WHAT IS SKIVE CHP PLANT PROJECT

- **Biomass gasification gas engine power plant**
- **Produces electric power and district heating**
- **Capacity**
  - **110 TPD of wood pellets**
  - **5.4 MW electric power**
  - **11.5 MW of district heat**
- **Plant located in Skive, Denmark**
- **CO_2 neutral Power generation**

MAP OF DENMARK SHOWING SKIVE

PROJECT PARTICIPANTS

Plant Owner:	**I/S Skive Fjernvarme**
Gasification & Gas Cleanup:	**Carbona**
Gas Engine:	**Jenbacher (GE)**
Balance of Plant:	**Danish Engineering Company**
Funding Agencies:	**U.S. Department of Energy** **European Union** **Danish Energy Agency**

DOE/NREL FUNDING

Contract for 50/50 cost share.

DOE-NREL share	**$ 3.0 MM**
Carbona/Plant owner share	**$ 3.0 MM**
Total contract	**$ 6.0 MM**

This contract pays for Gasification Plant Engineering and equipment.
Requires testing of completed plant & commercialization plans.

DOE-NREL expenditure to date	**$ 1.5 MM**
Carbona expenditure to date	**$ 1.5 MM**
Total	**$ 2.8 MM**

Basic & Process Engineering for Galten, Lemvig and Skive.
Detailed Engineering of selected Skive equipment

DOE-NREL Funds available for Skive	**$ 1.5 MM**

EU FUNDING

Contract for 35/65 cost sharing by EU/Participants.

EU share	**EUR 2.1 MM**
Participants share	**EUR 3.9 MM**
Total contract	**EUR 6.0 MM**

This contract pays for eligible costs for entire Power Plant.
Requires testing & Information dissemination.

EU expenditure up to 6/2002	**EUR 0.3 MM**
Participant expenditure up to 6/2002	**EUR 0.6 MM**
Total	**EUR 0.9 MM**

Basic & Process Engineering for Lemvig.

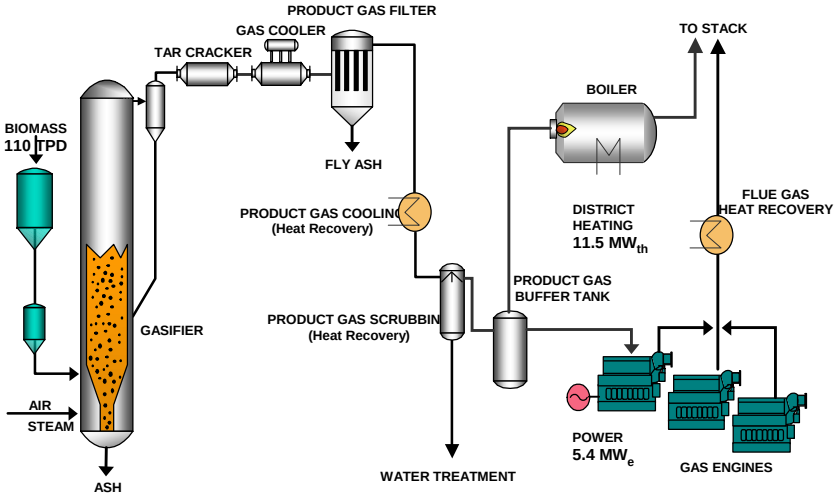
EU Funds available to Skive Project	**EUR 1.8 MM**

DEA FUNDING

Total funding of up to DKK 12.0 MM. (EUR 1.6 MM)

Performance, Economic and Enviromental Data

SKIVE PROJECT, DENMARK



SKIVE PROCESS DESIGN BASIS

- **Plant Configuration:**
  - low pressure fluidized bed gasifier
  - tar cracking
  - gas cooling and scrubbing
  - gas engines
  - district heating system
- **Plant Capacity:**
  - biomass feed 110 tpd
  - power generation max. 5.4 MW
  - 11.5 MW district heat, supply at 94/50 °C
- **Fuel:**
  - wood pellets (20.2 MJ/kg HHV d.b.) of 9.5 % moisture content
- **General:**
  - annual operation 8000 hours
  - technical life time 15 years
- **Plant Efficiency:**
  - electrical efficiency 30 % (LHV)
  - overall efficiency 90 % (LHV)

SKIVE PROCESS DESIGN BASIS

- **Gasifier:**
  - fluidized bed gasifier with one cyclone
  - operation at 29 psia pressure
  - dry ash removal
  - gasification with air and steam
  - heat input: 66.5 MMBtu/h
  - product gas composition to gas engine:

CO	%-vol	23.41
CO_2	%-vol	9.90
H_2	%-vol	20.71
H_2O	%-vol	3.32
CH_4	%-vol	0.93
C_2H_4	%-vol	0.001
C_xH_y	%-vol	0.001
N_2	%-vol	41.72
H_2S+COS	%-vol	0.008
NH_3+HCN	%-vol	0.005
HCl	%-vol	0.003

  - product gas heating value:

LHV	Btu/lb	2242

SKIVE PROCESS DESIGN BASIS

- **Tar Cracker:**
  - Ni based catalyst blocks
  - decomposes tars and ammonia
  - operating temperature 1650 °F
  - gas combustion with air to compensate heat consumption of catalyst process
  - nitrogen back - pulsing
- **Gas Cooling and Cleaning:**
  - water cooled, fire tube type, steam generating gas cooler from 1560 to 400 °F
  - bag filter operated at 400 °F, nitrogen back pulsing
  - two gas scrubbers using water to cool from 400 °F to 85 °F
  - gas heater to adjust relative humidity in gas

SKIVE PROCESS DESIGN BASIS

- **Gas Engines:**
  - **3xJMS620GS from Jenbacher AG, Austria**
  - **four-stroke, 20 cylinders, turbocharged**
  - **engine capacity 2 MWe**
  - **cooling heat recovered as district heat**
  - **exhaust gas heat recovered as district heat**
- **District Heating System:**
  - **connected to existing system**
  - **gas cooler heat recovered**
  - **gas engine cooling heat recovered**
  - **gas engine exhaust gas heat recovered**

JENBACHER ENGINE

GAS ENGINE GAS QUALITY REQUIREMENT

GAS ENGINE GAS QUALITY REQUIREMENT (JENBACHER)

	Jenbacher limits	
Temperature	104	°F
Pressure	4	psig
Relative humidity	80	%
Particle content	10	ppmw
Sulfur content	197	ppmv
Halogen content	9-37	ppmv
Ammonia content	11	ppmv
Oil (tar) content	0.21	ppmv
Jenbacher experience with gas LHV:	46-230	Btu/scf

TAR CRACKER

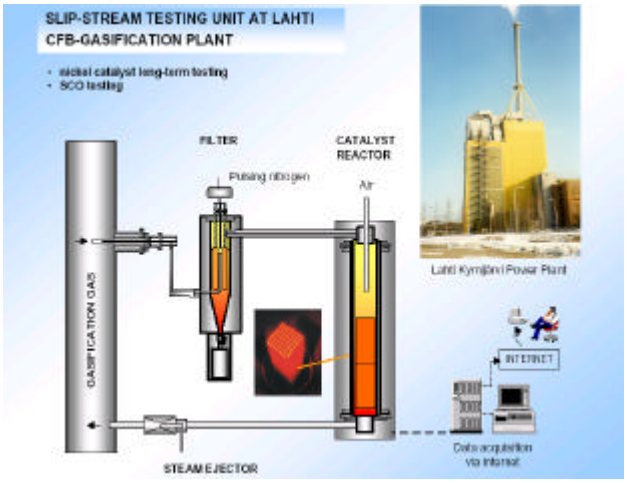
General

- **Removes tars and higher hydrocarbons from gas**
- **Converts tars and higher hydrocarbons to lighter combustible gas components: Carbon monoxide (CO) and hydrogen (H_2)**
- **Removes also ammonia (NH_3)**
- **No loss of energy**
- **No waste**

Performance

		GAS FROM GASIFIER	GAS FROM CRACKER
Temperature	°C	850	835
Mass flow	kg/s	1.087	1.151
CO	%-vol	17.17	19.13
CO2	%-vol	12.17	10.47
H2	%-vol	15.18	18.52
H2O	%-vol	12.41	11.52
CH4	%-vol	3.35	0.82
C2H4	%-vol	0.04	0.00
C3H8	%-vol	0.00	0.00
C6H6	%-vol	0.11	0.00
N2	%-vol	39.50	39.52
H2S	ppmv	75	68
NH3	ppmv	574	42
HCl	ppmv	59	54
TOTAL	%-vol	100.0	100.0
LHV	kJ/kg	4769	4473

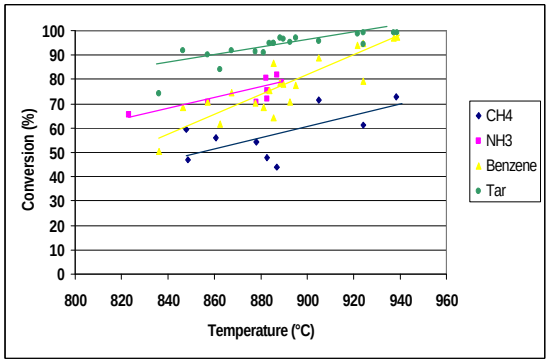
SLIP-STREAM TESTING UNIT



TAR CRACKER

Catalyst

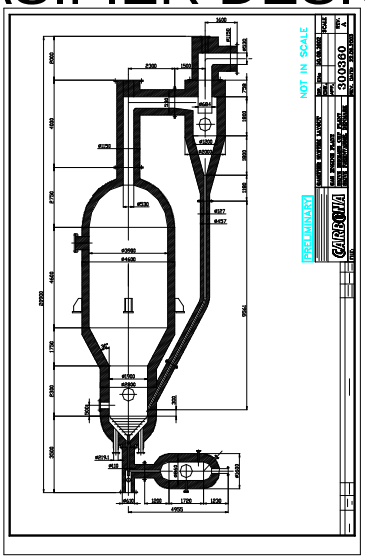
Performance



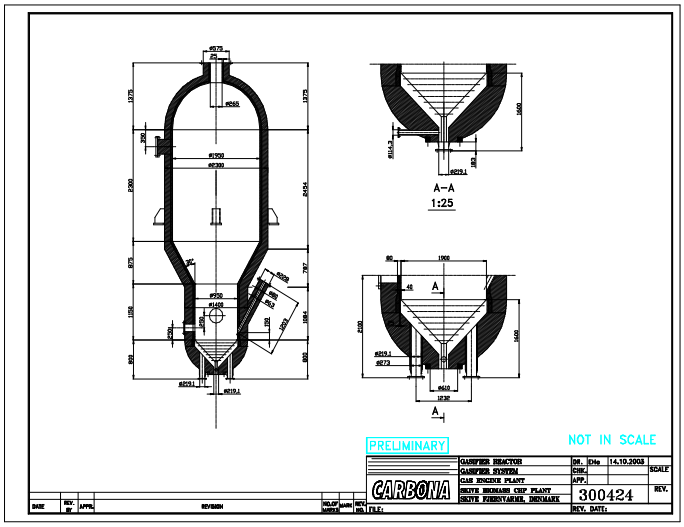
STATUS

- DOE – NREL has no objection to move project from Lemvig to Skive.
- EU has been requested to move project from Lemvig to Skive and to change project coordinator and participants. Awaiting contract amendment.
- Skive has obtained approvals from owners and City Council for plant construction & investment.
- Skive has made the main engineering contracts.
- Basic engineering and substantial part of detailed engineering has been done.

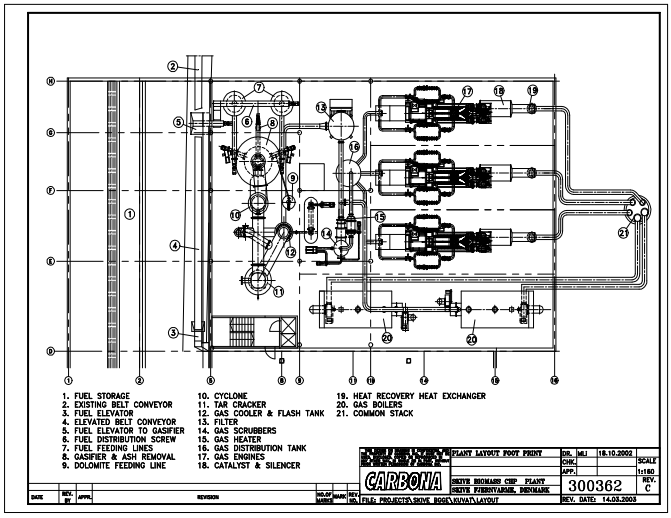
GASIFIER DESIGN



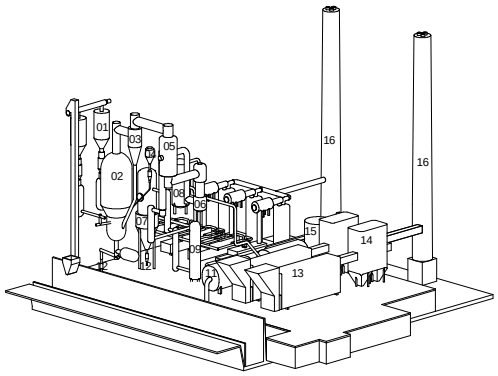
GASIFIER PARTS DESIGN



SKIVE CHP PLANT

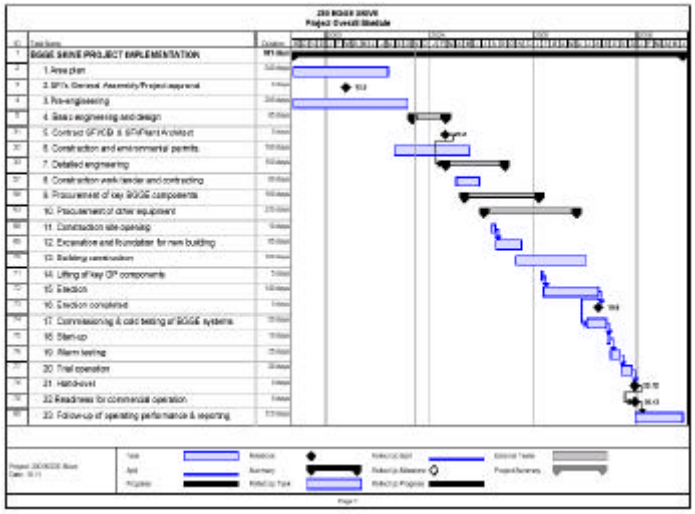


SKIVE CHP PLANT



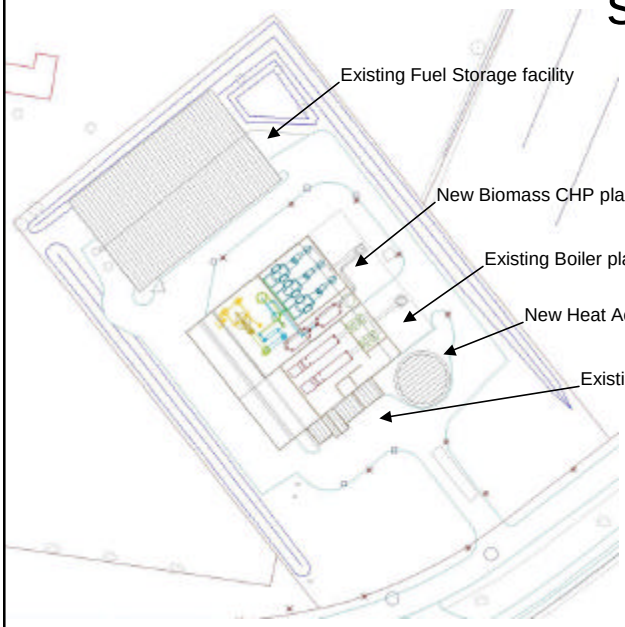
01 Feeding system
02 Gasifier
03 Cyclone
04 Dolomite feeding
05 Tar cracker
06 Heat exchanger
07 Filter unit
08 Gas tank
09 Scrubber
10 Gas engines and silencers
11 Gas boilers
12 Ash removal
13 Exist. biomass boilers
14 Exist. filter units
15 Lime storage
16 Stacks

SKIVE PROJECT SCHEDULE



Utilization of site & plant layout

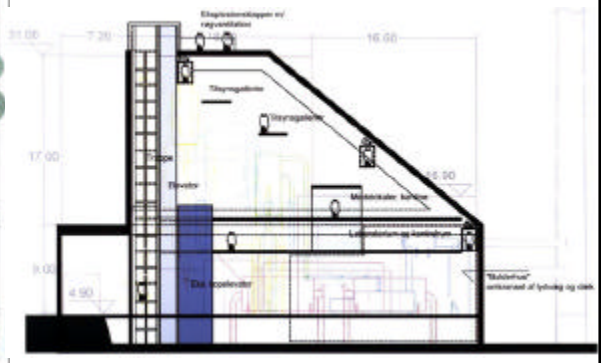
The following 4 architectural proposals designed by the tendering companies, are all based on a main layout of the CHP plant components as shown here.



n proposal - Ramvad Thomsen Architects

This 3rd proposal is from The Architects Ramvad & Thomsen. The proposal is well proportioned and very functional.

The company also prepared the models and drawing material for the exhibition.



New Biomass CHP plant

International tendering of Consultancy

1. **District Heating Consultancy & Project Management**
2. **Building Consultancy**
3. **Architectural Assistance**

AAEN Consulting Engineers Slide no. 1 November 2003

New Biomass CHP plant

Applicants for prequalification

Samarbejds-aftale	Dataark nr.	Virksomhed	Fjernvarme & projektledelse	Bygnings-rådgivning	Arkitekbistand	Godkendelse af Prækva-lifikations-materiale	Firmaets Samlede Score
(Sæt X)			(Sæt X)	(Sæt X)	(Sæt X)	Ja/nej	
X	1	Elsam Engineering A/S	X			ja	7,75
	2	Bascon Arkitekt- og Ingeniørfirma A/S		X	X	ja	7,3
X	3	RAMBØLL	X	X		ja	7,7
	4	Arkitektfirmaet C. F. Møller			X	ja	6,5
X	5	Bruun & Sørensen Energiteknik A/S	X			ja	7,75
	6	COWI A/S		X		ja	6,65
	7	KPF Arkitekter			X	ja	5,9
X	8	MidtConsult A/S	X	X		ja	7
	9	Arkitekterne Ramvad og Thomsen A/S			X	ja	6,45
X	10	Carl Bro A/S	X	X		ja	6,35
	11	Arkitema k/s			X	ja	6,9
X	12	ISC Rådgivende Ingeniører A/S	X	X		ja	6,5
	13	Friis & Moltke A/S			X	ja	6,7
X	14	DAI Gruppen A/S - Christensen & Hofmeister Råd.Ing. A/S	X	X	X	ja	6,1
X	15	NIRAS Rådgivende Ingeniører og planlæggere A/S	X	X		ja	6,65
	16	Gjørtz, Pank & Partnere A/S			X	ja	5,05
X	17	dk-TEKNIK ENERGI & MILJØ	X			ja	5,9
	18	EKJ - Erik K. Jørgensen AS, Rådgivende ingeniører		X		ja	5,8
	19	BALSLEV Rådgivende Ingeniører A/S	X	X		ja	6,1
	20	Aarhus Arkitekter A/S			X	ja	6,2
X	21	DDH Contractors A/S	X	X	X	ja	6
X	22	Moe & Brødsgaard A/S, rådgivende ingeniører	X	X		ja	5,6
	23	Grue & Hornstrup Rådgivende Ingeniører A/S	X	X		ja	4,45
	24	Gottlieb & Paludan A/S, Arkitekter MAA.			X	ja	6,75
X	25	Åris Petersen Arkitekter ApS		X	X	ja	5,65
	26	Møller & Grønborg Arkitekter og Planlæggere AS		X	X	ja	5,2
	27	OBH Rådgivende Ingeniører A/S, Rådgivende ingeniører F.R.I.		X		ja	5,8
X	28	Ingeniørfirmaet Palle Christensen A/S		X		ja	5,75
	29	Arkitektfirmaet Kjær & Richter A/S			X	ja	4,4
X	30	Arkitektfirmaet Tegnestuen Steudel & Knudsen Pedersen A/S			X	ja	4,2

In total 30 different companies sought to be prequalified for the opportunity of submitting tender.

The applying companies present a very broad selection of Danish companies working within the energy sector, along with some of the leading architectural studios.

AAEN Consulting Engineers Slide no. 2 November 2003

New Biomass CHP plant

Evaluation of Applicants

I/S Skive Fjernvarme - Biomasse Kraftvarme		13. Oktober 2003		*Dataark nr.*	*11*
				Konsortium - dataark nr.	*12 og 13*

Evalueringsskema for individuel score i forbindelse med prækvalifikation

Virksomhed: **Bruun & Sørensen Energiteknik A/S**

Generelle oplysninger

		Vægt	Point	Vægtet point
skala 0-8 point	**Nøgletal for seneste 3 års regnskab**	15%	8	1,2
skala 0-8 point	**Virksomhedens placering**	5%	5	0,25
skala 0-8 point	**Forslag til konsortium**	5%	7	0,35
skala 0-8 point	**Erfaring med udviklings projekter**	5%	7	0,35
			Score sum	2,15

Referencer

		Vægt	Point	Vægtet point
skala 0-8 point	**Referencer for relevante arbejder**	40%	8	3,2

Anlægstype	**Antal**	**Gen-nemført**	**Arbejdsbeskrivelse**	**Budgetterede anlægspriser**
Kraftvarme anlæg, gasmotorer	4+	4+	Naturgasfyret kraftvarmeanlæg i Skive, Kraftvarmeværk Herning, Samt flere anlæg i både DK og Udland.	
Kraftvarme anlæg, biomasse			Assens Kr.V.værk, Aarhus Nord Forbrænding,	
Fjernvarme anlæg, biomasse	2+	2+	Flere Kedelcentraler til trapiller og flis	
Andere relevante anlæg	200+	200+	200 fjernvarmeværker og ledningsanlæg i DK. Herunder SRO-anlæg, Haslev Pyrolyseanlæg.	
Byggeri div. Industribygninger				
Byggeri til div. Fjv/KV anlæg				

Personale

		Vægt	Point	Vægtet point
skala 0-8 point	**Personalets erfaring og ekspertise**	30%	8	2,4

Personale				**Generelle bemærkninger**
Antal ansatte S/M/L/XL	0			Firmaet kan også indgå i samarbejde med andre underrådgivere. Det mangler dog at blive klarlagt, hvorvidt firmaet vil kunne udføre opgaven uden COWI A/S som underrådgiver. Dette forhold accepteres dog indtil videre.
Ekspertise tilbilt projekt	del 1	del 2	del 3	
Alle Bruun & Sørensen Energiteknik's ansatte er ansat i COWI A/S. Personale forhold skal derfor afklares juridisk med selve tilbudsgiveren.				

Samlede vurdering

	Del 1	**Del 2**	**Del 3**		
Der bydes på	**x**			**Vægtet score i alt:**	**7,75**

All 30 applicants were evaluated according to human resources, work experience and economical resources.

The companies were then assigned score points and rated in relation to each other.

AAEN Consulting Engineers Slide no. 3 November 2003

New Biomass CHP plant

Final tendering for Consultancy

	Prækvalificerede virksomheder		
Samarbejde	Entreprise 1 Projektledelse & fjernvarme install.	Entreprise 2 Bygningsrådgivning	Entreprise 3 Arkitektbistand
x	Bruun & Sørensen Energiteknik A/S		
		COWI A/S	
			KPF Arkitekter
x	MidtConsult A/S		
		MidtConsult A/S	
			Arkitekterne Ramvad & Thomsen P.A.R Aps
x	RAMBØLL		
		RAMBØLL	
			C.F. Møller
x	Elsam Engineering A/S		
		Bascon Arkitekt- og ingeniørfirma A/S	
			Bascon Arkitekt- og ingeniørfirma A/S

Out of the 30 companies applying for prequalification, 9 companies with the highest score, were selected to tender for the different contracts.

These proposals are currently being evaluated.

AAEN Consulting Engineers Slide no. 4 November 2003

New Biomass CHP plant

Biomass CHP plant – a new landmark

The new biomass CHP plant will be visible upon entering the town of Skive.

The main features of the plant will be the 32 meter high gasifier tower and the 72 meter high twin chimneys.

View of new plant from Viborgvej (large arrow on map)

AAEN Consulting Engineers Slide no. 5 November 2003

New Biomass CHP plant

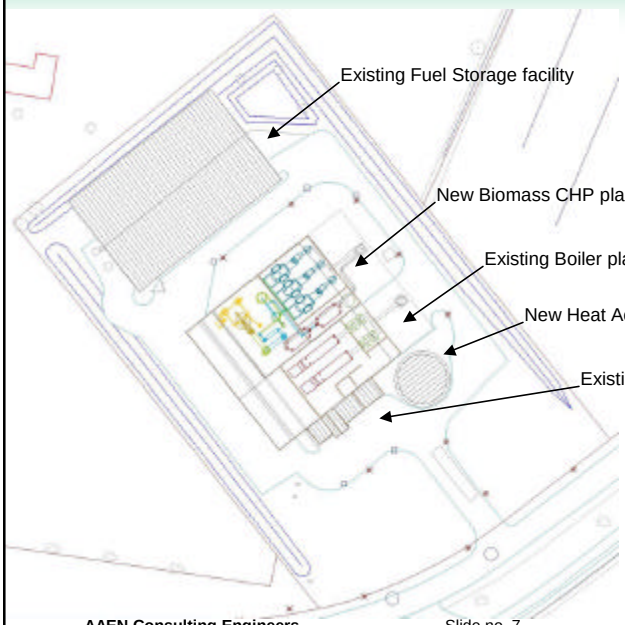
Location of site

The biomass CHP plant will be visible from most parts of Skive, and by this becoming a landmark for the town.

AAEN Consulting Engineers Slide no. 6 November 2003

New Biomass CHP plant

Utilization of site & plant layout

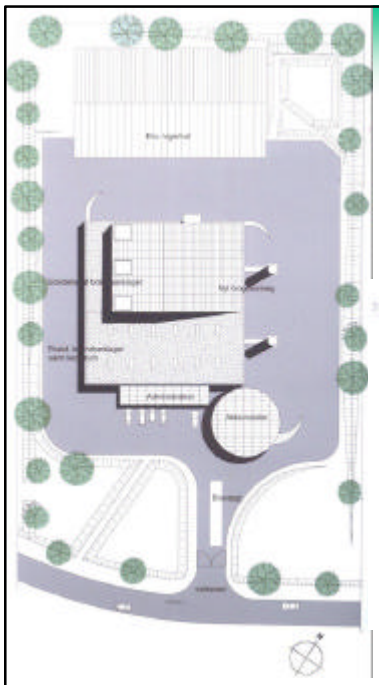


The following 4 architectural proposals designed by the tendering companies, are all based on a main layout of the CHP plant components as shown here.

AAEN Consulting Engineers Slide no. 7 November 2003

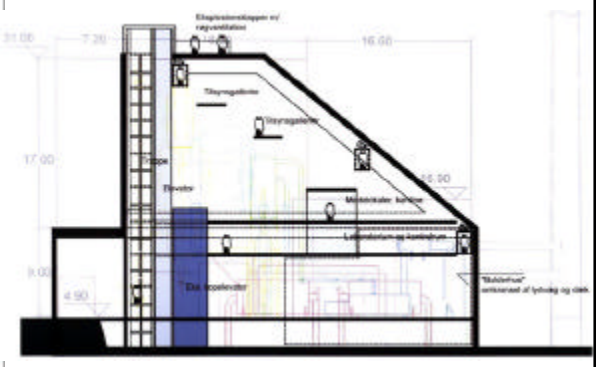
New Biomass CHP plant

1st design proposal - Ramvad & Thomsen Architects



The 1st proposal is from The Architects Ramvad & Thomsen. The proposal is well proportioned and very functional.

The company also prepared the models and drawing material for the exhibition.



AAEN Consulting Engineers Slide no. 8 November 2003

New Biomass CHP plant

1st design proposal - Ramvad & Thomsen Architects

Materials:

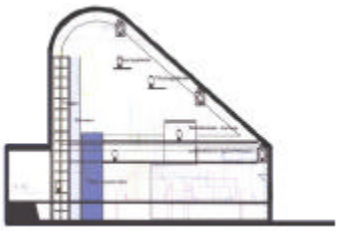
Gasifier tower – Flexible aluminium plates.

Chimneys – Flexible aluminium plates.

Heat Accum. tank – Flexible aluminium plates.

Building base – Dark plating.

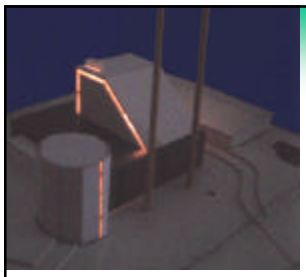
The design proposal suggests the use of flexible aluminium plates as front coating, making the design proposal for the gasifier tower flexible, so that alternative shapes can be created.



AAEN Consulting Engineers Slide no. 9 November 2003

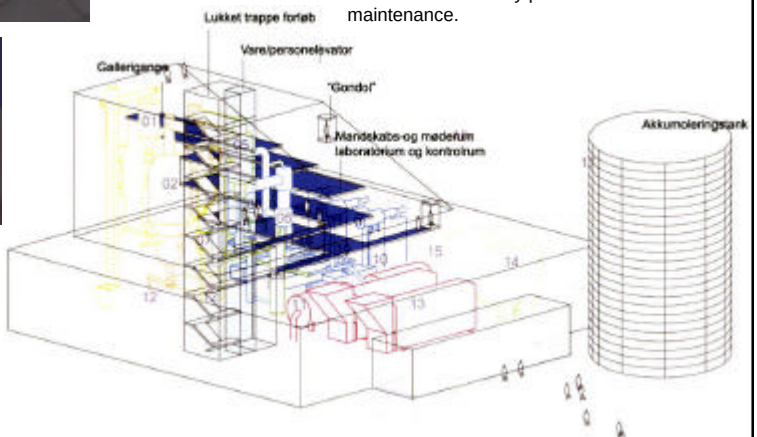
New Biomass CHP plant

1st design proposal - Ramvad & Thomsen Architects



One of the main visual features of the proposal, is a band of windows along the edge of the front. The windows becomes a band of light after dark.

Aluminium is a proven material and should not cause any problems with maintenance.



AAEN Consulting Engineers Slide no. 10 November 2003

New Biomass CHP plant

2nd design Proposal - KPF Architects

The 2nd design proposal is from KPF Architects.

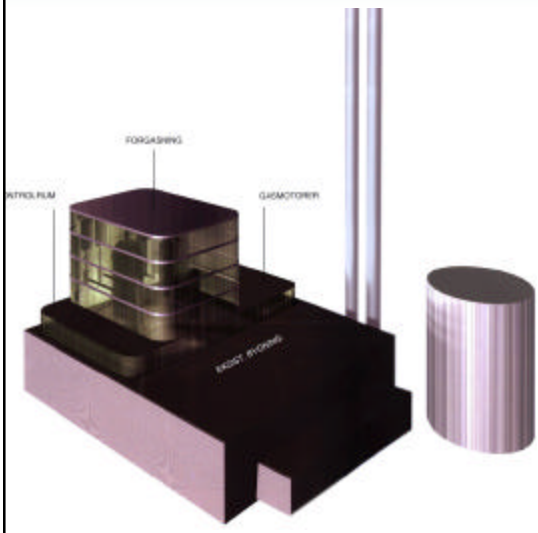
The front coating of the gasifier tower is made of semi-transparent industrial glass, while the chimneys and accumulation tank are covered by aluminium plates.

The new chimney has been moved close to the existing one, creating a visually more balanced composition of the main building

AAEN Consulting Engineers Slide no. 11 November 2003

New Biomass CHP plant

2nd design Proposal - KPF Architects



Materials:

Gasifier tower – green semi transparent industrial glass and aluminium bands.

Chimneys – Aluminium plating.

Heat Accum. tank – Aluminium plating.

Building base – Dark plating.

AAEN Consulting Engineers Slide no. 12 November 2003

New Biomass CHP plant

2nd design Proposal - KPF Architects

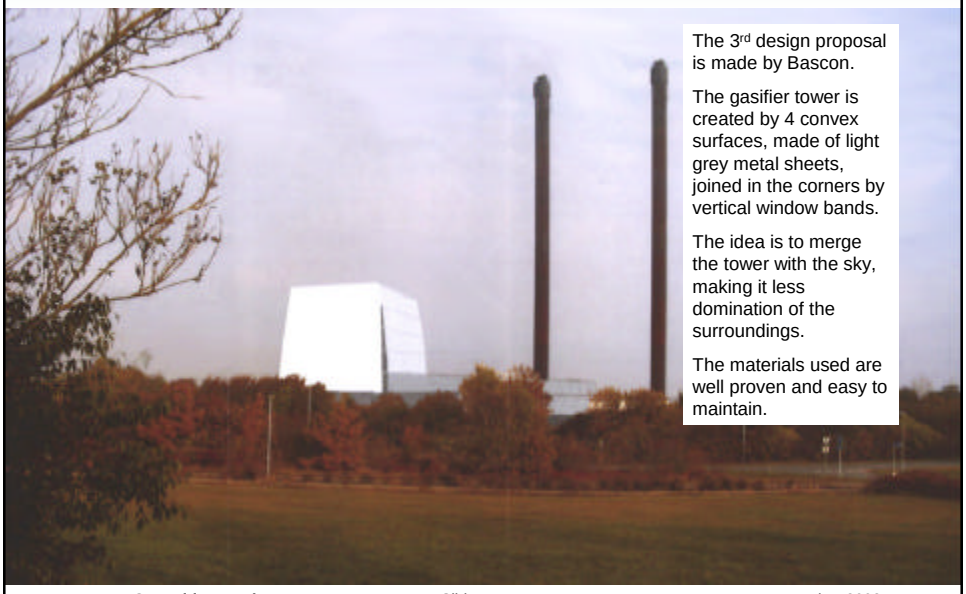
After dark the large surfaces of semi-transparent glass on the gasifier tower will be glowing brightly.

Maintenance of the glass walls will be further discussed.

AAEN Consulting Engineers Slide no. 13 November 2003

New Biomass CHP plant

3rd design Proposal - Bascon Engineers & Architects



The 3rd design proposal is made by Bascon.

The gasifier tower is created by 4 convex surfaces, made of light grey metal sheets, joined in the corners by vertical window bands.

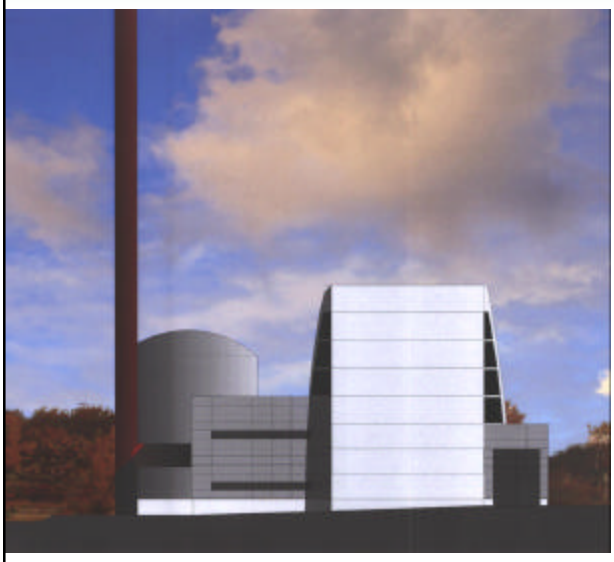
The idea is to merge the tower with the sky, making it less domination of the surroundings.

The materials used are well proven and easy to maintain.

AAEN Consulting Engineers Slide no. 14 November 2003

New Biomass CHP plant

3rd design Proposal - Bascon Engineers & Architects



Materials:

Gasifier tower – light grey metal sheets and custom-made window bands.

Chimneys – corroded iron plating.

Heat Accum. tank – dark grey metal sheets.

Building base – dark grey metal plates.

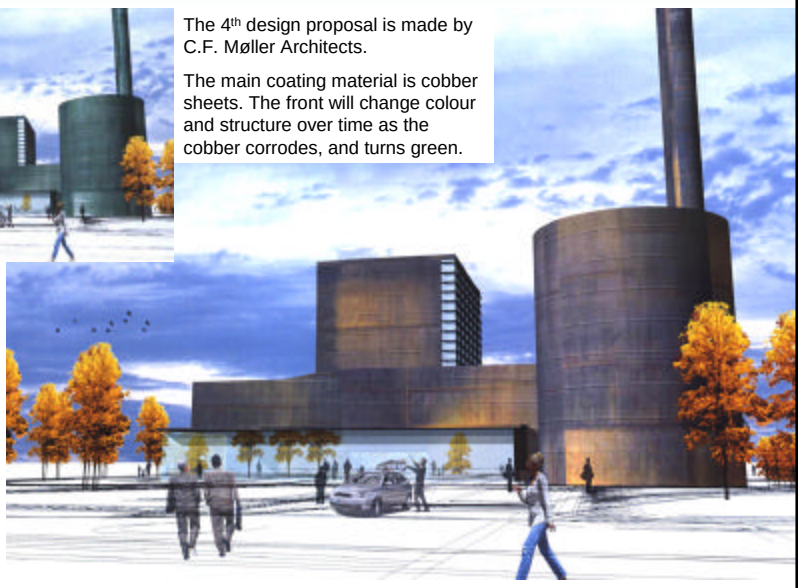
AAEN Consulting Engineers Slide no. 15 November 2003

New Biomass CHP plant

4th Proposal - C.F. Møller Architects

The 4th design proposal is made by C.F. Møller Architects.

The main coating material is cobber sheets. The front will change colour and structure over time as the cobber corrodes, and turns green.



AAEN Consulting Engineers Slide no. 16 November 2003

New Biomass CHP plant

4th Proposal - C.F. Møller Architects

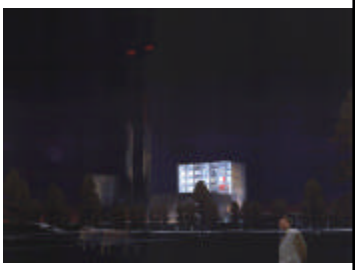
Materials:

Gasifier tower – Cobber sheets and custom-made window bands.

Chimneys – Cobber sheets.

Accu. tank – Cobber sheets.

Building base – Cobber sheets and glass fronts.



AAEN Consulting Engineers Slide no. 17 November 2003

New Biomass CHP plant

4th Proposal - C.F. Møller Architects

AAEN Consulting Engineers Slide no. 18 November 2003

New Biomass CHP plant

Main Activities

- **Decision on the architecture of the new plant by the Board of I/S Skive Fjernvarme.**
- **Continuation of the design of the gasifier by Carbona.**
- **Commencement of detailed design and tendering of the building for the gasification plant.**
- **Construction of the heat accumulator, when the building permission has been obtained.**
- **Construction of the CHP gasification plant according to the time schedule.**

AAEN Consulting Engineers Slide no. 19 November 2003

Biomass CHP plant

The most Important Conditions

- Green electricity price 543 DKK, now 600 DKK (80 Euro) per MWh in 10 years
- Wood pellets 700 DKK./tons (95 Euro)
- Total investments 110 mill. DKK. exclusive subsidy
- Variable heating price 360 DKK(49 Euro) per MWh

AAEN Consulting Engineers Slide no. 1 November 2003

Biomass CHP plant

I/S Skive Fjernvarme, Income and Operation cost

Economy

	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12
Income for sale of heat	42.589.051	42.589.051	42.589.051	42.589.051	42.589.051	42.589.051	42.589.051	42.589.051
Income for sale of elektricity	23.663.416	23.663.416	23.663.416	23.663.416	23.663.416	23.663.416	23.663.416	23.663.416
Income for sale of elektricity (green power)	18.845.423	18.845.423	18.845.423	18.845.423	18.845.423	18.845.423	18.845.423	18.845.423
Government contribution on elektricity	640.000	640.000	640.000	640.000	640.000	640.000	640.000	640.000
Duty on heat connection	13.529.025	13.529.025	13.529.025	13.529.025	13.529.025	13.529.025	13.529.025	13.529.025
Rent of meter	7.015.050	7.015.050	7.015.050	7.015.050	7.015.050	7.015.050	7.015.050	7.015.050
Running income	106.281.965	106.281.965	106.281.965	106.281.965	106.281.965	106.281.965	106.281.965	106.281.965
Fuel								
- Solid fuel	19.251.777	19.251.777	19.251.777	19.251.777	19.251.777	19.251.777	19.251.777	19.251.777
-DOG oile	2.912.035	2.912.035	2.912.035	2.912.035	2.912.035	2.912.035	2.912.035	2.912.035
- natural gas								
- heat	19.786.752	19.786.752	19.786.752	19.786.752	19.786.752	20.236.451	20.236.451	20.236.451
- power	17.083.556	17.083.556	17.083.556	17.083.556	17.083.556	17.083.556	17.083.556	17.083.556
Administration	2.916.257	2.916.257	2.916.257	2.916.257	2.916.257	2.916.257	2.916.257	2.916.257
operation and maintenance costs								
- District heating station, biomass	329.187	329.187	329.187	329.187	329.187	329.187	329.187	329.187
- District heat and power station, natural gas	4.847.730	4.847.730	4.847.730	4.847.730	4.847.730	4.847.730	4.847.730	4.847.730
- District heating station, naturalgas	13.602	13.602	13.602	13.602	13.602	13.602	13.602	13.602
- District heat and power station, biomass	3.814.590	3.814.590	3.814.590	3.814.590	3.814.590	3.814.590	3.814.590	3.814.590
- Heat distribution	2.235.925	2.235.925	2.235.925	2.235.925	2.235.925	2.235.925	2.235.925	2.235.925
- Power and water	1.314.937	1.314.937	1.314.937	1.314.937	1.314.937	1.314.937	1.314.937	1.314.937
- Other costs	6.012.900	6.012.900	6.012.900	6.012.900	6.012.900	6.012.900	6.012.900	6.012.900
Operating costs	80.519.247	80.519.247	80.519.247	80.519.247	80.519.247	80.968.946	80.968.946	80.968.946
Contribution margin	25.762.718	25.762.718	25.762.718	25.762.718	25.762.718	25.313.019	25.313.019	25.313.019

AAEN Consulting Engineers Slide no. 2 November 2003

Biomass CHP plant

I/S Skive Fjernvarme, Capital expenses

Capital expenses

		04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12
Eksisting debt (91.696.400 i 1994/1995)									
-interest	2.665.581	1.833.785	1.706.845	1.569.157	1.420.109	1.259.052	1.085.308	898.163	696.867
-repayment	4.174.010	6.547.300	6.858.624	7.184.752	7.526.387	7.884.267	8.259.164	8.651.887	9.063.284
payment	6.839.592	8.381.085	8.565.469	8.753.910	8.946.496	9.143.318	9.344.471	9.550.050	9.760.151
Reinvestment (Annuritetslån 6%, 8 år, kurs 100)									
-interest		240.000	190.048	462.802	371.481	306.811	478.260	655.644	488.934
-repayment		404.144	454.096	986.522	1.077.843	1.142.513	1.615.208	2.243.004	2.409.714
payment		644.144	644.144	1.449.324	1.449.324	1.449.324	2.093.468	2.898.648	2.898.648
New investment (Annuritetslån 6%, 10 år, kurs 98,86)									
-interest		6.600.000	5.547.197	4.972.959	4.364.268	3.719.054	3.035.128	2.310.167	1.541.707
-repayment		8.517.823	9.570.626	10.144.864	10.753.556	11.398.769	12.082.695	12.807.657	13.576.116
payment		15.117.823	15.117.823	15.117.823	15.117.823	15.117.823	15.117.823	15.117.823	15.117.823
Result		1.452.683	1.259.597	379.257	209.278	42.958	-999.707	-1.773.773	-1.897.405

AAEN Consulting Engineers Slide no. 3 November 2003

Biomass CHP plant

Construction cost

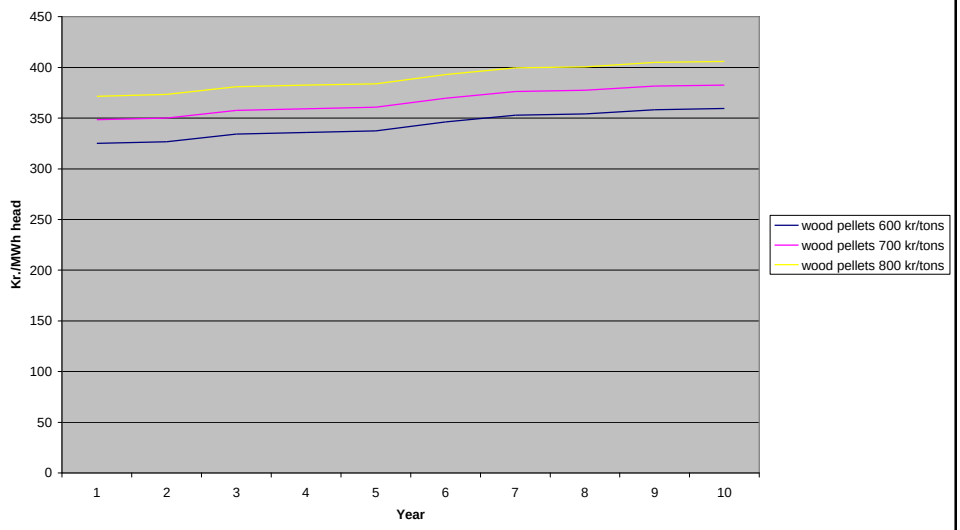
I/S Skive Fjernvarme, biomass gasification CHP plant		
Building and civil work	25.000.000	25.000.000
o Excavation		
o Fundation		
o New building		
o Extension to exsisting building		
o Building power and samitary work		
o surrounding area		
Biomass gasification plant (DOE- and EU-fund deducted):	80.000.000	80.000.000
Installation works of the gasifiaction plant		
o Boiler	4.000.000	
o DH connection	1.000.000	
o Boiler connection	1.000.000	
o Chimney	2.000.000	
Installation works total	8.000.000	8.000.000
Gasengine's with generator system:	19.400.000	19.400.000
o Gasengine with gastrain		
o Generatorsystem		
o Lubricating oil- and heatexchange		
Other installations og installation work for engines/generators:		
o Silencers	510.000	
o Power connection	550.000	
o Exhaust gas heat recovery and exhaust gas chanels		
o Exhaust gas cleaning, - CO2 catalyst	7.400.000	
o Lubricating oil tanke etc.		
o Ventilation system		
Other installations etc. Total	8.460.000	8.460.000
Other installations:		
o Crane and transportsystem in storage	1.950.000	
o Rebuilding/development of existing SRO-system to connect the new biomass plant to I/S Skive Fjernvarmes DH network.	2.500.000	
Other installations Total:	4.450.000	4.450.000
SUM		145.310.000
Funding from NREL, DEA, EU		-35.000.000
Total investments		110.310.000

AAEN Consulting Engineers Slide no. 4 November 2003

Biomass CHP plant

Fuel prices

The price on solid fuels influence on the variable heat price

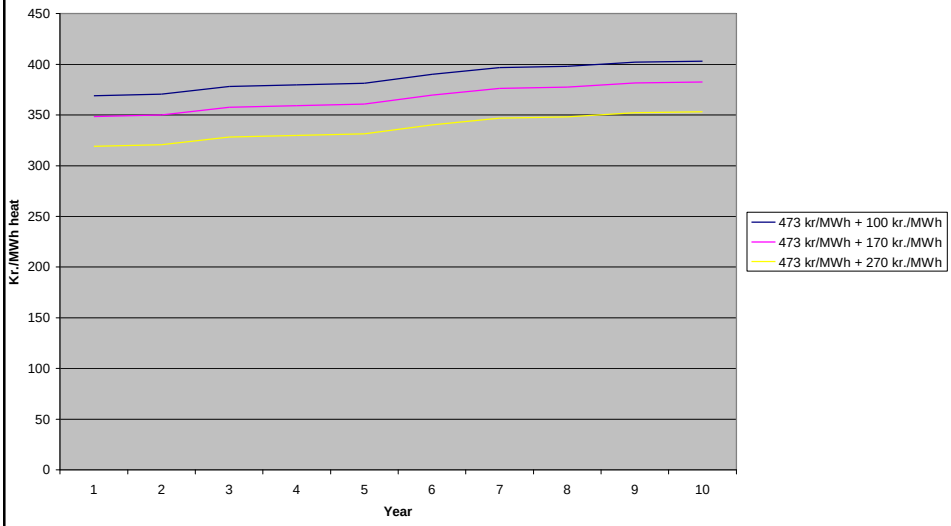


AAEN Consulting Engineers Slide no. 5 November 2003

Biomass CHP plant

Electricity prices

Influence on the variable heat price from the "green elektricity" price



AAEN Consulting Engineers Slide no. 6 November 2003

Biomass CHP plant

Approvals by the authorities

Approval of the municipal heating plan

- Submitted the 14. May 2001
- Approved by the City Council on the 19. September 2001

Approval of the “local” planning

- Published in November 2002
- Public hearing period closed the 12. February 2003
- The local plan was approved by the City Council on the 24. June 2003

Applications for environmental permits and building licence has been submitted in November 2003

AAEN Consulting Engineers Slide no. 7 November 2003

Biomass CHP plant

Time schedule for I/S Skive Fjernvarme

Tidsplan for: I/S Skive Fjernvarme

2003	Jan	Feb	Mar	Apr	Maj	Jun	Juli	Aug
## Finansiering								
## Lokalplan								
## Byggetilladelse og miljøgodkendelse								
## SF's godkendelse og beslutning om:			(1)					
## Kontrahering af rådgivningsbistand								
## Projektering (forprojekt og detailprojekt)								

2004	Jan	Feb	Mar	Apr	Maj	Jun	Juli	Aug
## Byggetilladelse og miljøgodkendelse								
## Projektering (forprojekt og detailprojekt)								
## Udbudsmateriale og overslagspriser								
## Licitation for *								
## Vurdering af tilbud og kontrahering								
## SF's godkendelse og beslutning om:								
## Opførelse af varmeakkumulator								
## Udgravning, fundament til nybygning								

2005	Jan	Feb	Mar	Apr	Maj	Jun	Juli	Aug
## Udgravning, fundament til nybygning								
## Bygningsændringer og nybygning								
## Forgasningsanlæg								
## Indkøring af forgasser								
## SF's godkendelse og beslutning om:								

2006	Jan	Feb	Mar	Apr	Maj	Jun	Juli	Aug
## Motoranlægget								
## Indkøring af motoranlæg								
## Befæstede udenomsarealer								
## Kommerciel drift								
## SF's godkendelse og beslutning om:								

Forudsætninger:

Finansiering:
(A) Værkpulje tilsagn, 17 juni 2002
(B) Tilsagn om tilskud fra EU og DOE til projektet, oktober 2002
(C) Godkendelse af tillægskontrakt fra EU, september 2003
(D) Øvrig finansiering, oktober 2002

* Licitation for hovedentreprisernе bygning og forgasningsanlæg

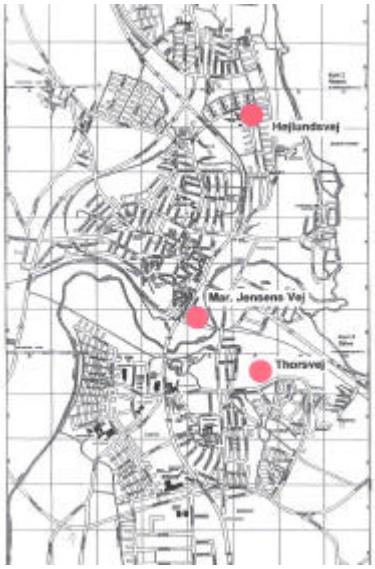
Skive Fjernvarmes (SF's) godkendelse og beslutning om:
(1) Afholdelse af ekstraordinær generalforsamling, 12 marts 2003
(2) Godkendelse af reslutat af licitationen af KV-anlæg, senest primo oktober 2004
(3) Underskrivning af kontrakt for bygningen i oktober og for forgasseren i november 2004
(4) Godkendelse af forgasningsanlægget
(5) Godkendelse af hele kraftvarmeanlægget

AAEN Consulting Engineers Slide no. 8 November 2003

I/S Skive Fjernvarme

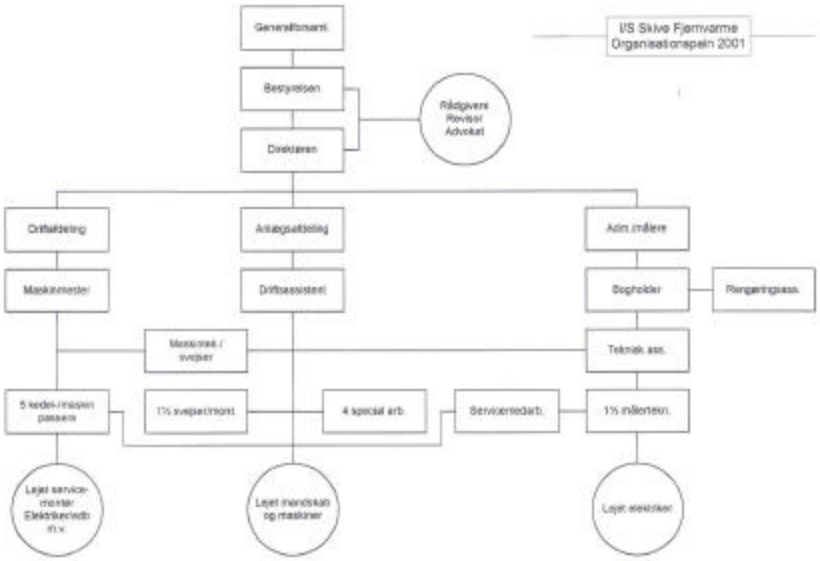
Biomass CHP Plant Slide no. 1 20th November 2003

I/S Skive Fjernvarme



Biomass CHP Plant Slide no. 2 20th November 2003

I/S Skive Fjernvarme



Biomass CHP Plant Slide no. 3 20th November 2003

I/S Skive Fjernvarme

I/S Skive Fjernvarmes samlede produktionsanlæg:

Varmeproduktion:

Kraftvarmeproduktion

Marias Jensens Vej (installeret 1994)

4 stk. naturgasfyrede motorer	MW	16,00
Akkumuleringstank (10-16 MW)	MW	13,00

Varmeproduktion

Thorvej (installeret 1984)

2 stk. bolsendebelskedler	MW	17,00

Marias Jensens Vej

1 stk. olie* fyret kedel (2002)	MW	10,00
2 stk. olie* fyrede kedler (1964-69)	MW	16,27
1 stk. olie* fyret kedel (1994)	MW	6,30
1 stk. olie* fyret kedel (1974)	MW	12,50

*genraffineret spildolie (DOG 25/RAPS OLIE)

Spids- og reservelast.

Højbaudrej (installeret 1977/96)

2 stk. naturgasfyrede kedler	MW	9,30
Varmeproduktion i alt	MW	100,37

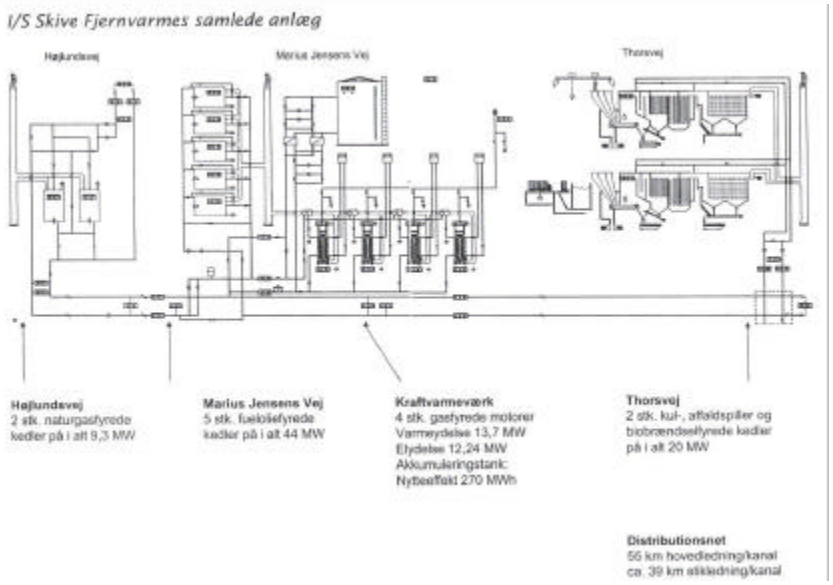
El produktion

4 stk. naturgasfyrede motorer	MW	12,24
Total produktion	MW	112,61
Maksimalbelastningen pr. 31. maj 2002	kW	102697

Til fordeling af fjernvarme råder I/S Skive Fjernvarme over ca. 60,4 km hovedledninger og ca. 48,8 km stikledninger.

Biomass CHP Plant Slide no. 4 20th November 2003

I/S Skive Fjernvarme



I/S Skive Fjernvarme

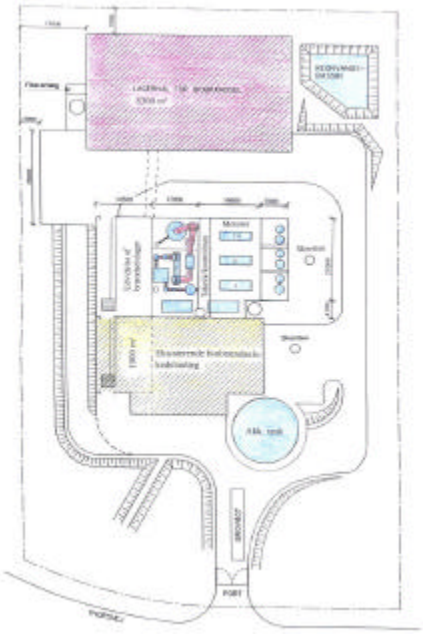
I/S Skive Fjernvarme

Biomass CHP Plant Slide no. 7 20th November 2003

I/S Skive Fjernvarme

Biomass CHP Plant Slide no. 8 20th November 2003

I/S Skive Fjernvarme

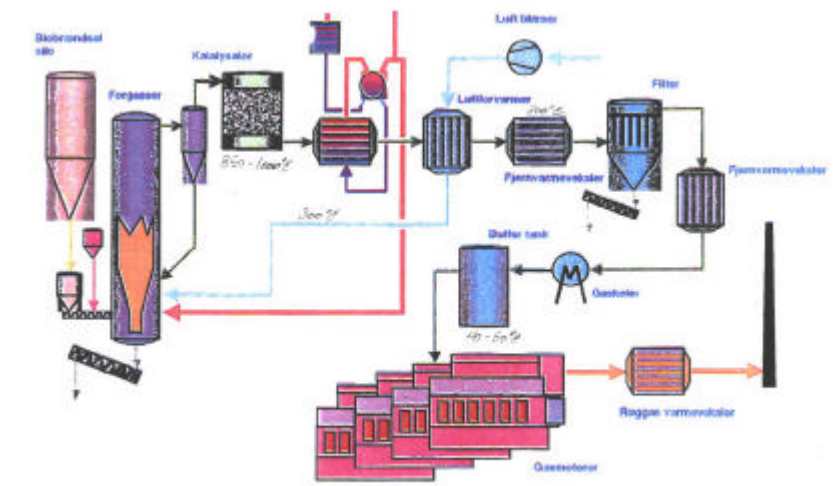


Biomass CHP Plant Slide no. 9 20th November 2003

I/S Skive Fjernvarme

Biomass CHP Plant Slide no. 10 20th November 2003

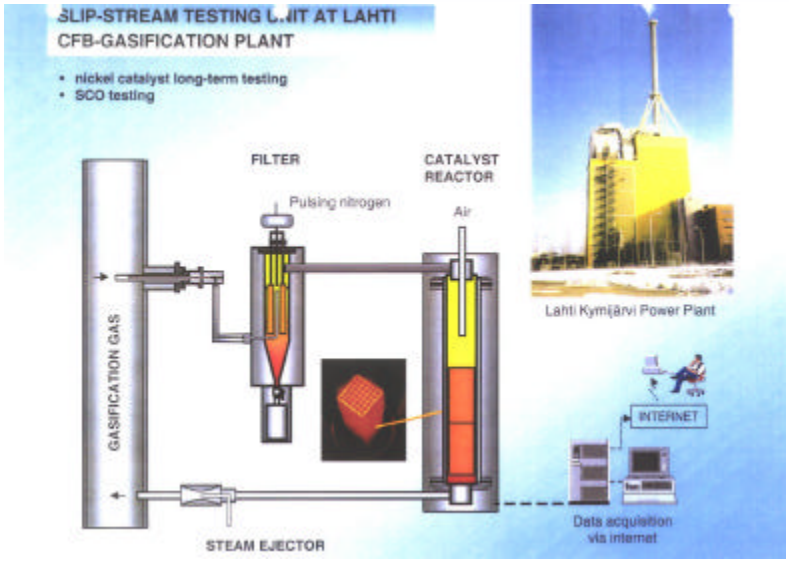
I/S Skive Fjernvarme



Figur 5. Forgasningsproces med gasmotorer.

Biomass CHP Plant Slide no. 11 20th November 2003

I/S Skive Fjernvarme



Biomass CHP Plant Slide no. 12 20th November 2003

Long Term Testing of Ni-Monolith Catalyst

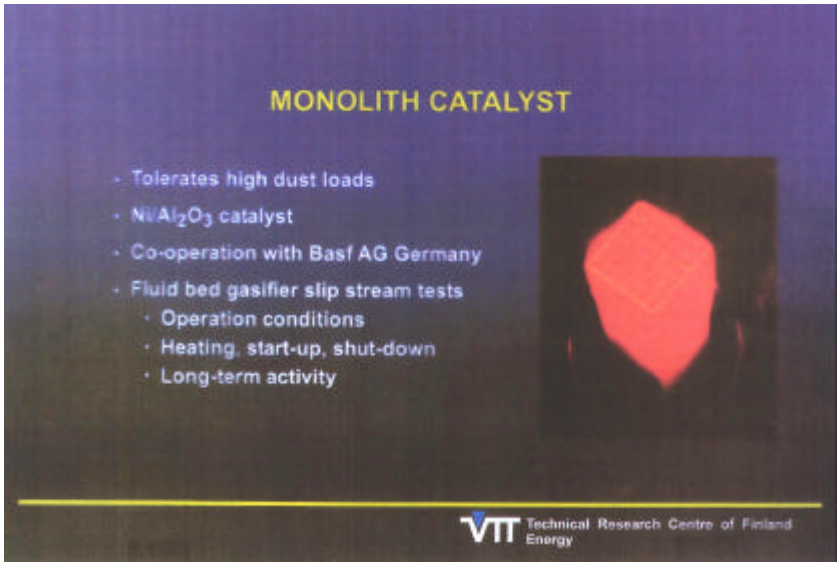
I/S Skive Fjernvarme

- CFB Gasifier of 50 MW_{th} capacity.
- Fuels include biomass, REF, plastics, shredded tires, railway ties.
- Catalyst Reactor consists of 2 monolith blocks of 15 cm x 15 cm x 30 cm.
- One block tested for 3500 hrs and another for 2300 hrs.
- No decrease in activity or performance to date.
- Heavy tar inlet 8-14 g/m^3; outlet extremely low.
- Gas impurities worse than in normal biomass fuel.
- Performance not deteriorated by S, Cl or metals.
- No sign of soot or carbon build-up.
- Reactor design based on SCR system for NO_x control in coal boilers to handle dust in gas.
- Strong design basis for Skive.

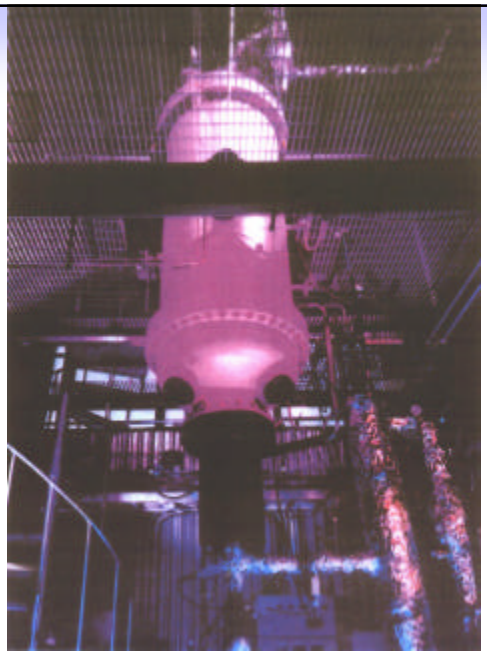
CARBONA

Biomass CHP Plant Slide no. 13 20th November 2003

I/S Skive Fjernvarme



Biomass CHP Plant Slide no. 14 20th November 2003



I/S Skive Fjernvarme

Biomass CHP Plant Slide no. 15 20th November 2003

I/S Skive Fjernvarme

Biomass CHP Plant Slide no. 16 20th November 2003

I/S Skive Fjernvarme

Biomass CHP Plant Slide no. 17 20th November 2003

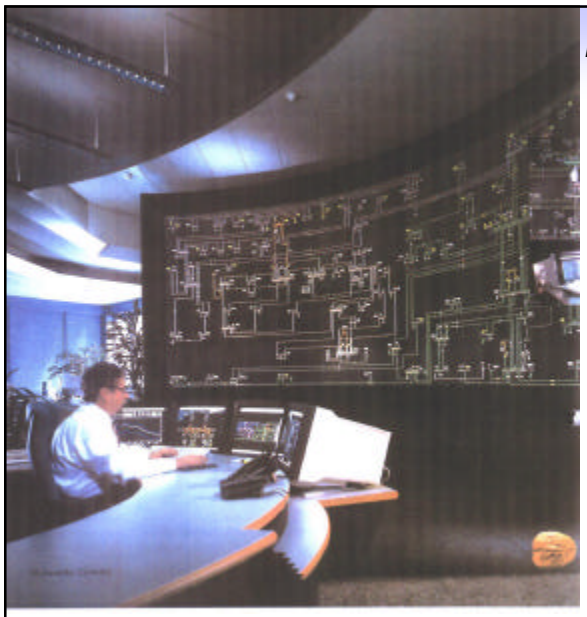
I/S Skive Fjernvarme

Biomass CHP Plant Slide no. 18 20th November 2003

I/S Skive Fjernvarme

Biomass CHP Plant Slide no. 19 20th November 2003

I/S Skive Fjernvarme



Biomass CHP Plant Slide no. 20 20th November 2003

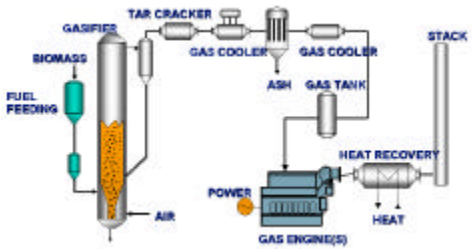
Proposed Biomass CHP System
Gasification – Cleanup – ICE

At Skive Fjernvarmer I/S
Skive, Denmark

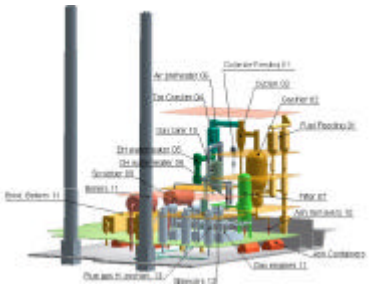
August 2003

Richard Bain

NyHavn, Copenhagen, Denmark



Process Schematic



3-D View of Process

Model of Proposed Plant

Artists View of Proposed Plant

Skive Fjernvarme – Existing Oil-Fired Boilers

Skive Fjernvarme – 5 MWe Natural Gas Engine

Skive Fjernvarme – District Heating Accumulator Tank

Skive – View from Accumulator

Skive – View from Accumulator

View of Harbor from Accumulator

Project Team - Tour

Proposed Site – Existing Stoker Boiler Building

Wood Pellet Receiving Area

Automated Pellet Transfer Bucket

Pellet Receiving Area

Pellet Storage Building – Capacity 600,000 tons

One of two 14 MWt Stoker Boilers

14 MWt Stoker Boiler

Planned Site – with Existing Stoker Building In Background

Planned Site – with Pellet Storage Building in Background