas for demonstration (10%)
- Product gas cleaning & "Green Gas" *(attractive demo with possible subsidies)*

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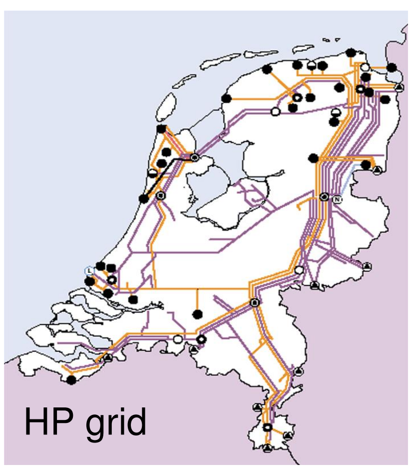
Conclusions

Natural gas in the Netherlands

- Almost 50% of primary energy is natural gas
- Almost 40% of CO_2 emissions result from natural gas consumption
- 135 000 km pipe line: in average *within 120 m*
- 94% of houses connected to gas grid
- ~70% of the gas is used for heating


HP grid


“central heating”


“radiator”


cooking

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Conclusions

- Natural gas increasingly important as fuel for medium-long term
- Green gas important as renewable fuel
- Green gas comprises biogas and SNG; SNG will however be main source
- SNG mainly for heat in the Netherlands, excellent existing infrastructure
- Biomass import required to meet targets
  - sufficient biomass available globally
  - logistics easily adaptable in existing infrastructure
- Today, SNG is more expensive than natural gas
  - but SNG is more attractive option then most green electricity routes
- Implementation via phased approach with stepwise larger plants
- Development & Demonstration requires financial support
- SNG offers excellent opportunities for Dutch industry.

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Thank you for your attention

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