TECHNOLOGY FACTSHEET



GAS-FIRED CHP PLANT - ELE	ECTRICITY PRODUCTION A	AND DISTR	RICT HEATING								
Date of factsheet Author	30-11-2018 Robin Niessink										
Sector	Built environment										
FTS / Non-FTS	Other sectors										
Type of Technology	СНР										
Description	 Working of the Technology: A 'modern' natural gas-fired power plant can be a combined heat and power plant (CHP). In case of a combined cycle gas turbine/CCGT (Dutch: Stoom en Gasturbine/STEG) there is a gas turbine and steam turbine. In the first turbine, gas is expanded to drive the turbine. The second turbine, a steam turbine, is being driven by the residual heat of the gas turbine. Water is evaporated using heat from the waste heat recovery unit steam generator (heat exchanger) to produce high pressure steam which is expanded in a steam turbine to generate electricity using a generator. From the drain of a steam turbine, heat can be fed into a heat distribution network. Heat can be supplied to different sectors such as the built environment or industry. This factsheet focuses on a CHP plant that delivers heat to the built environment. A CHP plant without carbon capture and storage (CCS) is considered in this factsheet. Main components: Components of a gas-fired power plant for the production of electricity and district heating typically are an (inlet) air compressor, gas turbine and generator, heat recovery boiler, condensor, cooling technique, and flue gas cleaning equipment. Energy production related aspects: The downside of utilizing heat for district heating is that the electrical efficiency of the CHP plant is lowered (loss of electricity production) (ECN, 2011). Loss of electricity production (GJe/GJth supplied) depends on the temperature of heat disconnection. Figures about losses are included in this factsheet. 										
	Besides CO2 emissions, a STEG also presented in this factsheet.	emits NOx (Ec	ofys, 2014). A power pla	int is equipped with	flue gas cleaners to limi	t NOx emissions. The	flue gas cleane	r is included in	n the costs		
TRL level 2020	TRL 9 The technology is already being app Netherlands consists of gas-fired CH	olied on a large IP (ECN, 2017b	-scale and can therefore). Gas-fired CHP is one c	be considered to be bf the main heat sou	mature. A substantial a rces for district heating	amount of the install in the Netherlands in	ed capacity in tl 2015 (ECN, 20	he electricity s 17a).	sector in the		
TECHNICAL DIMENSIONS	Functional Unit				Value and	l Range					
Capacity	MWe		200					500			
	MWe NL		Curre	nt	203	2050					
Potential			A.4.	-	A. 41 -	-	0.41		-		
Market share	%	Share of final	Min -	2 Max	Min -	Max -	Min	-	Max		
		heat demand	2 -	2	Min -	Мах	Min	-	Max		
Capacity utlization factor Full-load running hours per year							0,80				
Unit of Activity	PJe/year								12,6		
Technical lifetime (years)							30				
Hourly profile	Yes						-				
COSTS	 Full ioad nours per year for electricity production are case-dependent. It depends strongly on the position of these plants within the electricity market (ECN, 2017b). The increasing share of intermittent renewable electricity generation may decrease full load hours, because plants do not have to operate when there is sufficient production from renewable sources (ECN, 2019). Gas-fired CHP could then provide back-up capacity. From a general historical perspective, a gas-fired CHP plant used for district heating typically runs as base load plant for electricity production; 6:000 to 8:000 full load hours per year (ECN, 2010); Gasterra, 2008). In case of 7:000 full loads hours to a capacity utilitzation factor for 80%. Indeed, IEA (2010) indicates 75 to 85% as capacity utilization factor for GOG CHP (IEA ETSAP, 2010). A CHP plant with a capacity of 500 MWe and 7:000 full load hours or heat delivery are not the same. Indeed, heat demand peaks in winter and in other seasons there is a (much) lower heat demand heat is available when the plant produces electricity, but due to limited overlap with the heat demand peaks in winter and in other seasons there is a (much) lower heat demand peaks in winter and in other seasons there is a (much) lower heat demand peaks in winter and in other seasons there is a (much) lower heat demand peaks in winter and in other seasons there is a (much) lower heat demand peaks in winter and in other seasons there is a (much) lower heat demand output capacity of district heating in storce needs to produce about 1,3 Pith per year. Assuming 4.500 full load hours (ECN, 2017a). This means the heat source needs to produce about 1,3 Pith per year. Assuming 4.500 full load hours (Energy Matters, 2012), the needed thermal output capacity for district heating is 20MWth. A minimum heat disconnection capacity for district heating is 10MWth (Ecofys, 2014). Heat Supply by Gas-fired Power Plants In The Netherlands About 4% of the final heat demand of large scale heat net										
rear of Euro	Euro per Functional Ur	nit	Curre	nt	203	0		2050			
Investment costs	mln. € / MWe		0.07	1,01	0.05	1,00	0.00		0,98		
Other costs per year	mln. € / MWe		0,87 - Min -	1,22 - Max	0,85 - Min -	1,19 - Max	0,83 Min	-	1,16 - Max		
Fixed operational costs per year	mln. € / MWe			0,05	0.04	0,05	0.04		0,05		
	mln. € / MWe			0,08	0,04 -	0,08	0,04		0,08		
Costs explanation	Overview: The ETRI (2014), Energy Matters (20 fixed operational costs (FOM), and v Costs explanation per source: • ■TRI (2014) indicates the CAPEX of 2030 and a CAPEX of 830-1150 €/kV refurbishment (ETRI, 2014). The VO year. In the CAPEX the following cos indirect costs, Development costs and • Energy Matters (2012) indicates in ncludes Civil and structural costs, M Million Euros per year (Energy Matt • According to the IEA (2010) the in a power plant, depending on the cas fixed and variable, are in the range of may lead to investment cost of \$120 When a CHP plant supplies heat to a • DRL (2017) indicates an investment	D12), IEA ETSA variable operative f a CCGT advant We for the plant M costs per ye st components nd Interconnect nvestment cost lajor equipment cers, 2012). This vestment cost apacity of the p of \$40/kWe to 00/kWe by 202 a heat network	P (2010) and PBL (2017) tional costs (VOM). Cost aced CHP (ETRI, 2014). E nt in 2050. The FOM cos ear in 2020, 2030 and 20 are included (ETRI, 2014) ction costs. Costs not inc ts of a STEG with capacit at costs including heat di is plant is used for electr of CCGT CHP plant (inclu- plant (IEA ETSAP, 2010). 9 \$60/kWe per year (typi 20 and \$1100/kWe by 20 c for the first time, there by rec 2017 (kWth output	and ECN (2011) repo s are described for d TRI indicates a CAPE ts per year in 2020, 2 50 amount to 4 €/M 4): Civil and structura luded are: Balance o y of 120MWe (Energ sconnection costs. Fi icity production and uding indirect costs of Typical investment of cally \$50/kWe). Acco 030 (IEA ETSAP, 2010 are additional invest	orts provide information ifferent capacity levels < of 870-1210 €/kWe fo 2030 and 2050 amount Wh (ETRI, 2014) and th al costs, Major equipme f plant costs and Insura gy Matters, 2012). Energ xed operational costs a disctrict heating. or IDC) is in the range of costs amount to \$1300/ ording to the IEA (2010) D).	n on gas-fired CHP' in expressed per unit of in the plant in 2020, a to 5,2% of the CAPE) ese are converted to ent costs, Electrical an nce costs (ETRI, 2014 gy Matters indicates a re zero (Energy Matt \$1100 to \$1800/kW /kWe (inc. IDC). The C) projection, increment sconnection:	ivestment costs capacity. CAPEX of 850- (, namely 3,9% €/MWe assum id I&C supply and (). an investment of ers, 2012). Vari ce , which is 10- 0&M costs, whi ntal improvement	/capital exper 1180 €/kWe f for FOM and ing 7.000 full nd installation of 1.050 euros iable costs per 45% higher th ich are given a ents and techr	nse (CAPEX), For the plant in 1,3% for FOM load hours per 1, Project s/kWe. CAPEX r year are 2,52 han the cost of as the total of hology learning		
	 PBL (2017) indicates an investment of 150-175 euros2017/kWth,output (PBL, 2017). The costs consist of the investment/CAPEX for heat disconnection (Dutch: 'kosten warmteuitkoppeling'). The fixed operational costs per year are 5% of the investment. ECN (2011) indicates an investment of 300 euros2011/kWth,output (ECN, 2011). The costs indicated consist of the investment/CAPEX for heat disconnection (Dutch: 'kosten warmteuitkoppeling'). 										

ENERGY IN- AND OUTPUTS												
	Energy carrier	Unit	Cu	urrent		2030			2050			
	Main output:	РJ		-1,00			-1,00				-1,00	
	Electricity		-1,00	1,00	-1,00	-	-1,00	-1,00	-		-1,00	
	Natural gas	РJ		2,00)		2,00				2,00	
Energy carriers (per unit of main output)			2,00	- 2,33	2,00	-	2,33	2,00	-		2,33	
	Heat	PJ	0.08	-0,80	0.08		-0,80	0.09			-0,80	
			-0,98	0,72	-0,98	-	-0,08	-0,98	-		-0,08	
		PJ	Min	- Max	Min		Max	Min	_		Max	
	Overview:											
	The electrical efficiency of existing combined cycle gas turbines in different OECD countries ranges between 39% and 61% (IEA, 2015). Depending on capacity of the plant, generally											
	lower efficiencies are found for smaller units and higher efficiencies for larger units (Gasterra, 2008).											
	The electrical efficiency of a CHP plant can only improve marginally due to further technical optimizations. The maximum possible efficiency of any heat engine is defined as the Carnot											
	enciency, which is not obtainable in practice. According to ETRI (2014) current combined cycle power plants used for cogeneration have a typical electrical efficiency of 59% at neak electrical load and a thermal efficiency of 46% at											
	peak thermal load (ETRI, 2014). Peak load efficiency means the efficiency if the plant maximizes one of its outputs. In case of CHP, a higher heat output lowers the electricity output											
	and vice versa.											
	Ratios (used to determine minmax	Ratios (used to determine minmax. range in table above):										
	• ECN (2011) indicates a 57% electrical efficiency and (possible) thermal efficiency of 40% for a gas-fired CHP plant used for electricity production and district heating (ECN, 2011).											
	pisconnecting 0,4GJth at 120 °C per GJ natural gas input results in a decrease of electricicity production from 0,5/GJe to 0,5GJe (ECN, 2011). For 2020, 2030 and 2050 the same values are assumed.											
Energy in- and Outputs explanation	• Energy Matters (2012) indicates a 42% thermal efficiency and a 43% electrical efficiency for a gas-fired combined cycle CHP used for large scale district heating (Energy Matters,											
	2012). For 2020, 2030 and 2050 the same values are assumed.											
	• IEA ETSAP (2010) indicates an electrical efficiency of 42-47% for a natural gas-fired combined cycle CHP and a thermal efficiency (steam) of 33-38% (IEA ETSAP, 2010). The 2020 projection is an electrical efficiency of 44-48% (46%) and a thermal efficiency of 32-36% (34%). The 2030 projection is an electrical efficiency of 46-49% (47,5%) and a thermal efficiency of 31-34% (32,5%) (IEA ETSAP, 2010). For 2050 the same efficiencies as 2030 are assumed.											
	= 100000000000000000000000000000000000											
	Other ratios:											
	• ETRI (2014) presents energy efficiencies of a CCGT advanced CHP (ETRI, 2014). Efficiencies at peak thermal load or peak electrical load are given in the report, which means that the											
	plant maximizes either its heat or el	lectricity outpu	it. In 2020, the max. t	thermal efficiency is 469	% and the max. el	ectrical effici	ency is 59% (ETF	RI, 2014). In 203	30, the max.	therm:	al EDL us us a ut	
	efficiency is $4/\%$ and the max. election does not give (max.) heat efficiency	efficiency is 47% and the max. electrical efficiency is 61% (ETRI, 2014). In 2050, the max. thermal efficiency is 49% and the max. electrical efficiency is 63% (ETRI, 2014). The ETRI report										
	toes not give (max.) heat efficiency when (max.) electrical efficiency is given and vice versa.											
MATERIAL FLOWS (OPTIONAL)												
	Material	Unit	C	urrent		2030			2050			
				-			-				-	
Material flows			Min	- Max	Min	-	Max	Min	-		Max	
				-			-			1	-	
			Min	- Max	Min	-	Max	Min	-		Max	
Material flows explanation		1										
Material flows explanation EMISSIONS (Non-fuel/energy-related er	nissions or emissions reductions (e.	g. CCS)			1	2020			2050			
Material flows explanation EMISSIONS (Non-fuel/energy-related er	nissions or emissions reductions (e. Substance	g. CCS) Unit	C	urrent		2030			2050			
Material flows explanation EMISSIONS (Non-fuel/energy-related er	missions or emissions reductions (e.a Substance	g. CCS) Unit	C	urrent -	Min	2030	- May	Min	2050		- May	
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