Electricity from Wind and Storage

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Why Electricity ?

This sector is the most carbon-intensive, due to high-carbon fuels and low conversion efficiencies

It is urgent, due to phase-out of old nuclear and coal plants and – unlike fuels – imports are limited

Nuclear, coal and fossil gas fuels are depletable, so their carbon intensities and costs increase over time

Why Wind ?

Of renewable energy sources, wind is second only to solar in scale and is available worldwide

Unlike solar, wind is available day and night, summer and winter, onshore and offshore

Wind energy converters – wind turbines – are available from several world-class suppliers

Wind power is lowest cost zero-carbon electricity

UK Offshore Evaluation

Total practical resource for offshore renewables

Technology	Currently allocated capacity (GW)	Currently allocated capacity (TWh)	Additional practical resource (TWh)	Total practical resource (TWh)
Fixed wind	47	165	241	406
Floating wind	-	-	1,533	1,533
Tidal stream	0.6	2	114	116
Tidal range	-	-	36	36
Wave	0.6	1	39	40
Total	48.2	168	1,963	2,131

	Installed capacity	Resource utilisation	Capital expenditure	Annual Revenue in 2050	
Scenario 1	78 GW	13%	£170B	£28B	50% UK demand
Scenario 2	169 GW	29%	£443B	£62B	Net *electricity* exporter
Scenario 3	406 GW	76%	£993B	£164B	Net *energy* producer

German Studies

They use not nuclear or fossil fuels with CCS but renewables and storage

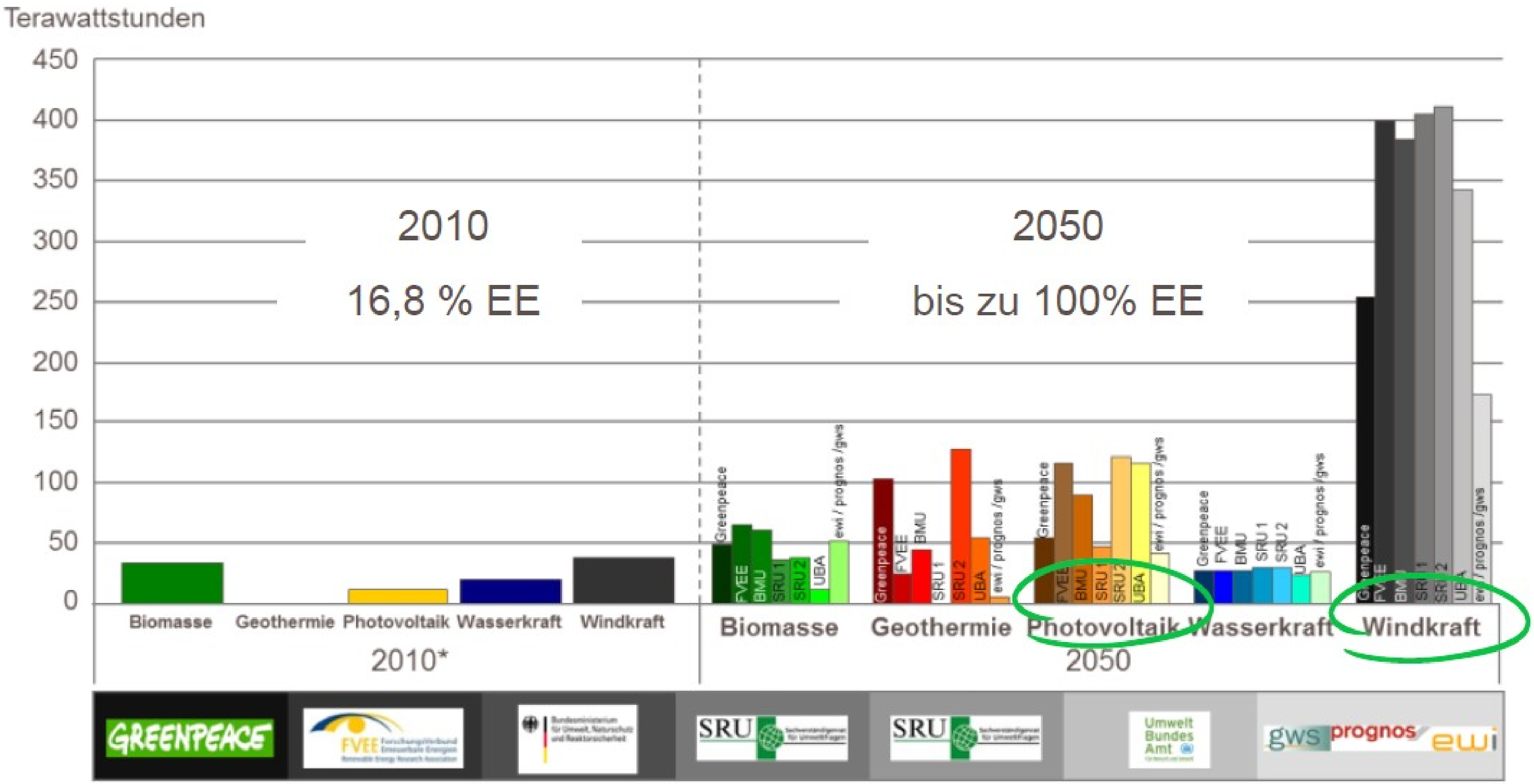
Biomass, geothermal and hydro can be on-demand, but have only minor potentials

Wind and solar PV have the largest potentials, but are variable

Hence the need for long-term storage

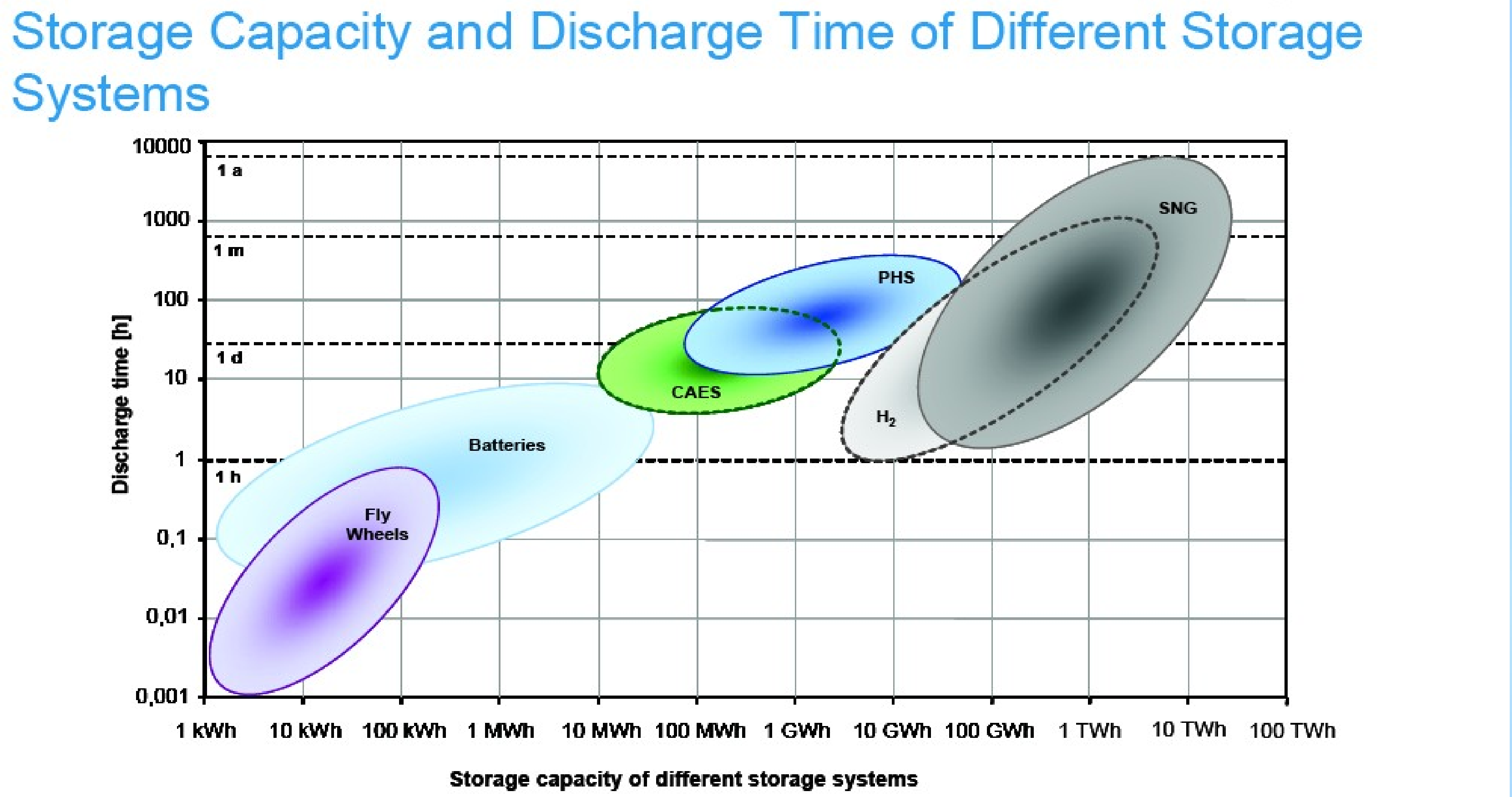
100% EE: Wind und PV werden die tragenden Säulen der Energieversorgung

juwi



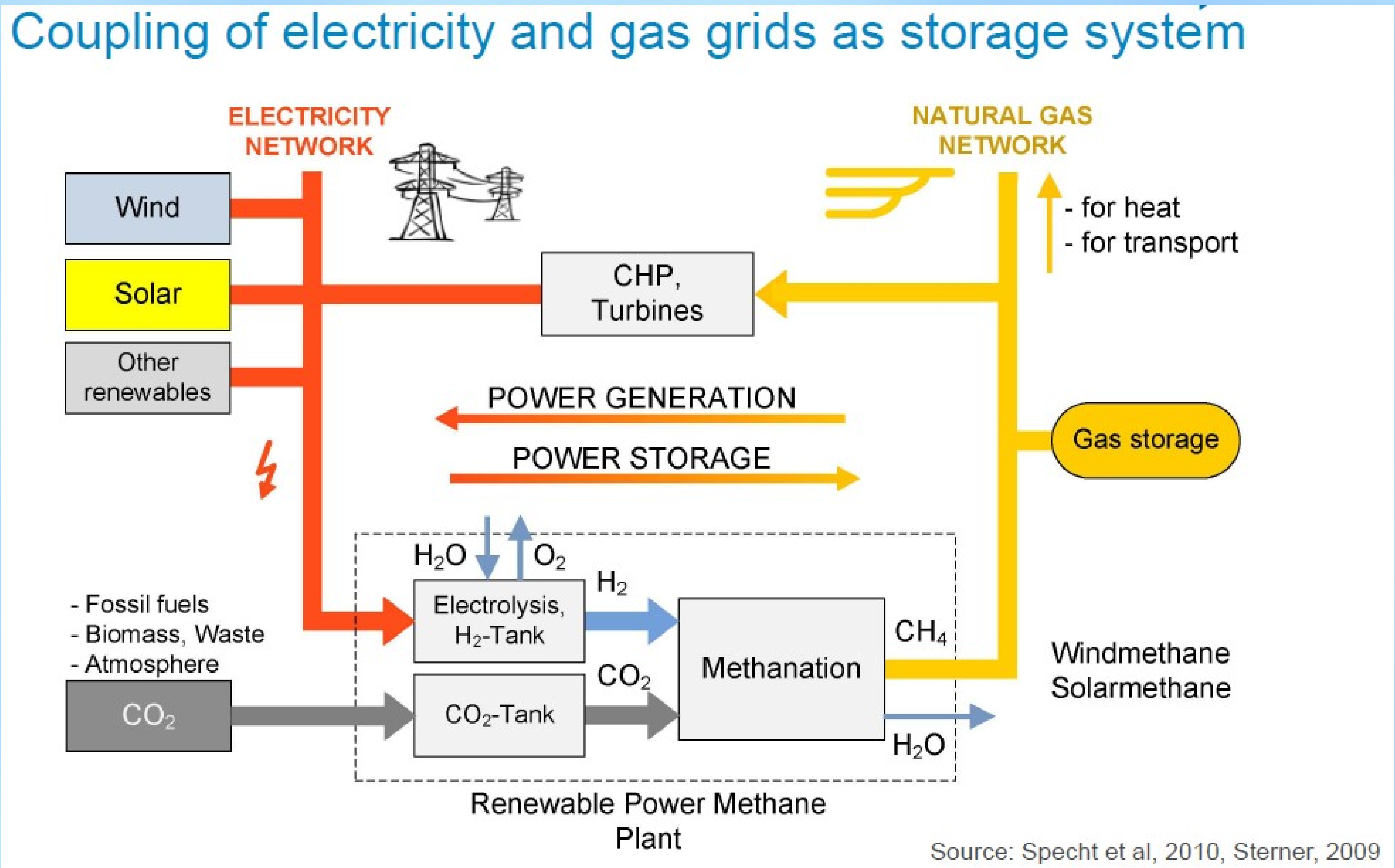
Quelle: Eigene Darstellung juwi Corporate Development und *BMU – Erneuerbare Energien 2010 (Musiol 2011, S.7)

Electricity Storage



Source: (Specht, M.; Baumgart, F.; Feigl, B.; Frick, V.; Stürmer, B.; Zuberbühler, U.; Sterner, M.; Waldstein, G. (2010): Speicherung von Bioenergie und erneuerbarem Strom im Erdgasnetz. FVEE Jahrestagung 2009. Forschen für globale Märkte erneuerbarer Energien. FVEE, Berlin.)

Electricity and Gas Storage



Electricity and Gas Storage

In Werlte (Niedersachsen) entsteht für AUDI die weltgrößte PtG-Anlage (6,3 MW_{el}) zur Einspeisung ins Erdgasnetz

Aktueller Stand auf der Baustelle in Werlte (E04/2013)

Abb.1: Elektrolyse-Halle

Abb. 2: Einer der drei 2 MW-Elektrolyseure

Abb. 3: Methanisierungsreaktor

Die PtG-Anlage in Werlte wird im 3. Quartal 2013 in Betrieb gehen und synthetisches Methan ins Erdgas-Transportnetz einspeisen.

Laufende Forschungsprojekte

- mit Fraunhofer IWES und ZSW: 250kW Methanisierungsreaktor
- mit ZSW: 250 kW Elektrolyseur-Entwicklung

Quelle: SolarFuel

SOLARFUEL

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My Study for the UK

The aim is electricity with 100% carbon reduction

The scenarios use wind turbines and gas storage

The gas stores are charged via Power-to-Gas plants, and discharged via Gas-to-Power plants

They use the existing gas grid, stores (gas fields and caverns) and Gas-to-Power plants for balancing

My System Model

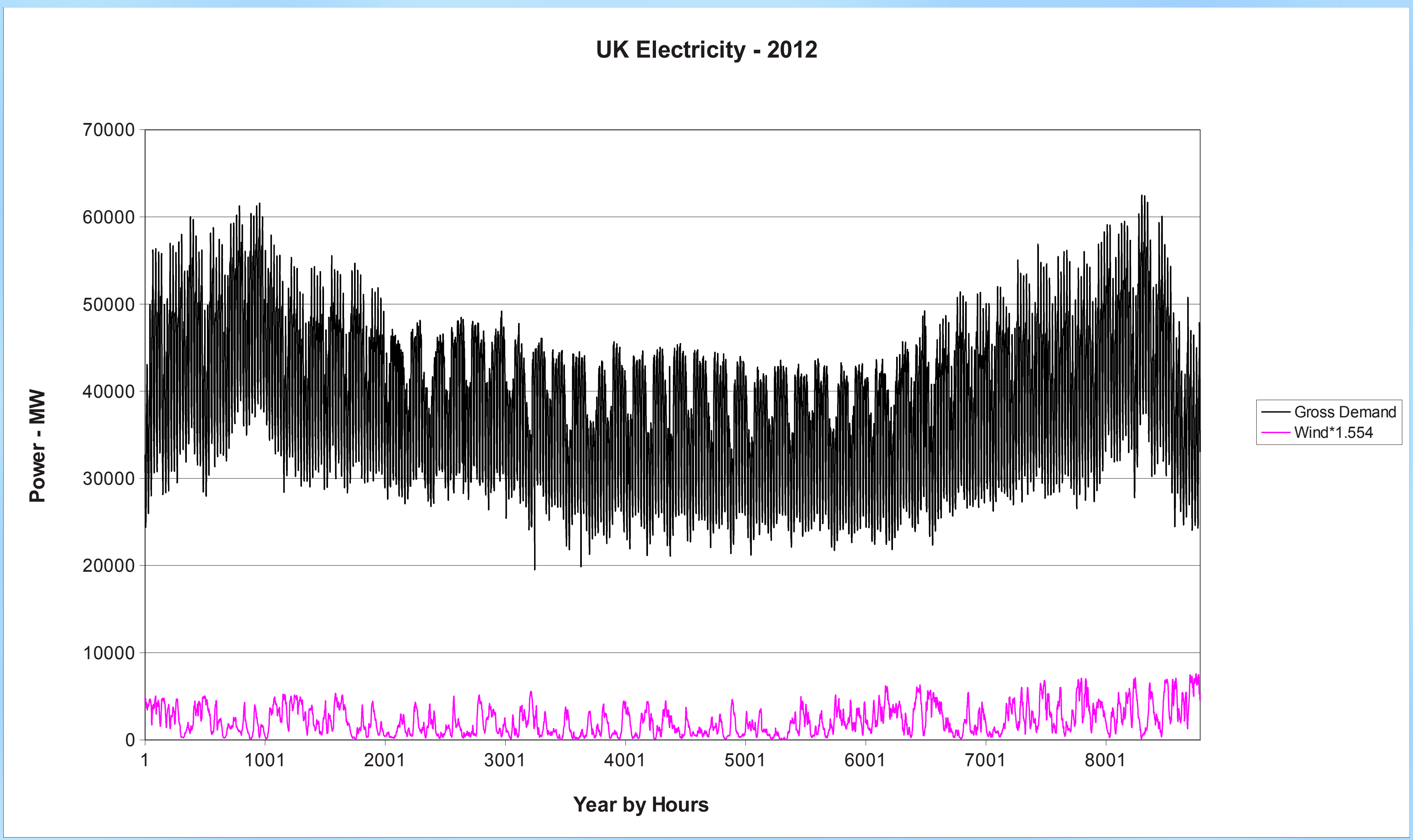
Hourly data for Electricity Demand and Wind Output

Wind power, PtG power and GtP power plants

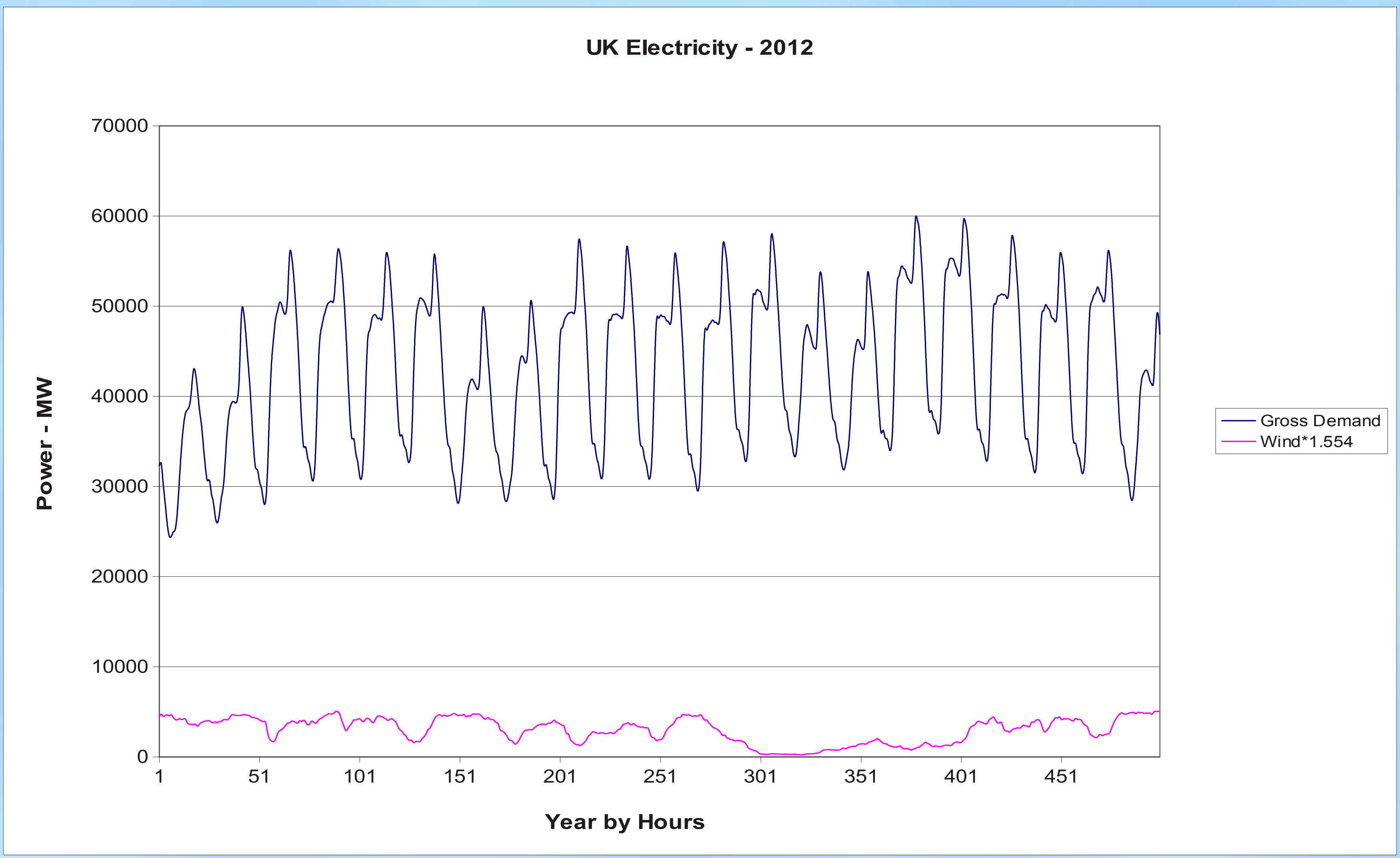
Combinations of Wind Power and PtG Power found for 100%, 75%, 50% and 0% carbon reductions

0% assumed to use only fossil Gas-to-Power

Electricity Demand and Wind Output - 2012



Electricity Demand and Wind Output - 2012



Electricity Demand and Wind Output - 2012

With wind power of 7.5 GW, output is already significant

At this level of wind power, electricity demand varies far more

The UK has huge wind resources – onshore, offshore, fixed and floating

Electricity with 100% C Reduction

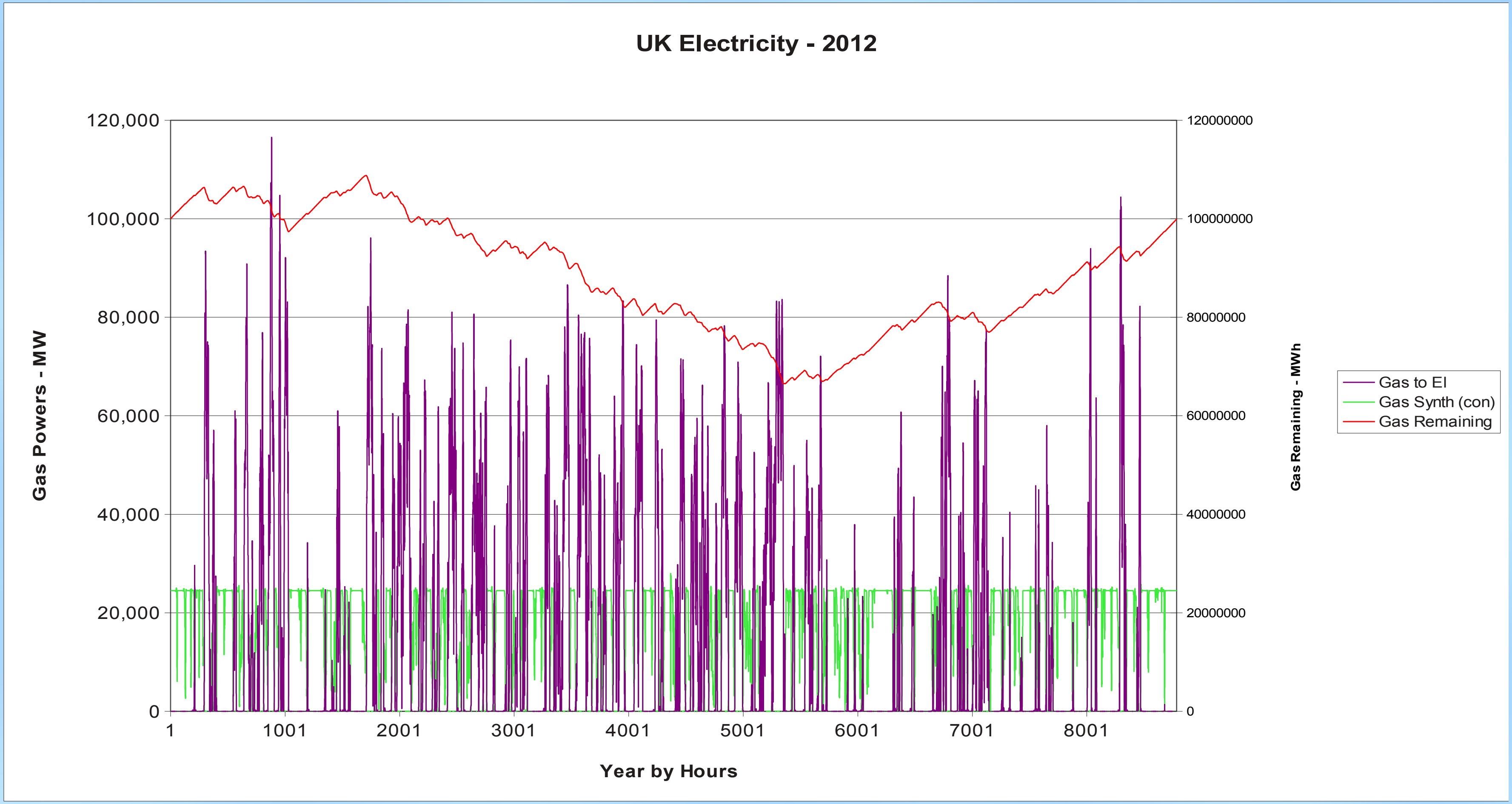
Wind power is chosen to meet most of the Demand

PtG power for Gas Synthesis is chosen to recharge the store by 100% over the year

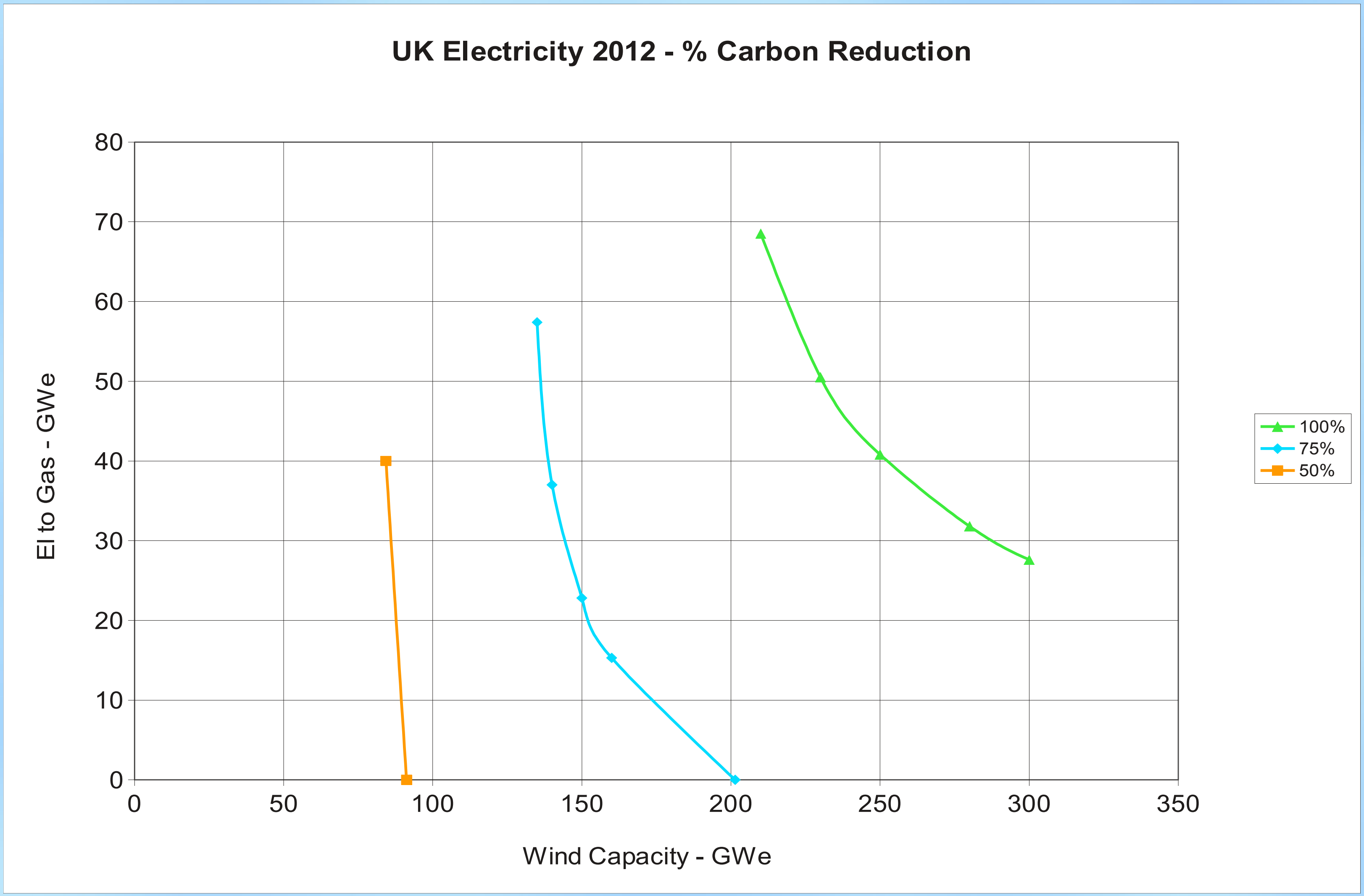
GtP power is required for balance of Demand

Gas Remaining in stores varies over the year and returns to the initial level

Electricity with 100% C Reduction, Wind Power 250 GW, PtG Power 41 GWe



Solutions for UK Electricity



Electricity with C-Reductions

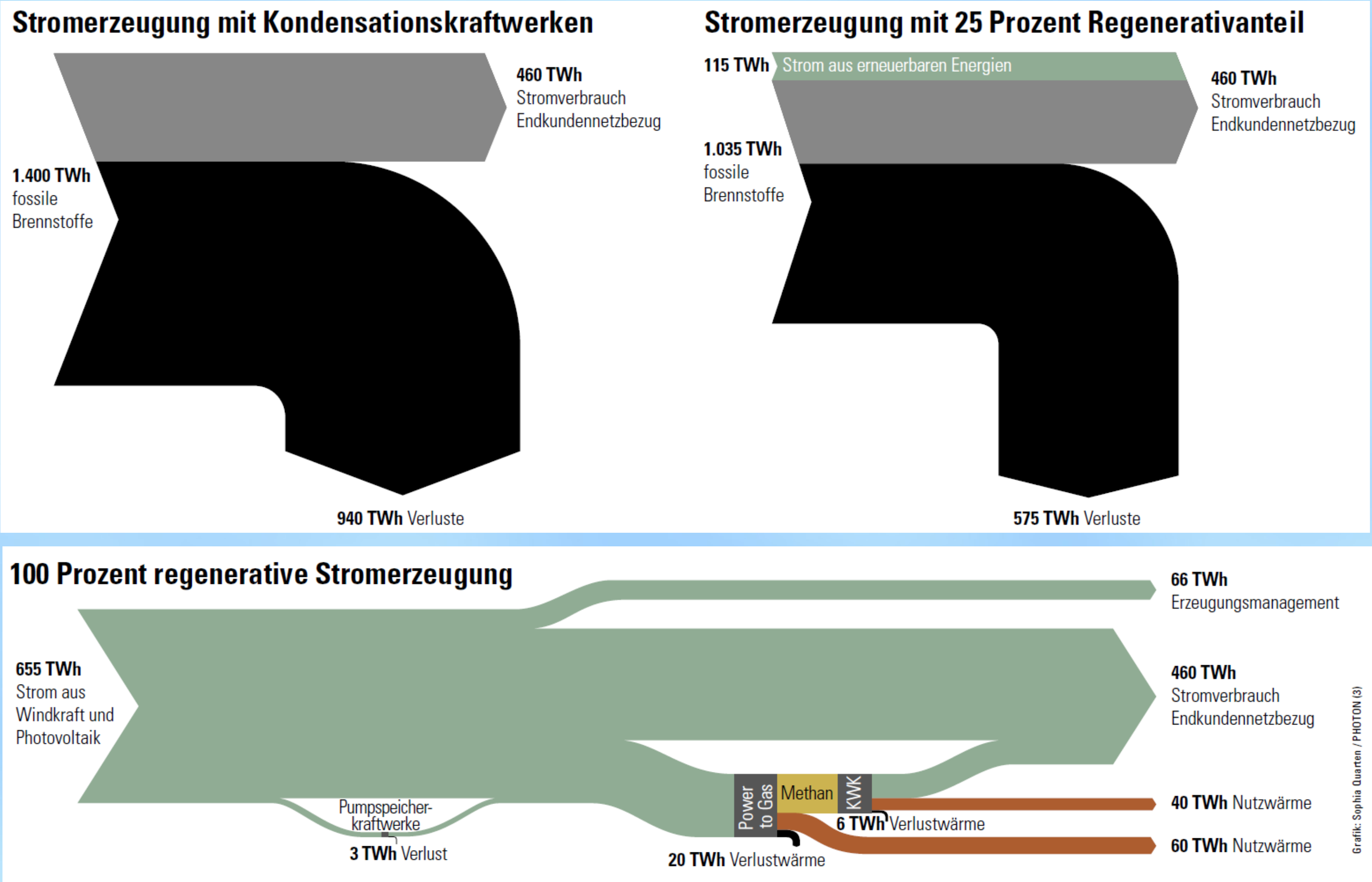
100% is possible, which is truly sustainable and wholly indigenous, giving real energy security

It also gives 100% savings of imported fuel and sustains many operation and maintenance jobs

Long-term storage is not essential until 75%, but if deployed, could reduce the required wind power

So Wind power and PtG power can be deployed flexibly as the technologies evolve

Energy Flows for Electricity



Electricity with C-Reductions

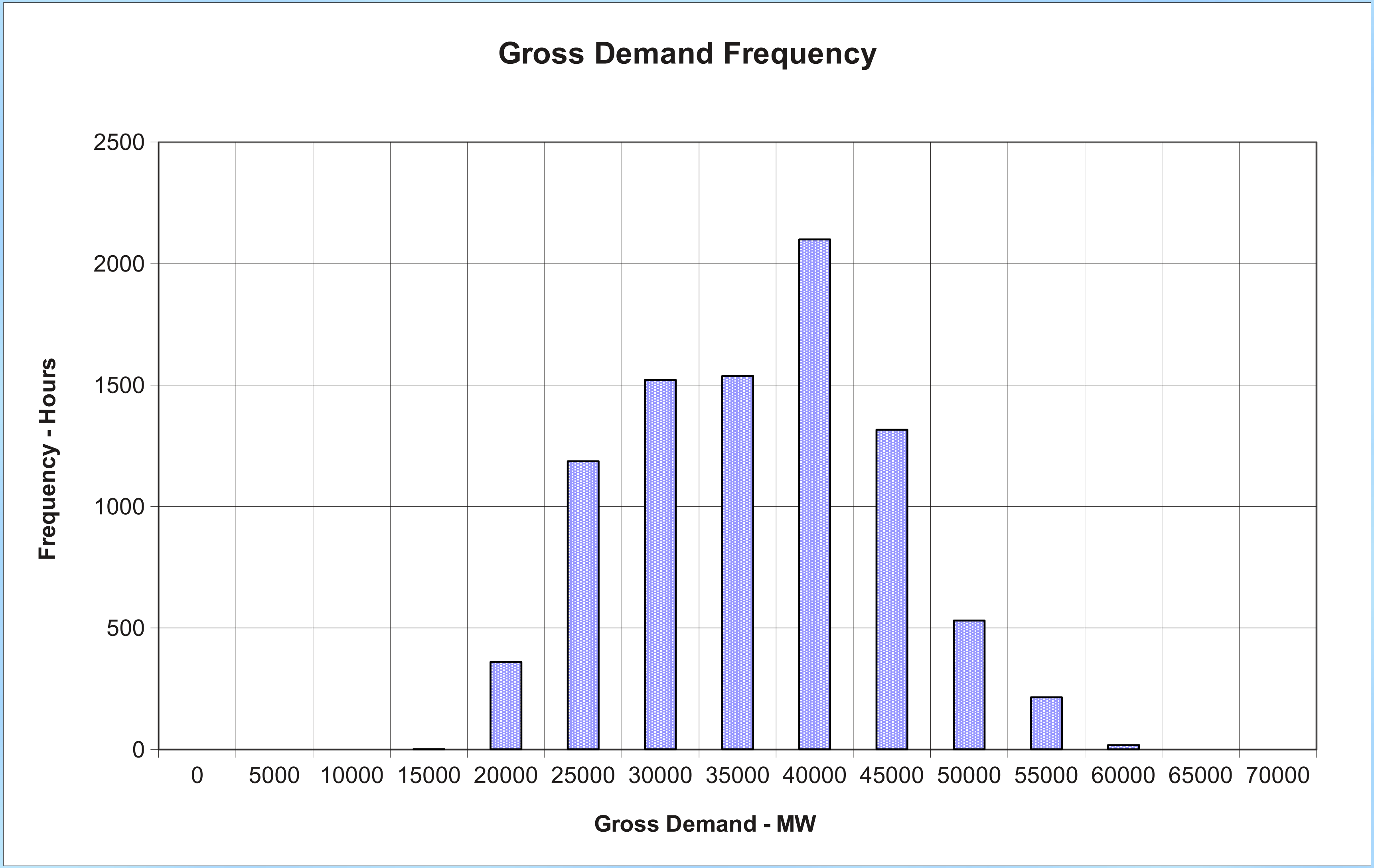
All the Wind Power and PtG power values are high, because electricity savings, solar PV, biomass, hydro, import/export and pumped storage are omitted from the model

For 100%, the gas storage energies go from 54 to 33 TWh. That existing is 49, and that proposed for 2020/21 is about 281 TWh

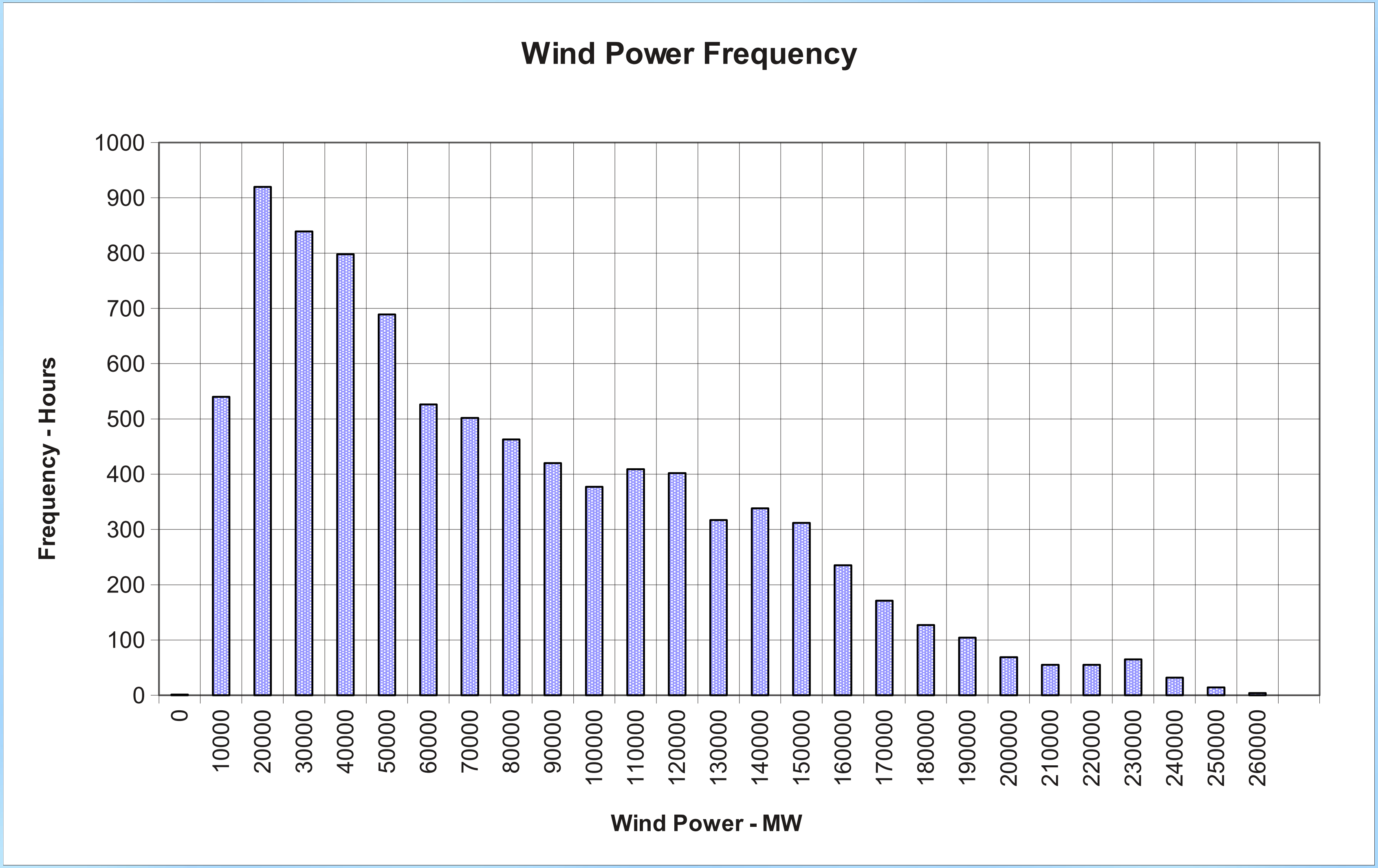
For 100%, the maximum GtP is about 59 GWe – i.e. 118 GWg. The existing gas 'deliverability' is 53 GWg, and that proposed is 271 GWg

Existing fossil power plants use about 44% of the fresh water abstraction for cooling. Renewable plants and those harnessing Reject Heats require no such fresh water

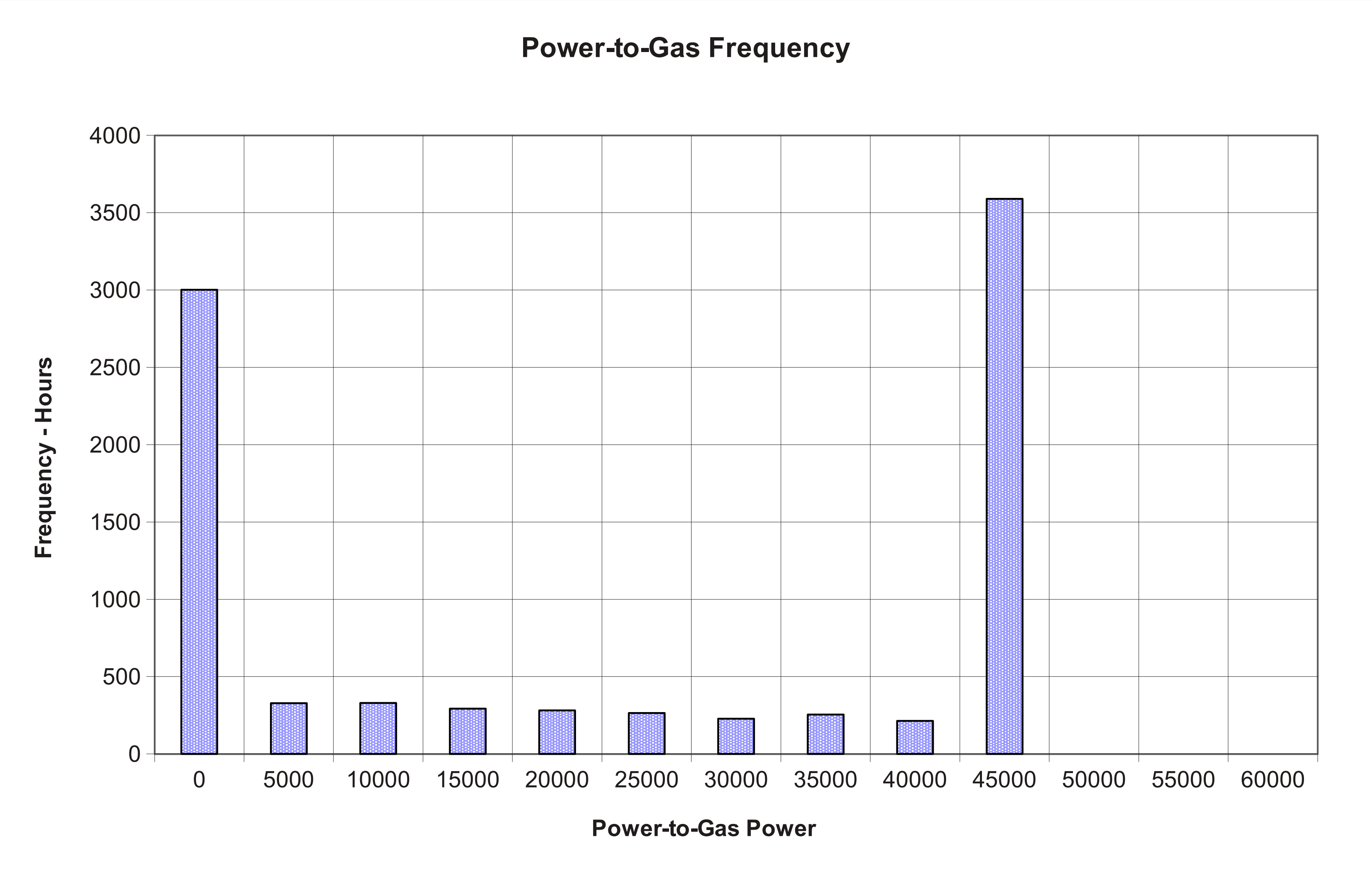
Electricity Demand



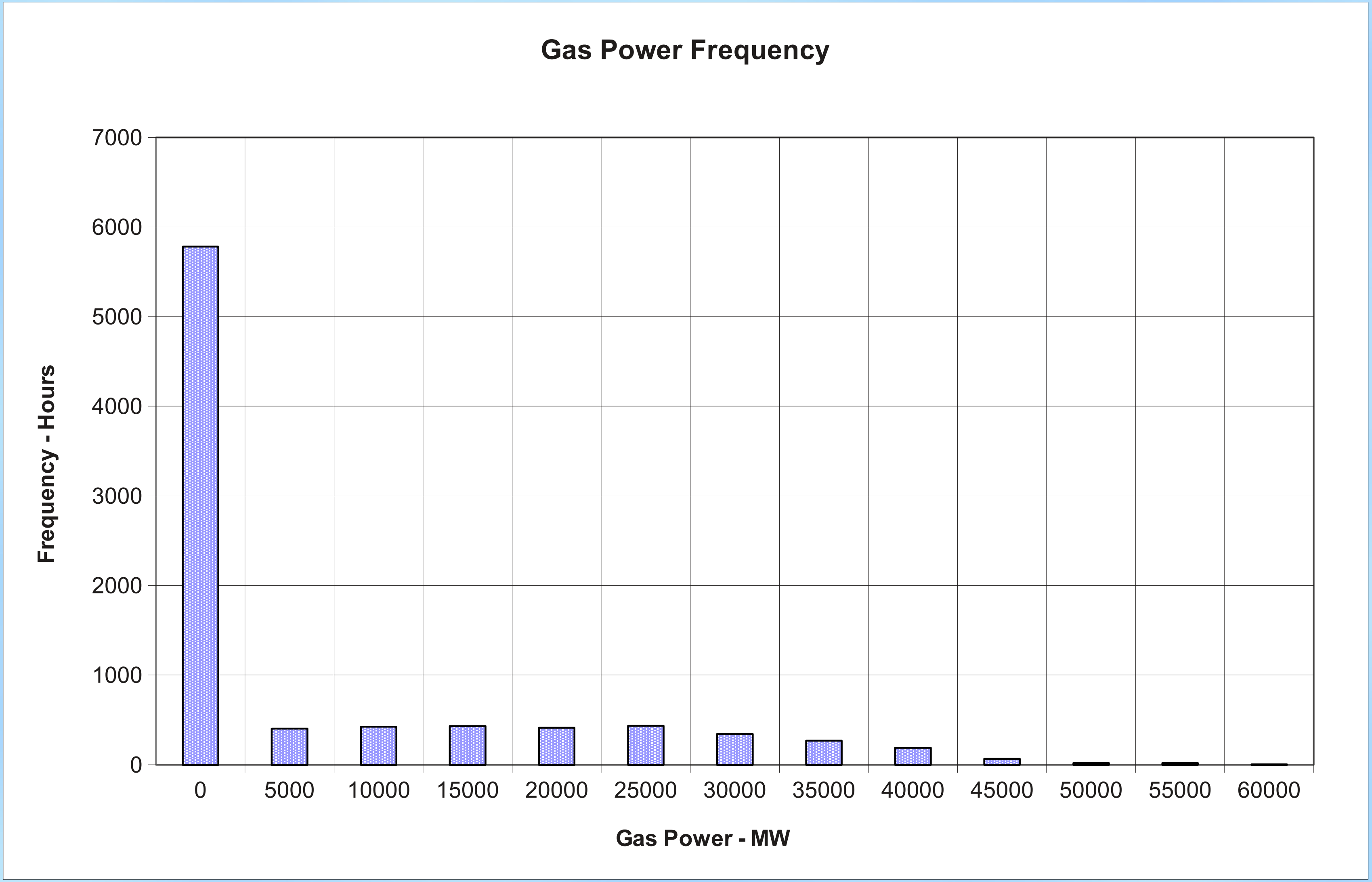
Wind Power Supply



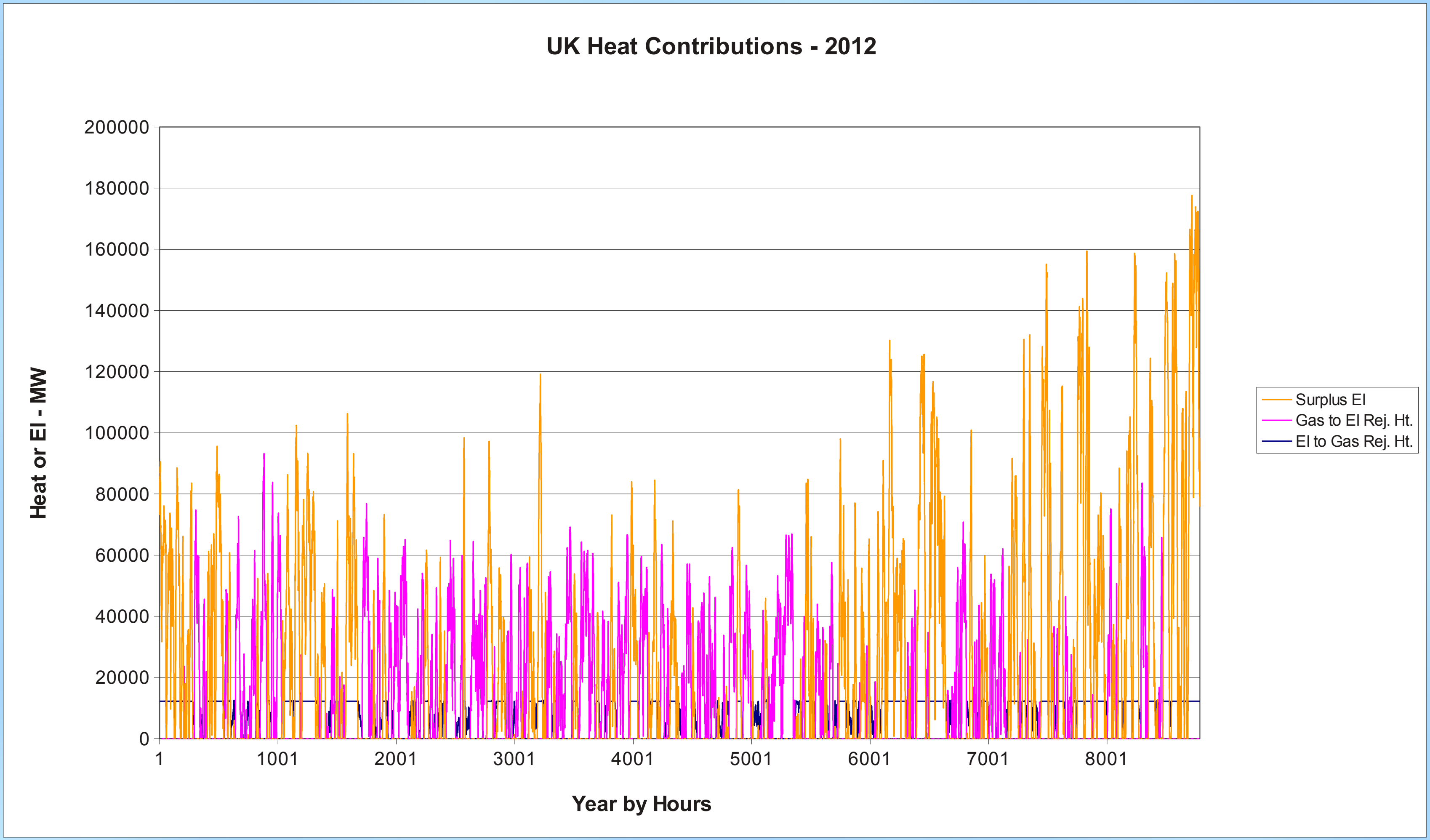
Storage Charging Power



Storage Discharging Power



Reject Heats and Surplus Electricity, Wind Power 250 GW, PtG Power 41 GWe



Reject Heats and Surplus Electricity, Wind Power 250 GW, PtG Power 41 GWe

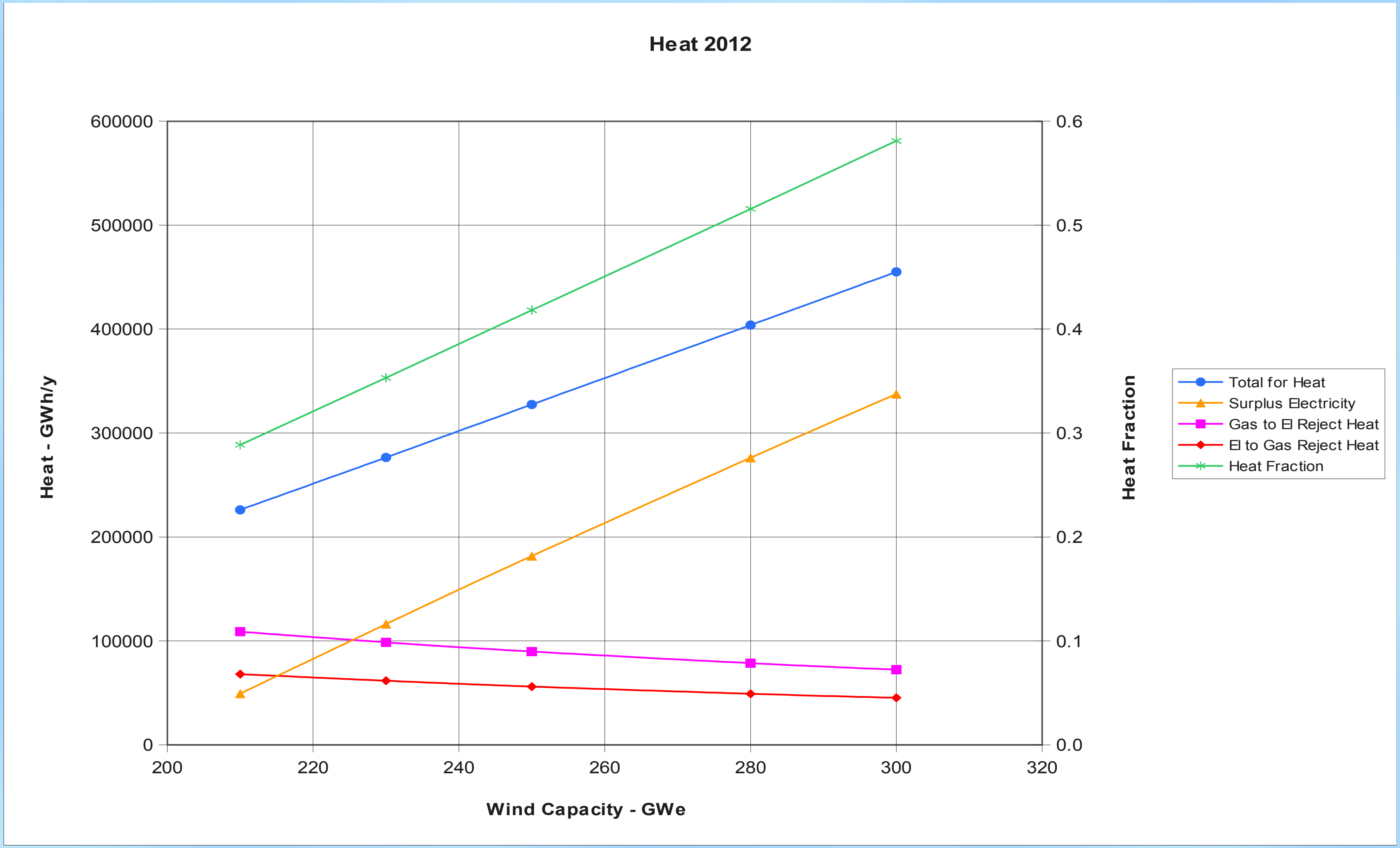
Co-products of the zero-carbon electricity are:

- Reject Heat from the PtG gas synthesis plants

- Reject Heat from the GtP balancing plants

- Surplus Electricity from the Wind Turbines

Reject Heats and Surplus Electricity, Totals thereof and Fraction of Heat Demand



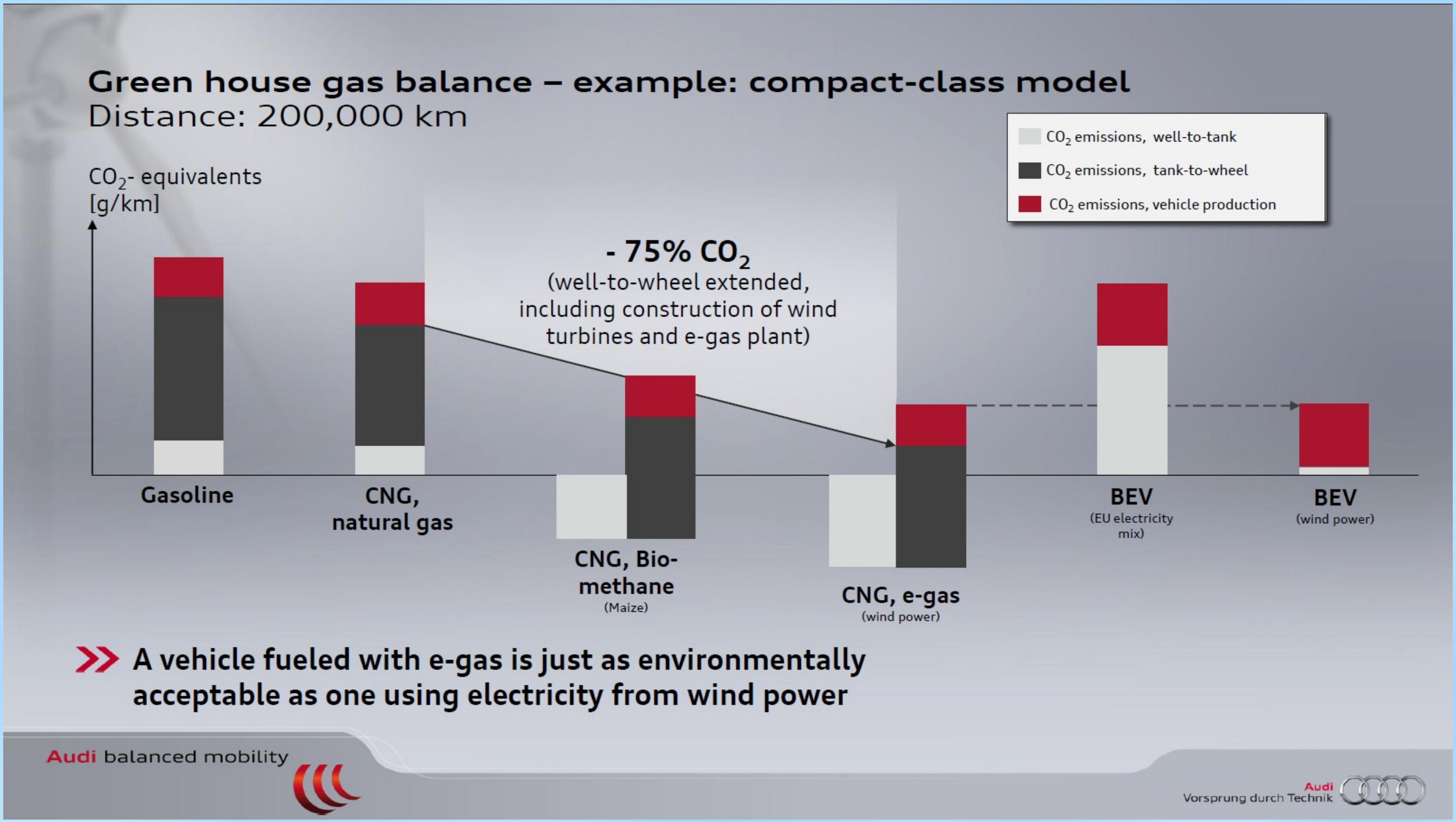
Reject Heats and Surplus Electricity, Totals thereof and Fraction of Heat Demand

As Wind Power goes from 210 to 300 GW:

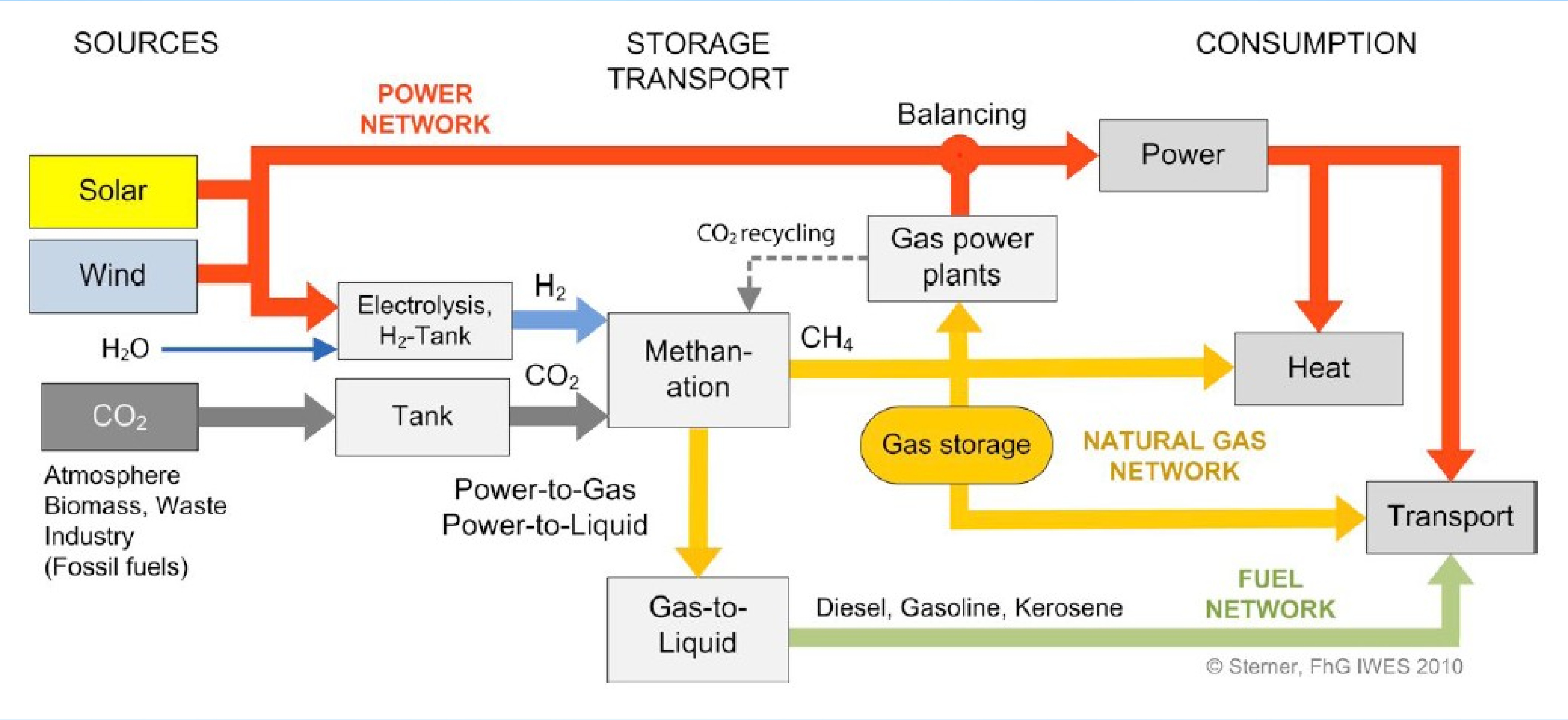
- PtG Reject Heat goes from 68 to 45 TWh/y
- GtP Reject Heat goes from 109 to 72 TWh/y
- Surplus Electricity goes from 49 to 338 TWh/y

I.e. Total for Heat goes from 226 to 455 TWh/y
And Heat Fraction goes from about 0.3 to 0.6
So should be used to reduce C intensity of Heat

Renewable Methane matches BEV



100% Renewables are Possible



Thank you for your attention

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Several energy presentations are at:
www.energypolicy.co.uk