How many mega is one peta?
How many kJ we need per day?
How many kilo wood replaces 1 m3 gas?
How MJ does one household need?
Why is saving on gas much more effective than saving on electricity?
How many Ws is one Joule?
How many kWh is one kJ?
How much PJ does our country use?
How much uses a town?
Why do we want sustainable energy?
What is the target for NL?
What is the production of sustainable energy now?
How many kWh does a PV panel produce?
And one windmill?
Is 4000 MW wind on land enough for our 2020 goals?

…4000 MW wind on land, will that be enough to reach our goals?

parken

staan

ote par-
ag zicht-
abel' zijn.
r en toerist.
al een onder-
e zogenoemde
olens. De ministe-
sche zaken en infra-
milieu bekijken de
nden de haalbaarheid
s binnen die 12-
steun van de provin-

cies is daarbij essentieel.

Het is de vraag of met deze nieuwe parken die 16 procent duurzame energie in 2020 wordt gehaald. Het ligt voor de hand dat Kamp zich ook zal inzetten voor meer turbines op land. Het grote voordeel: de relatief lage kosten. Windmolens op zee zijn aanzienlijk duurder. De minister zal dan wel de strijd moeten aangaan met het massale protest vanuit de samenleving.

WORKSHOP introduction into energy

October 1 – Groningen

Energy Academy Europe

Frans Debets

www.debetsbv.nl

How much energy do we need?
As a person…

We use food as a source of energy.

We need 100.000 calorie per hour = 100 kcal

2400 kcal per day

fuel	Energy content in kcal
potato	750 kcal per kg
vegetable oil	8600 kcal per kg
sugar	4000 kcal per kg

Per day we need 2400/750 = 3,2 kg potatoes

The standard unit is not calorie but Joule (J)

1 cal= 4,18 Joule

A person needs 10.000 kJ per day (4,18* 2400 kcal)

Fuel	**kcal**	**kJ**
Potato	750	3.140 kJ per kg
Egg		5.720 kJ per kg
Sugar		17.000 kJ per kg
Olive- of rapeseedoil		36.000 kJ per kg
Natural gas		31.000 kJ per m^3
Petrol, benzine		47.000 kJ per kg
Petrol, benzine		35.000 kJ per ltr
Hydrogen gas		120.000 kJ per kg
Coal		20.000 kJ per kg
Peat		16.000 kJ per kg
Dry wood (25% moisture)		14.000 kJ per kg
Lead battery – Li-ion		100 kJ per kg - 500 kJ per kg

Energy = Power * time

J= Watt sec

1 sec. = 1/3600 hour

1J = 1 Ws = 0,000277 Wh

I kJ = kWs = 0,000277 kWh = 0,277 Wh

kJ → kWh divide by 3600

kWh = kW * h **kW= kWh/h** **h= kWh/kW**

Energy content in **kJ** ánd **kWh**

kJ/3600 = kWh

Brandstof	**kJ**	**kWh**
Potatoe	3.140 kJ per kg	0,872 per kg
Egg	5.720 kJ per kg	1,588 per kg
Sugar	17.000 kJ per kg	4,72 per kg
Vegetable oil	36.000 kJ per kg	10 kWh per kg
Natural gas	31.000 kJ per m^3 = 31 MJ	8,61 per m^3
Petrol / benzine	47.000 kJ per kg	13,05 per kg
Petrol / bezine	35.000 kJ per ltr	9,7 per ltr
Coal	20.000 kJ per kg	5,55 per kg
Peat	16.000 kJ per kg	4,44 per kg
Dry wood (25% moist.)	14.000 kJ per kg	3,88 per kg

Prefixes for larger values

SI prefix	SI one letter abbreviation	Value	Words (Dutch)	Powers of 10
kilo	**k**	**1.000**	**duizend**	**10^3**
mega	**M**	**1.000.000**	**miljoen**	**10^6**
giga	**G**	**1.000.000.000**	**miljard**	**10^9**
tera	**T**	**1.000.000.000.000**	**biljoen**	**10^{12}**
peta	**P**	**1.000.000.000.000.000**	**biljard**	**10^{15}**
exa	**E**	**1.000.000.000.000.000.000**	**triljoen**	**10^{18}**
zetta	**Z**	**1.000.000.000.000.000.000.000**	**triljard**	**10^{21}**

How much uses a household?

	Average use per year	Energy per unit	in MJoule	in kWh	%
gas	1500 m^3	31 MJ/ m3			
electricity	3300 kWh				
Total					
Benzine/ Petrol	1000 ltr	35 MJ/ ltr			
Total					

Use of a household

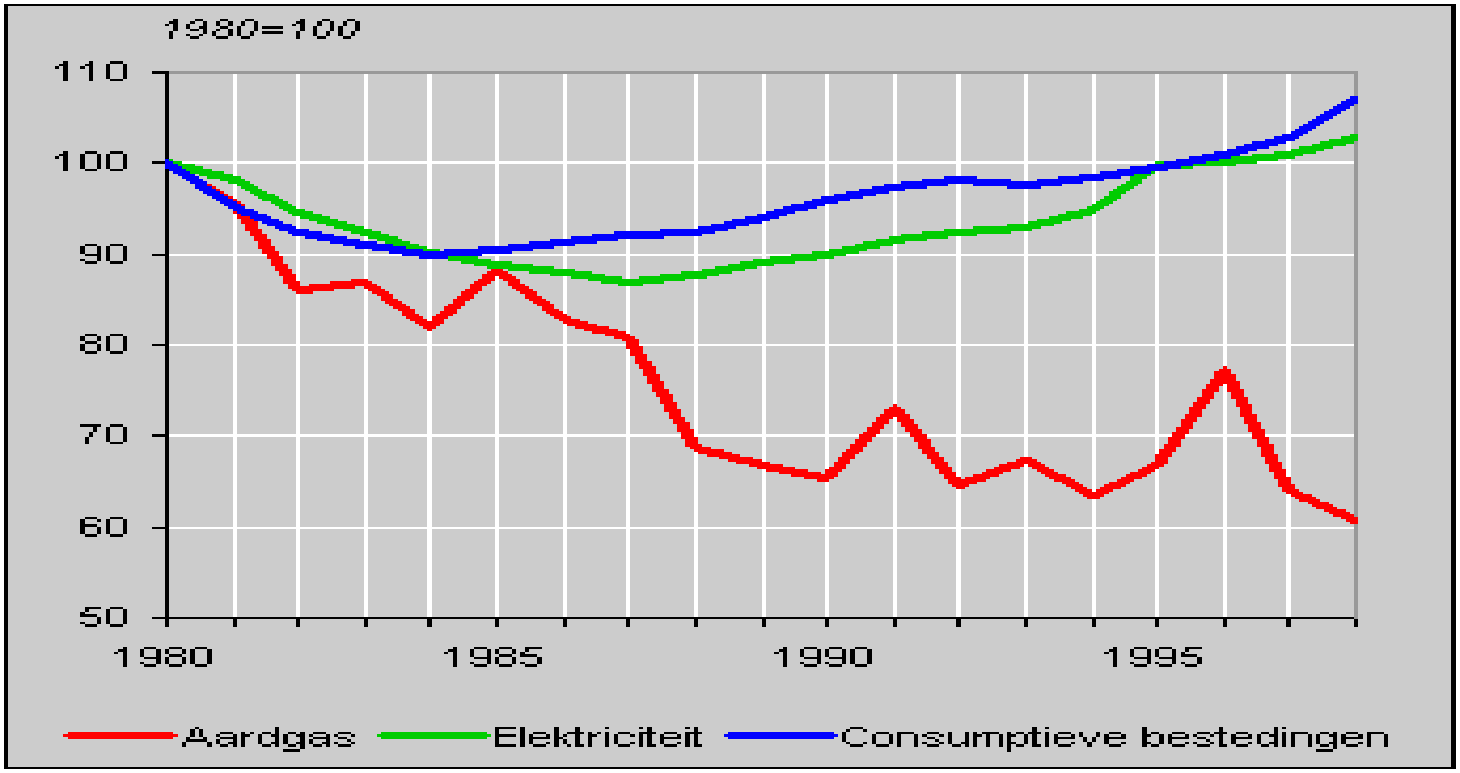
	Use per year	Energy	in MJoule	in kWh	%
gas	1500 m^3	31 MJ/ m3	46.500	12.917	80%
electricity	3300 kWh		11.880	3.300	20%
			58.380	**16.217**	100%
Benzine/petrol	1000 ltr	35 MJ/ltr	35.000	9.722	
			93.380	**25.939**	

7 million households use 420 PJ

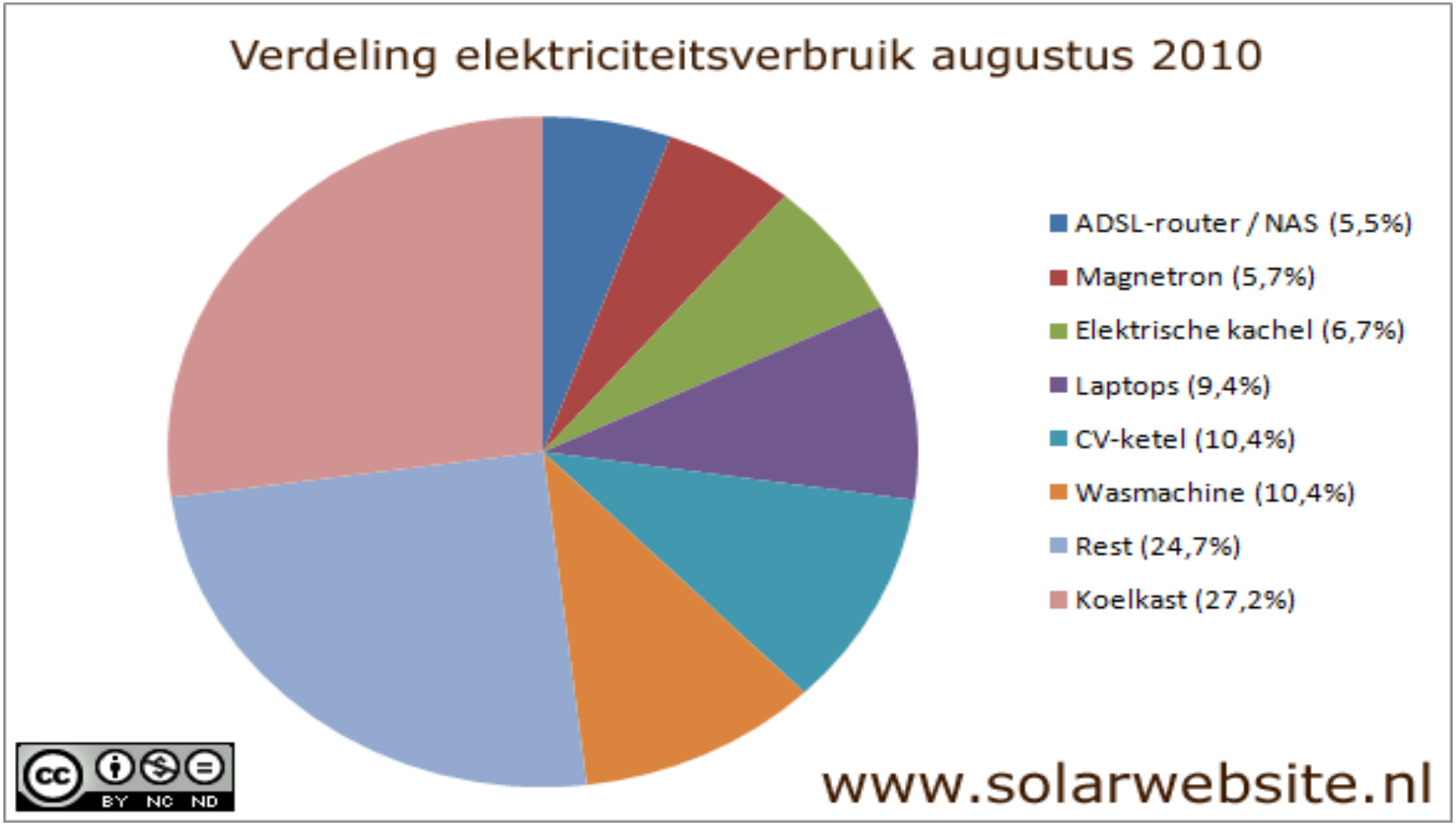
If I produce 50% of my own electricity, 1650 kWh, with how many ltr petrol does this compare?

1650/9,7 = 170 ltr

Gas consumption in households decreased, from 3300 m3 (1980) tot 1500 m3 now



Electricity in a household



Energy = power * time
kWh = Watt * hours/1000

Question:

- How much uses an electric clock of 3Watt?

Clock: (3* 24 * 365)/1000 = 26 kWh = €5,70

- A vacuum cleaner of 1500 Watt, that is in use three times a week, half hour?

Vacuum cleaner: (1500* 3*0,5 *52) /1000= 117 kWh = €25,-

- A fridge, 75 Watt, 5000 hrs per year.

Fridge: (75 *5000)/1000 = 375 kWh = €82,50

Energy use in Euro

	use	€ per unit	Energy	in MJoule	in kWh	%	In Euro
gas	1500 m^3	**0,50**	31 MJ/ m3	46.500	12.917	80%	750
electricity	3300 kWh	**0,22**		11.880	3.300	20%	726
				58.380	**16.217**	100%	
petrol	1000 ltr	**1,70**	35 MJ/ltr	35.000	**9.722**		1700
				93.380	**25.939**		

	Eurocent per MJ		**Eurocent per kWh**			**Marketprice per kWh**	
Gas	0,50/31	**1,61 cent**	0,50/8,61	**5,8 cent**		2,6 cent	½
Electricty	0,22/3,6	**6,11**		**22**		4,7 cent	1/5
Petrol	1,70/35	**4,8**	1,70/9,7	**17,5**			

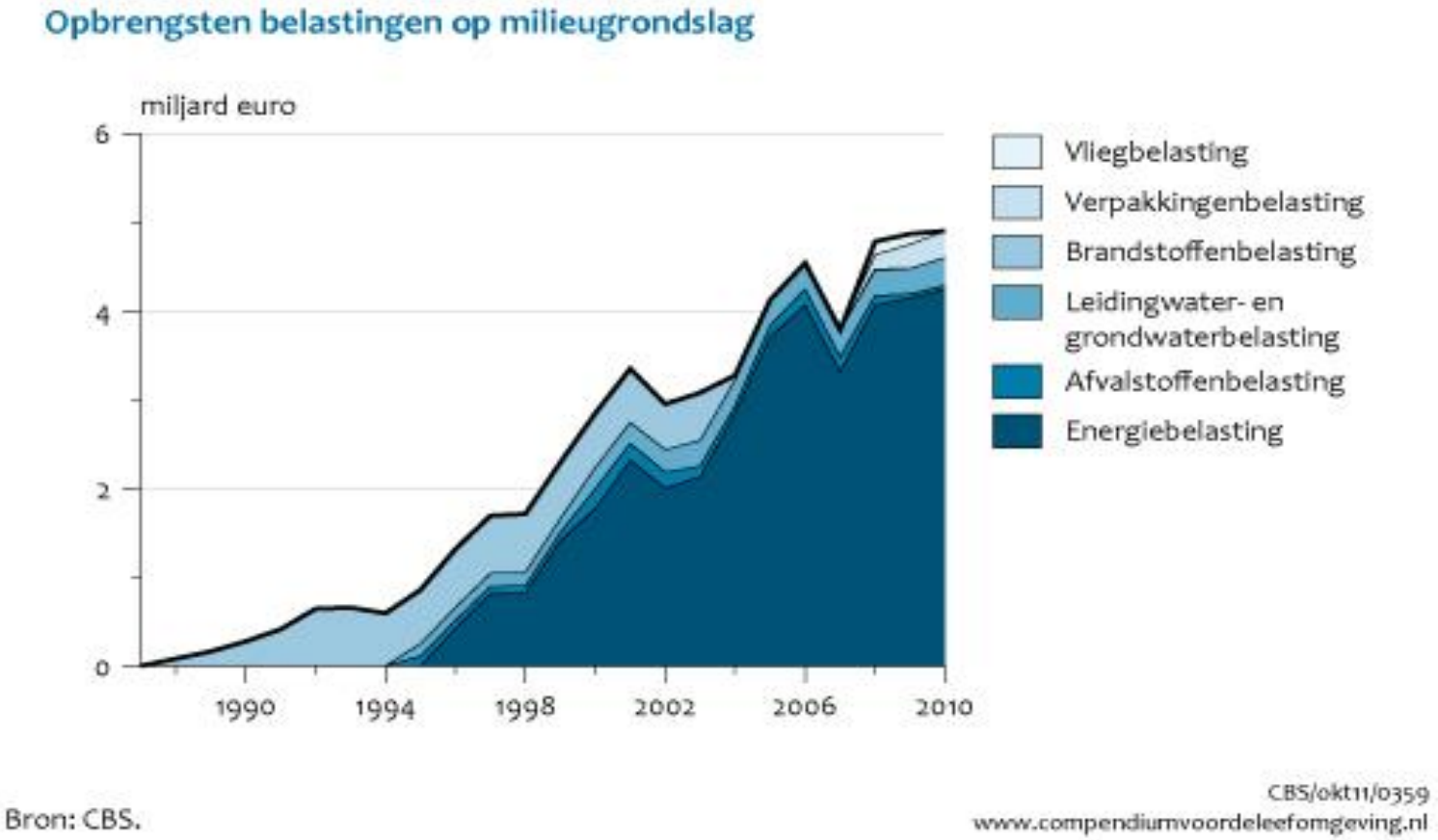
Why do we pay so much?

Energy taxes.

	2010	2011	2012	2014		2015	
Gas	**In Euro per m³**				**ODE**		**ODE**
<5000 m³	0,1629	0,1639	0,1667	0,1894	0,0046	**0,1911**	**0,0074**
5000- 170.000	0,1411	0,1419	0,1443				
170.000 - 1 miljoen	0,0391	0,0393	0,0400	0,0446	0,0017	**0,0677**	**0,0028**
1 - 10 miljoen	0,0124	0,0125	0,0127	0,0163	0,0005	**0,0247**	**0,0008**
Electricity	**In Euro per kWh**						
0 - 10.000 kWh	0,1114	0,1121	0,1140	0,1185	0,0023	**0,1196**	**0,0036**
10.000 - 50.000	0,0406	0,0408	0,0415	0,0431	0,0027	**0,0469**	**0,0046**
50.000 - 10 miljoen	0,0108	0,0109	0,0111	0,0115	0,0007	**0,0125**	**0,0012**
Meer dan 10 miljoen zakelijk	0,0005	0,0005	0,0005	0,0005	0,000034	**0,005**	**0,000055**

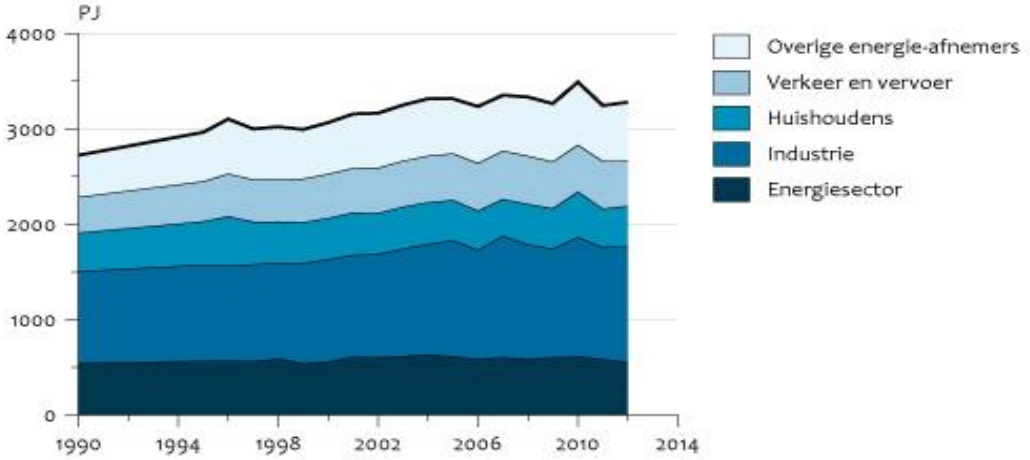
El. price: 6 cent (market) + 12 (tax) * 21% VAT = 21,8 cent
Gas: 22 cent (market) + 19 (tax) * 21% tax = 50 cent

N.B. 1. The user gets a tax rebate:
in 2013 en 2014 € 385,53, in 2015 €311,84 (ex VAT)



Energy use in Nederland
primary use: volume of fuels

• 10% coal	350 PJ	17,5 M ton
• 40% oil	1350 PJ	1 million barrels per day
• 40% gas	1350 PJ	43 G m3
• 10% others	340 PJ (nuclear + sustainable)	
Total	**ca. 3400 PJ**	



Bron: CBS.

CBS/aug13
www.clo.nl/nl005217

Primary energy use Nederland

3400 PJ

=

200 GJ per inh. (56.000 kWh)

=

500GJ per household (7 million)

138.000 kWh

	GJ	kWh	kWh Per day
Congo	11	3.055	8,4
Zambia	25	6.944	19,0
USA	327	90.832	249
UK	164	45.555	125

gross end use (or final use)

primary use without generation losses, non-energy use

not 3400 PJ but <u>2200 PJ</u>

households	425
transport	505
industry	710
0thers	560

Sustainable

Electricity	43 PJ	= 12 TWH =12.000 million kWh = 10% of 120 TWh
Heat	37 PJ	= 3% of 1265 PJ
Transport	13 PJ	= 3% of 505 PJ
Total	93 PJ	= 4,3 % of 2200 PJ (2013)

The EU RED (renewable energy directive) - 2020 % target is: 14% = 300 PJ

- Electricity = 430 PJ = 20% of 2200 PJ (77 is for households --- 7 million * 11 GJ)
- Transport = 505 PJ = 23%
- Heat = 1265 PJ = 57%

What if……
all households save 50% on their electricity use?

50% * 20% * 425 = 42,5 PJ

42,5/2200 = 1,9 %

Households	425
transport	505
industry	710
0thers	560
total	2200 PJ

What is the use of a town?
Based on end use: 2200 PJ

End use Nederland in: TWh en in PJoule		Per person : based on 17 million inhabitants	
TWh	PJ	MWh	GJ
611	2200	36	129
Noord Nederland: 1.7 miljoen inhabitants (10%)			
TWh	**PJ**		
61	220		
Province Groningen : 582.000 inh. (3,4%)			
21	75		
City Groningen, 195.000 inh. (1,14%)		(2200/17 million * 195.000) = 25 PJ	
6,7	25		
Gem. Xx 38,000 inh. (0,22%)			
1,3	4,8		

Why sustainable energy?

Four reasons come together in our time:

- **Climate, CO2 reduction etc.;**
- **Supply security;**
- **Environment;**
- **Economic oppertunities.**

Overkill of policies, high ambitions

Uncertainty and opposite views

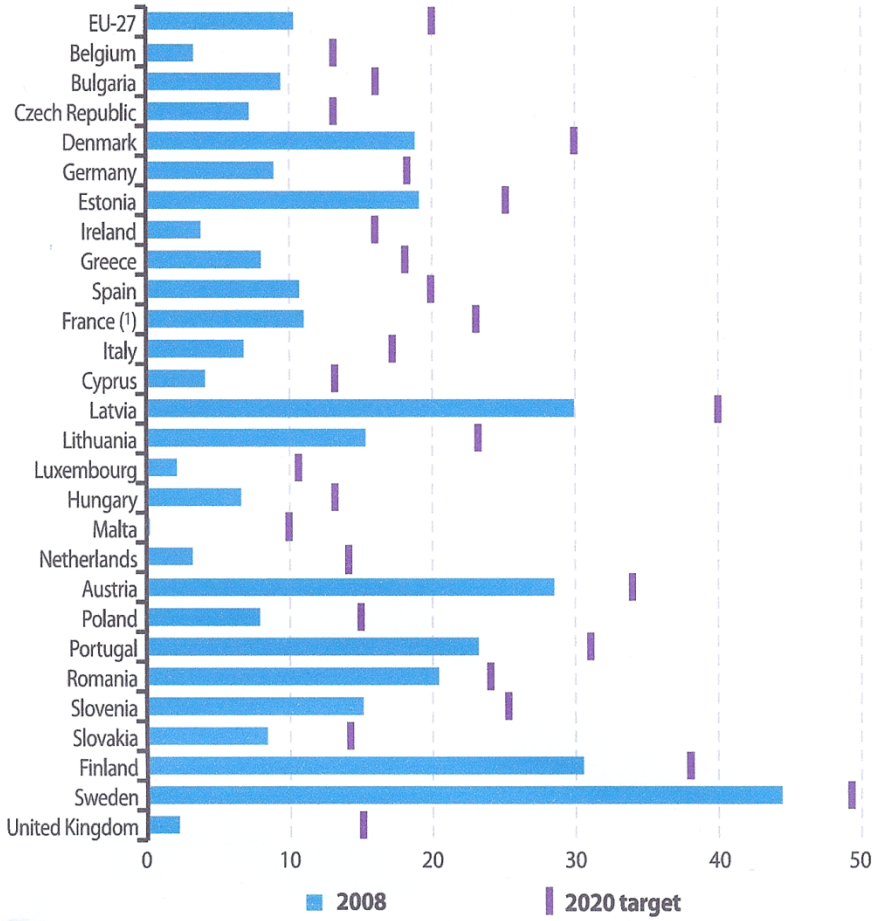
Technical divergency, old tech approach

Political, ethical, commercial forces

RED- EU goal: 20% renewable in 2020

Share per EU country

Figure 2.6.1: Share of renewable energy in gross final energy consumption and target for 2020 (%)



Bruto eindverbruik van hernieuwbare energie

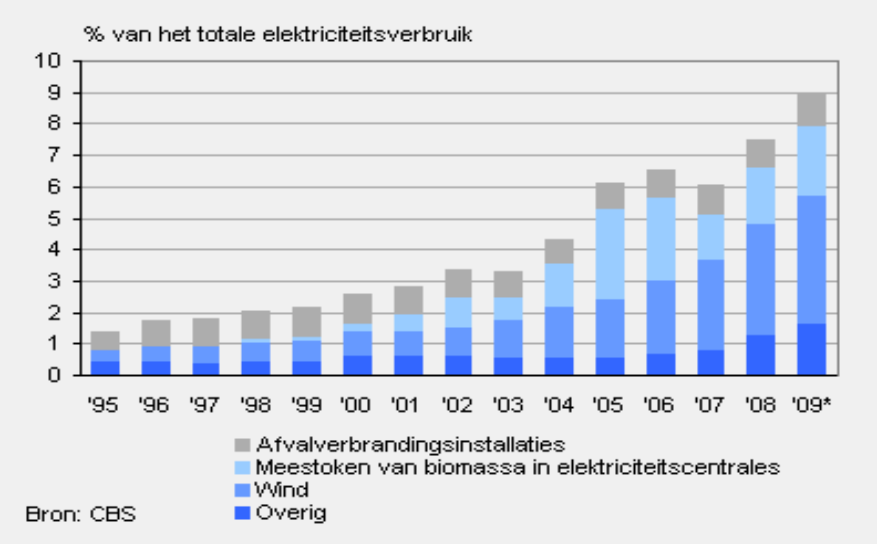
Bron: Hernieuwbare energie in Nederland 2013 (CBS)

Bruto eindverbruik van hernieuwbare energie	1990 (PJ)	**2013** (PJ)	2013 % van totaal hernieuwbaar
Bron-techniekcombinatie			
Waterkracht[1)]	0,3	**0,4**	0,4%
Windenergie[1)]	0,2	**19,3**	19,5%
op land	0,2	**16,6**	16,8%
op zee	-	**2,7**	2,7%
Zonne-energie	0,1	**2,9**	2,9%
zonnestroom	0,0	**1,8**	1,8%
zonnewarmte	0,1	**1,1**	1,1%
Bodemenergie	-	**4,1**	4,2%
Buitenluchtenergie	-	**3,0**	3,0%
Biomassa	20,3	**69,3**	70,0%
afvalverbrandingsinstallaties	3,7	**16,7**	16,9%
bij- en meestoken biomassa in centrales	-	**6,9**	7,0%
houtketels voor warmte bij bedrijven	1,7	**3,0**	3,1%
houtkachels bij huishoudens	12,2	**12,8**	13,0%
houtskool	0,3	**0,3**	0,3%
overige biomassaverbranding	0,4	**6,8**	6,9%
stortgas	0,2	**o,4**	0,4%
biogas uit rioolwaterzuiveringsinstallaties	1,4	**2,0**	2,1%
biogas, covergising van mest[2)]		**4,3**	4,3%
overig biogas	0,5	**3,0**	3,1%
biobrandstoffen voor het wegverkeer	-	**12,9**	13,1%
Energievorm			
Elektriciteit	2,9	**43,2**	43,6%
Warmte	18,0	**42,9**	43,3%
Vervoer	-	**12,9**	13,1%
Totaal eindverbruik hernieuwbare energie	20,9	**99**	100%
Berekening aandeel hernieuwbare energie			
Totaal bruto energetisch eindverbruik[3)] (PJ)	1.819	**2.200**	
Aandeel hernieuwbare energie in bruto energetisch eindverbruik	1,15%	**4,50%**	

[1)] Inclusief normalisatieprocedure uit de EU-Richtlijn hernieuwbare energie.

[2)] Tot en met 2004 onderdeel van overig biogas.

Wind energy, bio energy, solar energie


% van het totale elektriciteitsverbruik
10
9
8
7
6
5
4
3
2
1
0
'95 '96 '97 '98 '99 '00 '01 '02 '03 '04 '05 '06 '07 '08 '09*
Afvalverbrandingsinstallaties
Meestoken van biomassa in elektriciteitscentrales
Wind
Overig
Bron: CBS


Windvermogen, 2011
Groningen
Friesland
Flevoland
Noord-Holland
Zuid-Holland
Zeeland
Noord-Brabant
Overige provincies
Op land
Op zee
Nederland
0
400
800
1200
1600
2000
2400
Gerealiseerd vermogen (megawatt)
Bron: CBS.
CBS/juli12/0386
www.compendiumvoordeleefomgeving.nl

Energy production of wind at sea….

Sea Park Princes Amalia has 60 Vestas of 2 MW = 120 MW

Jaar	Productie	
2009	420 GWh	
2010	363 GWh	= 1 PJ
2011	419 GWh	
2012	422 GWh	
2013	433 GWh	
2014	418 GWh	= 1,5 PJ

How many hours (full load) do the mills produce?

Hours = Energy/Power = Wh/W

433.000/120 = 3600 hrs

363.000/120 = 3025 hrs

Wind on land….

Production of all mills on land 2010- 2014

Jaar	Productie	MW	aantal molens	
2010	3315 GWh	2009	1877	1
2011	4298 GWh	2205	1822	
2012	4193 GWh	2205	1882	
2013	4856 GWh	2485	1977	
2014	5097 GWh (18 PJ)	2645	1989	1,3

18 PJ = 0,8% of 2100 PJ

How many hours do the mills produce?

Hours = Energy/Power = Wh/W 5097.000/2645 = 1927 hours

Groningen on land 2014: 860.000/379 = 2269 hrs

…4000 MW wind on land, will that be enough to reach our go

parken

staan

ote par-
ag zicht-
abel' zijn.
r en toerist.
al een onder-
e zogenoemde
olens. De ministe-
sche zaken en infra-
milieu bekijken de
nden de haalbaarheid
s binnen die 12-
steun van de provin-

cies is daarbij essentieel.

Het is de vraag of met deze nieuwe parken die 16 procent duurzame energie in 2020 wordt gehaald. Het ligt voor de hand dat Kamp zich ook zal inzetten voor meer turbines op land. Het grote voordeel: de relatief lage kosten. Windmolens op zee zijn aanzienlijk duurder. De minister zal dan wel de strijd moeten aangaan met het massale protest vanuit de samenleving.

4000 MW * 2500 uur= 10.000.000 MWh

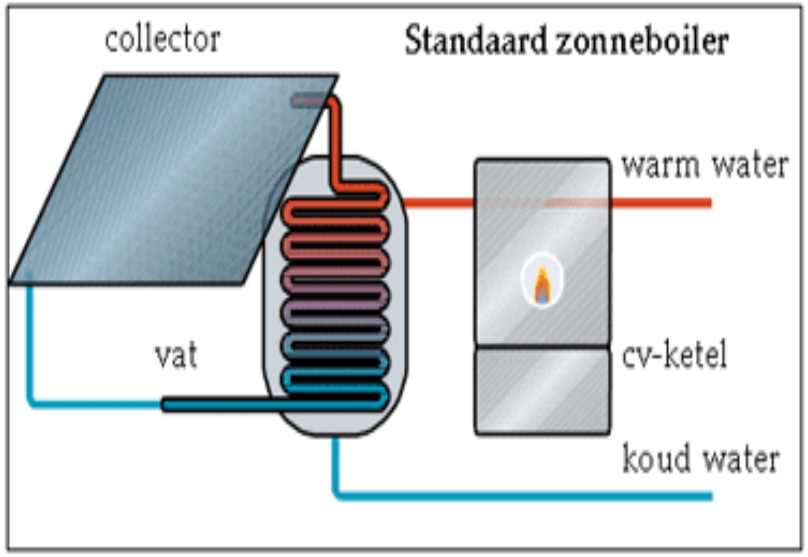
10 TWh =36.000 TJ = 36 PJ

36/2100 = 1,7% of 2100 PJ

No, it is not enough….

Energy from the sun

Photovoltaic (PV) cells and thermal systems

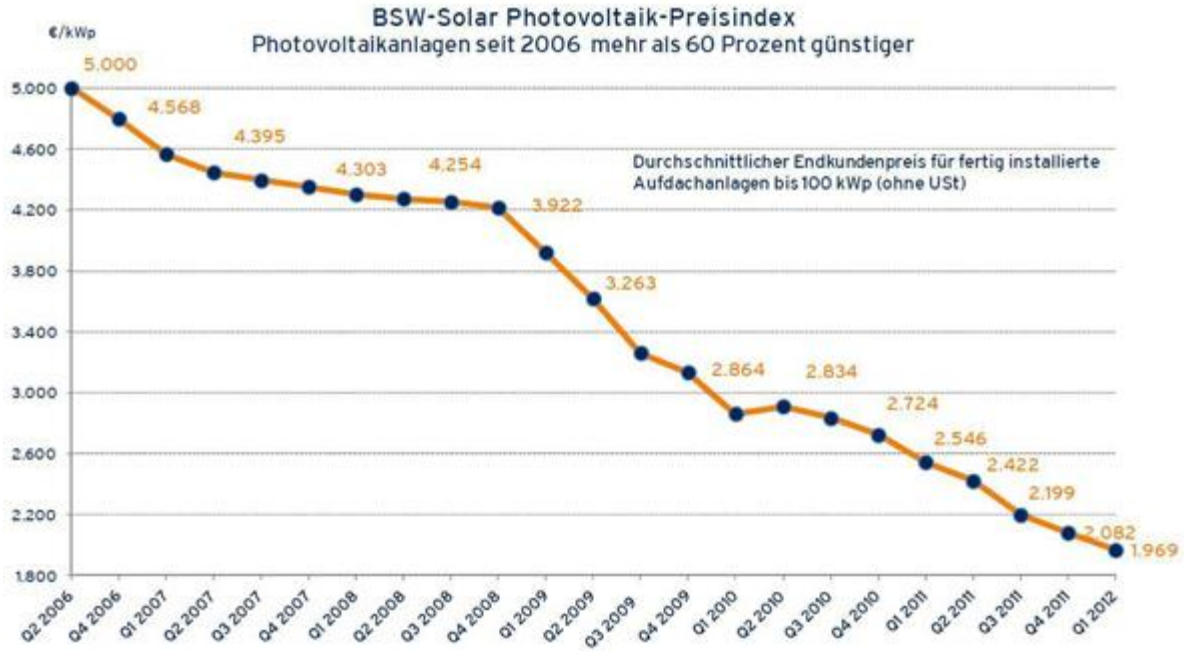


PV

The price can be expressed in Euro per Watt (Watt peak)

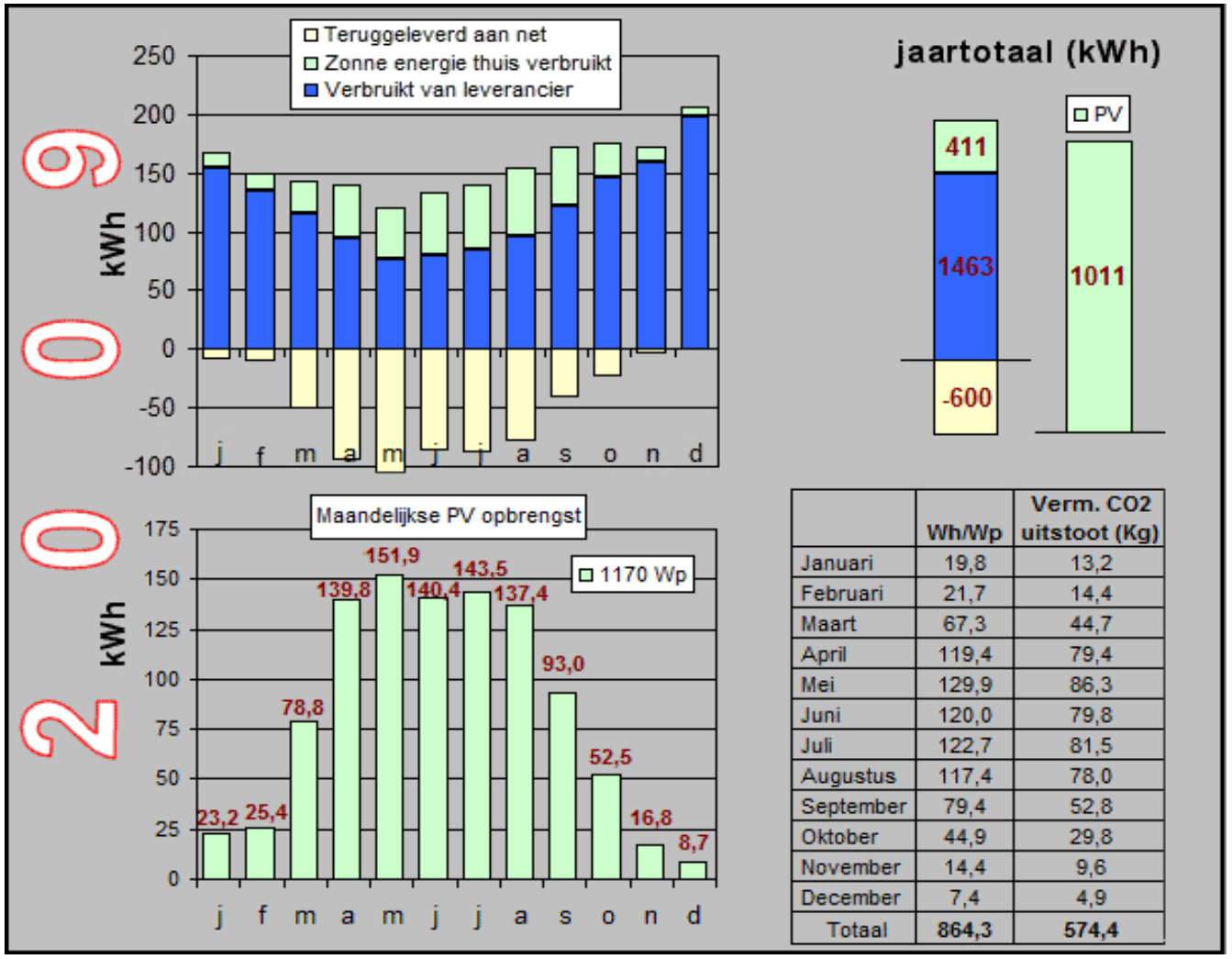
Wp price dropped rapidly

A panel is ca. 1,6 m^2, with €1,50 per Wp, a 250 Watt panel costs €375,-



Quelle: BSW-Solar 2/2012, PV-Preisindex

Production of a 1170 Wp system



	Wh/Wp	Verm. CO2 uitstoot (Kg)
Januari	19,8	13,2
Februari	21,7	14,4
Maart	67,3	44,7
April	119,4	79,4
Mei	129,9	86,3
Juni	120,0	79,8
Juli	122,7	81,5
Augustus	117,4	78,0
September	79,4	52,8
Oktober	44,9	29,8
November	14,4	9,6
December	7,4	4,9
Totaal	**864,3**	**574,4**

http://www.sma.de/unternehmen/pv-leistung-in-deutschland.html

PV

PV systems convert 12%-16% of the solar radiation into electricity

Radiation in NL: 1000W per m2 (Nederland) = 120 W – 160 W per m2

Production: ca. 850 hrs (vollast full load) per year.

850* 160 = 136.000 Wh = 136 kWh per m2.
(489 MJ of 0,49 GJ)

One kWh costs 21 cent, income is: 21 * 136 = €28,-

At €1,50 per Wp the investment is: €1,50 * 160 = €240.
R.O.I. is: 28/240 = 11,6% (9 years).

PV in field units:

per ha. panels (= 2 ha field):

10.000 * 160 * 850 = 1.360.000 kWh (400 hh) = 4.9 TJ

204 ha. per PJ

Solar heat

A solar **collector** “harvests” 30-40%, 335 kWh per m2 per jaar or 1,20 GJ per m2.
(vs 0,49 GJ bij PV)

- A system of 2,5 m^2 (= 3 GJ) + 100 liter storage vessel costs (incl. installation and VAT) € 2.500 – € 3.000.

- Approx. € 950 per GJ. Vacuümtubes are more expensive (+€200).

3 GJ= 100 m3 gas = €50,- (<2% €rendement).

R.O.I.: 50/2700 = 1,8%

Sun island Almere:
7000 m2 collectors
9750 GJ p.a.
1.4 GJ per m2

Burning biomass

Fuel	kJ	kWh
Potatoes	3.140 kJ per kg	0,872 per kg
Gas	31.000 kJ per m^3	8,61 per m^3
Petrol/ Benzine	35.000 kJ per ltr	9,7 per ltr
Petrol/ Benzine	47.000 kJ per kg	13,05 per kg
Coal	20.000 kJ per kg	5,55 per kg
Peat	16.000 kJ per kg	4,44 per kg
Dry Wood (25% moist)	**14.000 kJ per kg**	**3,88 per kg**
Pellets	**17.000 kJ per kg**	**4,72 per kg**
http://www.avih.nl/biomassakaart/		http://www.youtube.com/watch?v=3-8qWheKIIg

1 : 2,2

1 m^3 gas = 2-3 kg wood

- 3400 m3 gas = 10.000 kg wood.

- What can be the price of wood if gas costs 50 cent per m3?

1 m3 gas = 2,5 kilo wood

Price can be: 50/2,5 = 20 cent per kg = €200,- per ton.

Scenario for a 200.000 inh. town

Use: 2200/17.000.000 * 200.000 = 25,88 PJ

Target: 14% sustainable.

Overall reduction: 10%

20.000 houses a 30 m2 PV + 5 m2 solar heat

50 mills of 4 MW

20 big woodburners of replacing 30.000 m3 gas each

Scenario for a 200.000 inh. town

Target: 25,88 PJ – 10% = 23,29 PJ * 14% = **3,26 PJ**

20.000 houses a 30 m2 PV + 5 m2 solar heat

20.000 * 30 m2 * 160 Watt * 850 hrs = 81,6 GWh *3600 = 0,3 PJ

20.000 * 5 m2 * 1,2 GJ/m2 = 120.000 GJ = 0,12 PJ

50 mills 4 MW

50 * 4 MW * 2500 hrs = 500.000 MWh = 1,8 PJ

20 big woodburners of replacing 30.000 m3 gas each

20 * 30.000 * 31 MJ = 0,0186 PJ **(20*90 ton wood)**

Total: 0,3 + 0,12 + 1,8 + 0,0186 = **2,23 PJ**

1 PJ short,
what options?

2 ha PV?

20.000 m2 * 160 W* 850 hrs= 2.720.000.000 Wh = 2.7 GWh

2.7 GWh * 3600 = 9.720 GJ = 9,7 TJ = 0,0097 PJ.

We need 200 ha.

2.000.000 * 160 W *850 hrs = 1 PJ

Thank you!!

WORKSHOP

Sommen en Cijfers

Incl. boek + rekenmodel

Vrijdag – 4 november

Groningen

Frans Debets

Check the website

www.debetsbv.nl