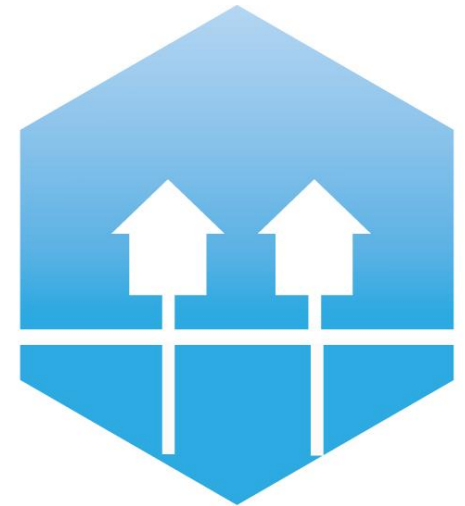
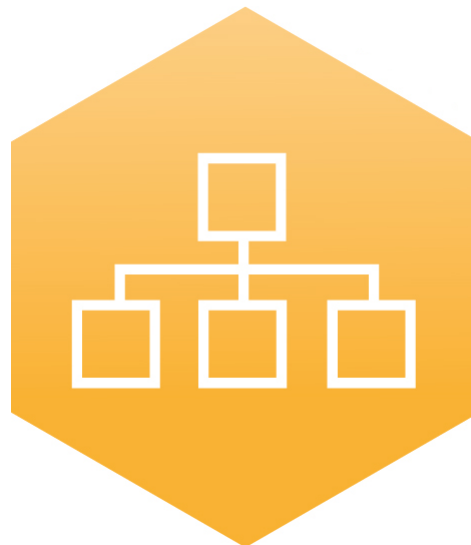


2<sup>nd</sup> International Conference on Smart Energy Systems and 4th Generation District Heating  
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## A critical analysis of the current primary energy assessment

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# 4DH

4th Generation District Heating  
Technologies and Systems

# Conclusion



**EU:s calculation of primary energy is not according to the laws of thermodynamics.**

**EU does not include the quality of the energy carrier**

**EU treat the heat a heat-pump absorb in the ambient as renewable solar energy. This is not correct.**



# Definition Primary Energy



**1 kWh of electricity per kWh of hydropower**

**1 kWh of electricity per 2 kWh of Natural gas**

**1 kWh of electricity per 2,5 kWh of Coal**



# Primary Energy for a system with 33% of hydro, natural gas and coal



**1 kWh of electricity per 1,8 kWh of  
“primary energy” (33% hydro-gas-coal)**

**Energies of different types and quality is  
summarized!**



# Energy quality-Exergi



The fraction which can be converted to work or electrical energy.



# Energy quality-Exergi!



- **Heat carriers are heat, fuel and electricity.**
- **They have different quality**
- **1 kWh of electricity is a larger resource than 1 kWh of fuel**
- **1 kWh of fuel is a larger resource than 1 kWh heat**

# Calculation of primary (heat ) Energy use

- **Today's method evaluates the heat value of the source**
- **1 kWh of hydro power get the same value as 1kWh of a fuel or 1kWh of heat**
- **The resource hydropower is underestimated**
- **The resource waste heat from cogeneration is overestimated**

# Primary Heat Energy-100kWh



	Mass	Heating Value
H <sub>2</sub>	2,5kg	100kWh
CH <sub>4</sub>	6,5kg	100kWh
C	11kg	100kWh
Biofuel	25 kg	100kWh
Hydro power, Fall height 367m	100 000kg	100kWh
Heat, $\Delta T=86K$ , water	1000kg	100kWh



# Primary exergi-100kWh



Resource	Mass	$\Delta G/\Delta H,$ $\epsilon$	Exergy Value
H <sub>2</sub>	3,0 kg	0,83	100kWh
CH <sub>4</sub>	7,0kg	0,92	100kWh
C	11kg	1,0	100kWh
Bio fuel	?	?	100kWh
Hydro power, Fall height 367m	100 000kg	1,0	100kWh
Heat, $\Delta T=86K$ ( $T_0=273K$ ) water	4166kg	0,24	100kWh

# Primary exergi

- The use of an exergy evaluation overrates the quality of fuels
- It assumes that the fuel generates electricity in an ideal fuel cell
- A fuel cell exist only of hydrogen

# Electric Efficiency

Energy source	Electric Efficiency
Hydro power	1
Natural gas	0,5
Coal	0,4
Bio fuel	0,33
Waste heat from CHP	0,15

# Identical Resources=1kWh electricity



- **1 kWh of electricity**
- **2kWh of Methane-Natural gas**
- **2,5 kWh of coal**
- **3 kWh of biofuel**
- **6 kWh of waste heat from a CHP system**



# Primary electric energy-100kWh



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Resource	Mass	Heating Value	Electric Efficiency	Electric Value
H <sub>2</sub>	5,0 kg	200kWh	0,5	100kWh
CH <sub>4</sub>	13,0kg	200kWh	0,5	100kWh
C	27,5 kg	250kWh	0,4	100kWh
Biobränsle	71 kg	100kWh	0,35	100kWh
Hydro power, Fall height 367m	100 000kg	100kWh	1,0	100kWh
Heat, $\Delta T=86K$ ( $T_0=273K$ ) water	10 000kg	1000kWh	0,10	100kWh

# Primary Electric factors

Energy source	Quality factors
Hydro power	3
Natural gas	1,5
Coal	1,2
Bio fuel	1,0
Waste heat from CHP	0,5

# Primary Electric Energy

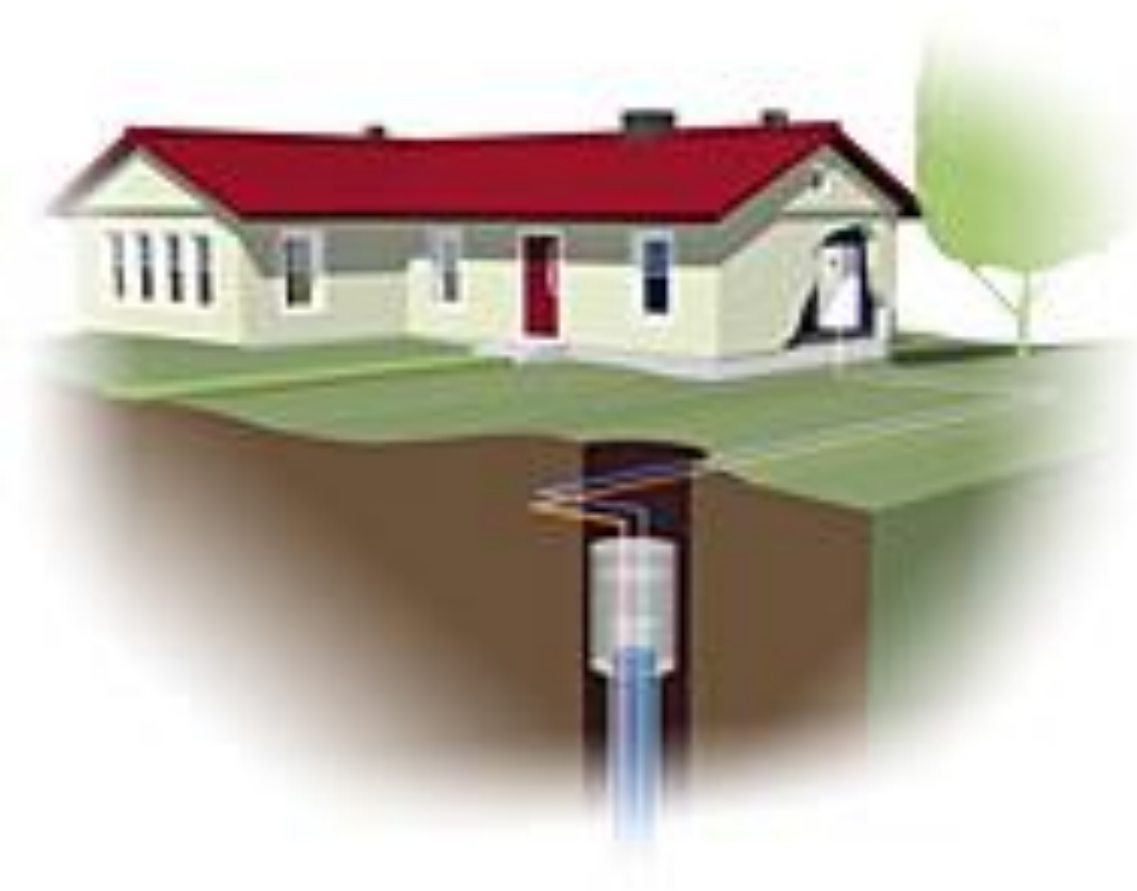


**The use of primary electric energy is not decreased if power is generated from natural gas with 50% efficiency instead of from coal with 40% efficiency**

**The use of primary electric energy is decreased if the efficiency is increased when generated from one source**



Heat pump, 1 kWh electricity =>  
3 kWh heat?





# Heat pump-problems?

- EU-method gets problems with heat pumps since they generate more heat than they use electricity
- 1kWh of heat = 1 kWh electricity!
- Ambient heat is defined as renewable solar energy!

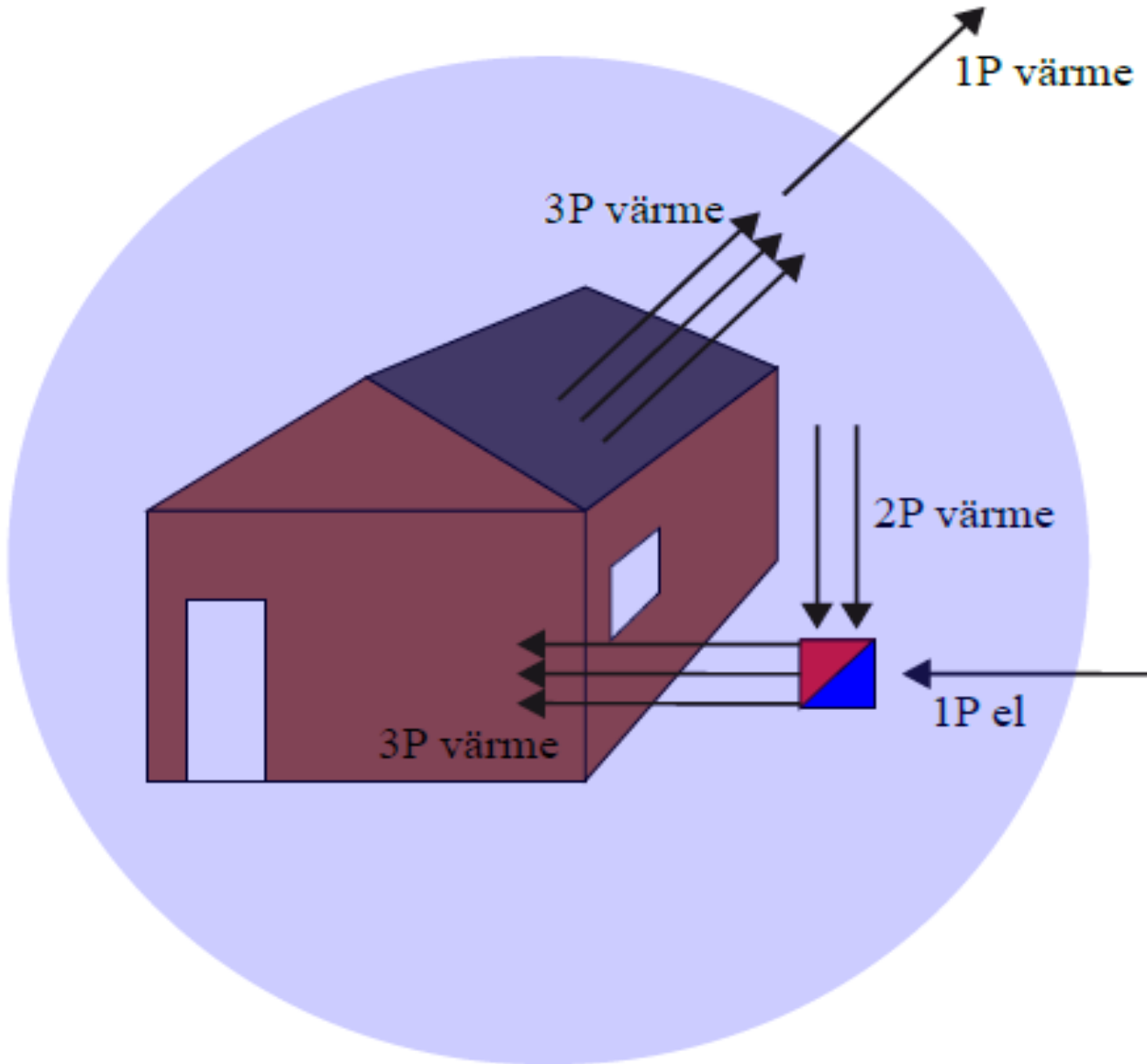
# Ambient Heat?



**EU define the heat a heat pump takes in the ambient as renewable solar energy!**

**Use of energy means that the energy is converted and exergy is used!**





# Ambient Heat?



- **The ambient heat circulates in the system**
- **It starts and ends up at the same temperature**
- **No exergy of the ambient heat is consumed**
- **Exergy is only consumed by the compressor**

# Conclusion



**EU:s calculation of primary energy is not according to thermodynamics.**

**EU does not include the quality of the energy carrier**

**EU treat the heat a heat pump absorb in the ambient as renewable solar energy. This is not correct.**

