VATTENFALL AND THE TRANSITION OF THE ENERGY SYSTEM

The past, the present and the future

February 2017/Mikael Nordlander

VATTENFALL

CONTENT

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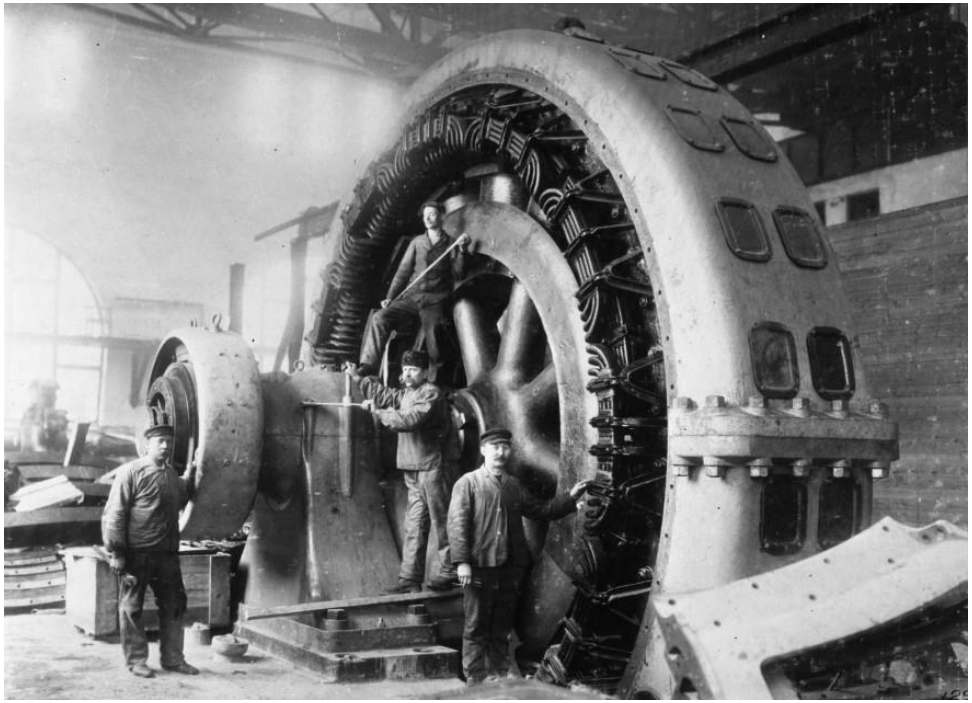
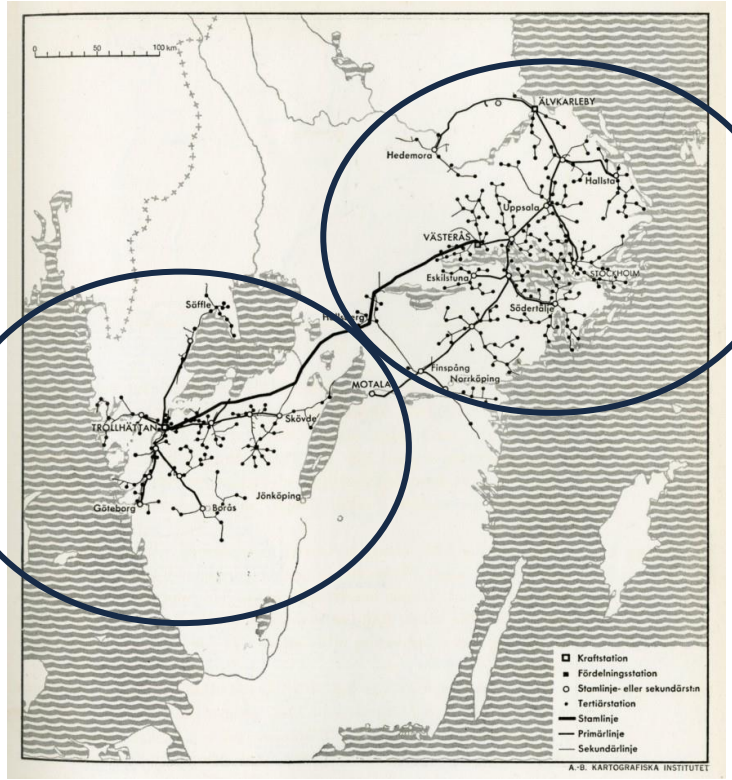
1909: FIRST HYDROPOWER PLANT – OLIDAN



KUNGL STYRELSEN VATTENFALLS

1922: THE ”CENTRAL BLOCK” DISTRIBUTION GRID



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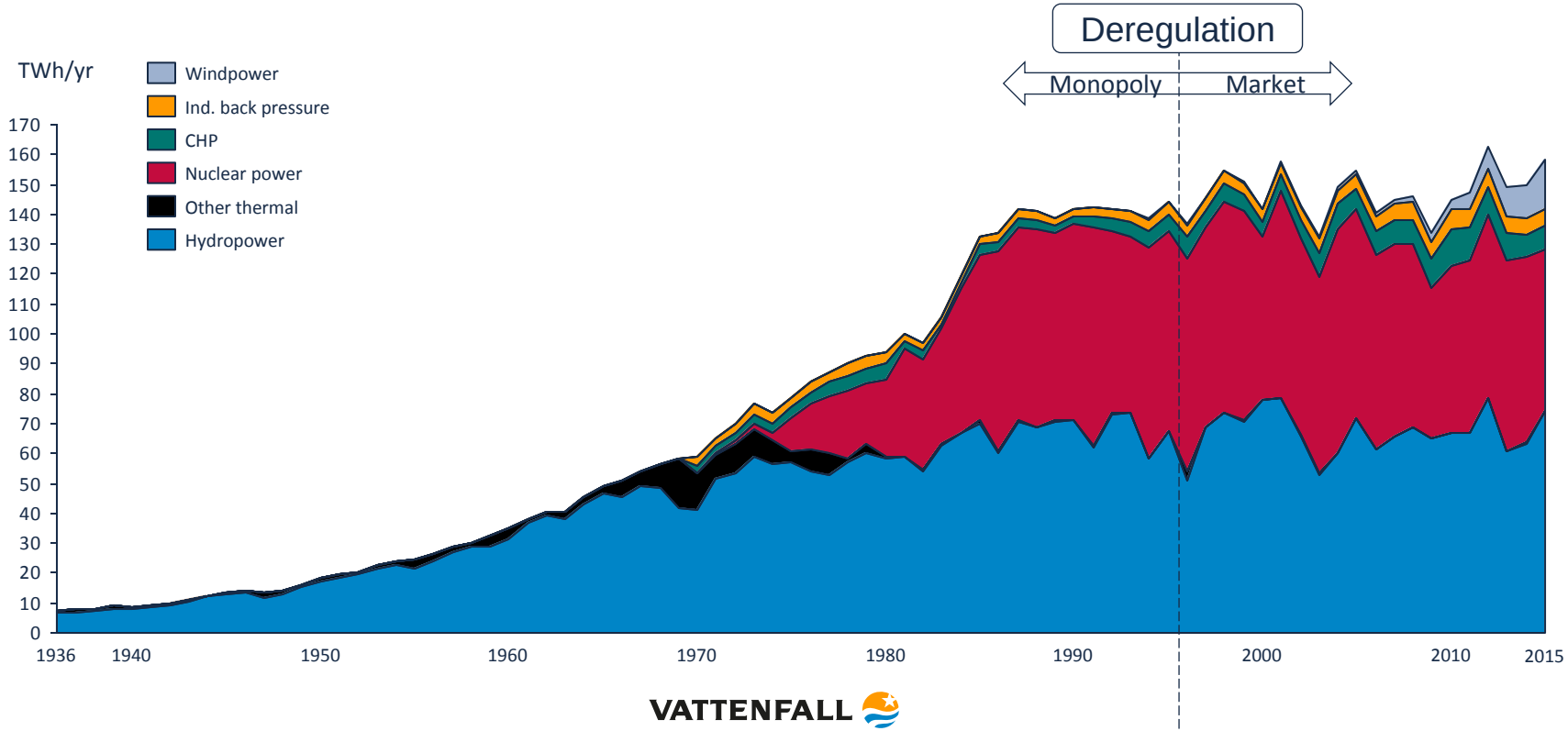
DEVELOPMENT OF ELECTRICITY GENERATION IN SWEDEN



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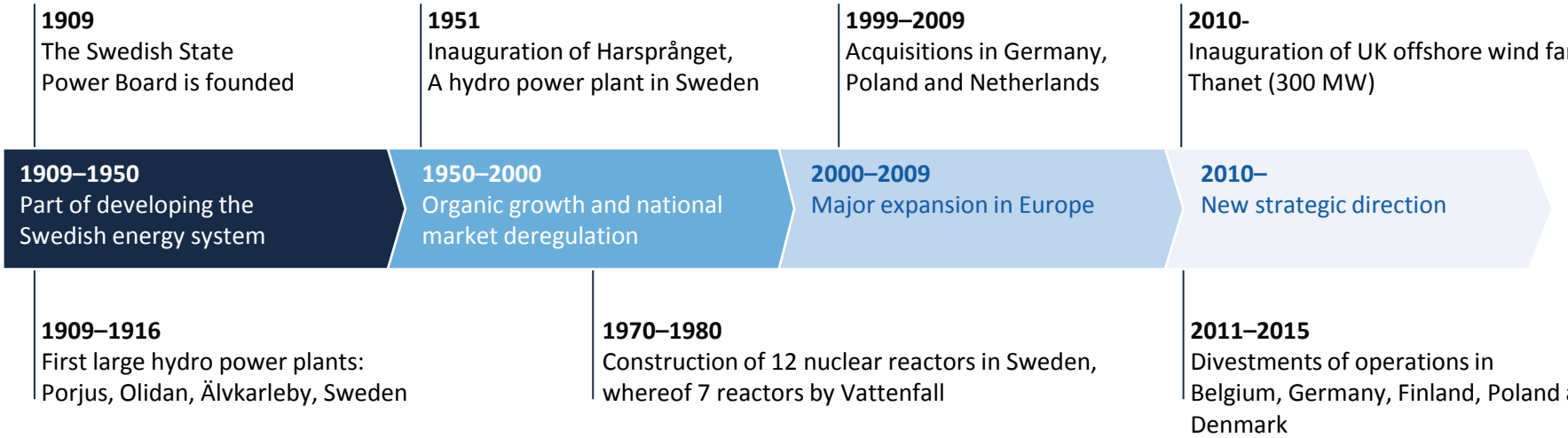
VATTENFALL'S HISTORY

From a domestic Swedish hydro power generator to a European energy company



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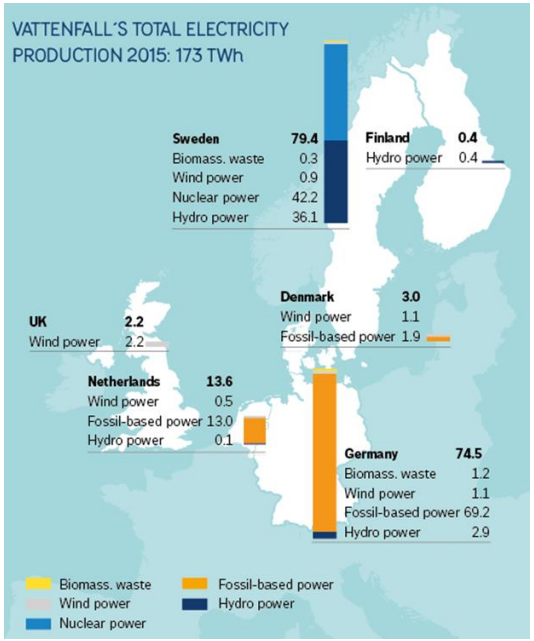
VATTENFALL AT A GLANCE

- One of Europe's largest generator of electricity and heat
- Vattenfall has approx. 6.2 million electricity customers, 3.2 million electricity network customer and 2.1 million gas customers
- 100% owned by Kingdom of Sweden
- Operations mainly in Denmark, Finland, Germany, Netherlands, Sweden and the UK
- Main products: electricity, heat, gas, energy services
- Business operations: Production, Trading, Distribution, Sales and energy services

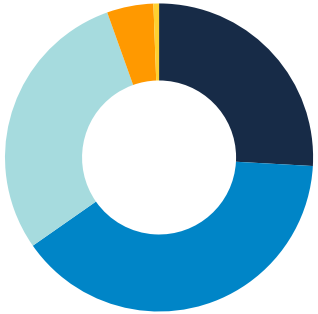


KEY DATA 2016 – LIFE AFTER LIGNITE

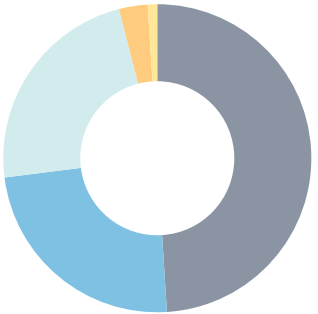
Key figures	2016[1]	2015
Net sales (MSEK)	139,200	164,510
Underlying operating profit (MSEK)[2]	21,700	20,541
Reported operating profit (MSEK)	1,300	-22,967
Profit after tax, (MSEK)	-2,200	-19,766
Cash flow from operating activities, (MSEK)	28,600	40,934
Total assets (MSEK)	409,260	462,317
Return on capital employed, %	0.5	-8.2
Return on capital employed, % excl. IAC	8.7	7.4
Number of employees (FTE)	19,935	28,567
CO_2 emissions (Mtonnes) [3]	23,1	83,8

1) Continuing operation, i.e. excl lignite operations
2) Underlying operating profit, excluding items affecting comparability.
3) Pro rata basis, corresponding to Vattenfall's share of ownership.

Electricity production mix, 2016 (119 TWh)



Electricity production mix, 2015 (173 TWh)



- Fossil-based power, 49%
- Nuclear power, 24%
- Hydro power, 23%
- Wind power, 3%
- Biomass and waste, 1%

SIX CROSS-BORDER BUSINESS AREAS (BA) REPLACE REGIONAL STRUCTURE

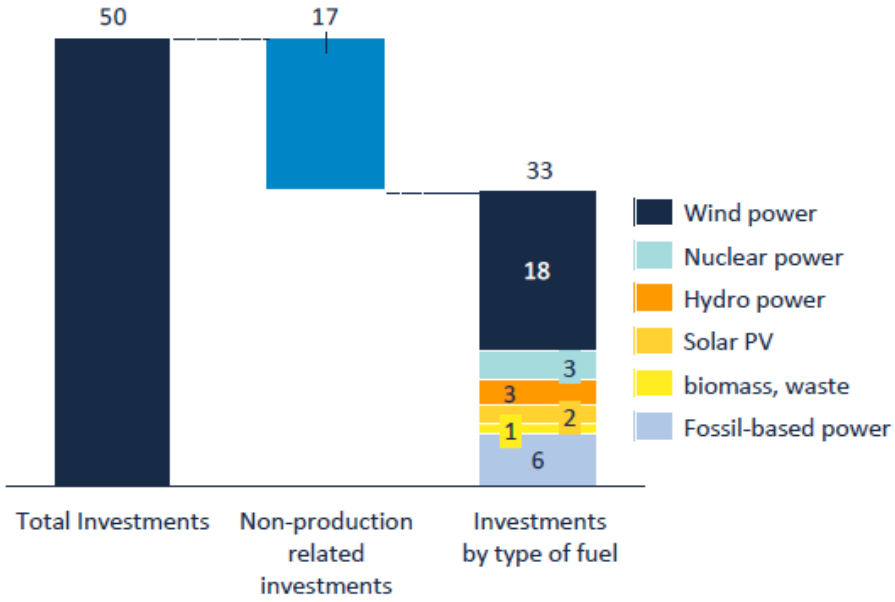
 **Heat**	All heat operations including all thermal operations except for the lignite operations
 **Wind**	All wind power operations
 **Customers & Solutions**	Sales to end customers
 **Generation**	All hydro and nuclear power operations
 **Markets**	Corresponds to the former Business Division Asset Optimisation and Trading
 **Distribution[1]**	Electricity distribution operations in Sweden and Germany

1) The distribution business is legally and functionally separated from Vattenfall's other operations.

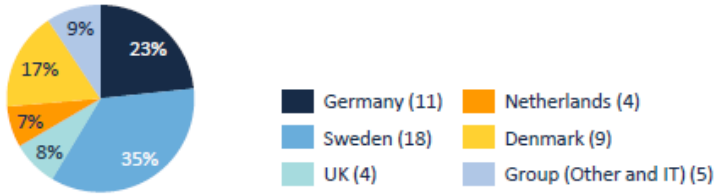
INVESTMENT PLAN 2017-2018

The investment plan reflects a clear shift in strategy, with the majority of growth investments in wind power, solar PV and distribution grids.

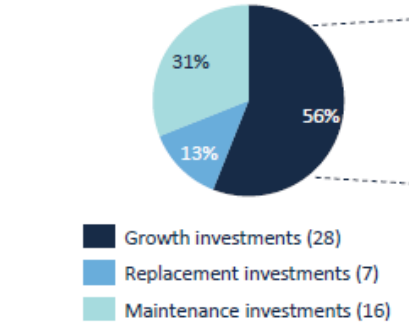
Total investments 2017-2018: SEK 50bn



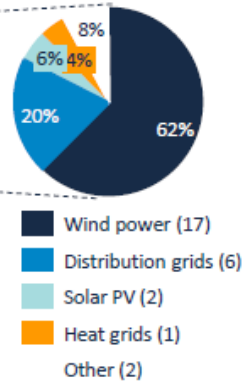
Geographical split (SEK bn)



Investment split by type (SEK bn)



Growth investment by technology: SEK 28bn



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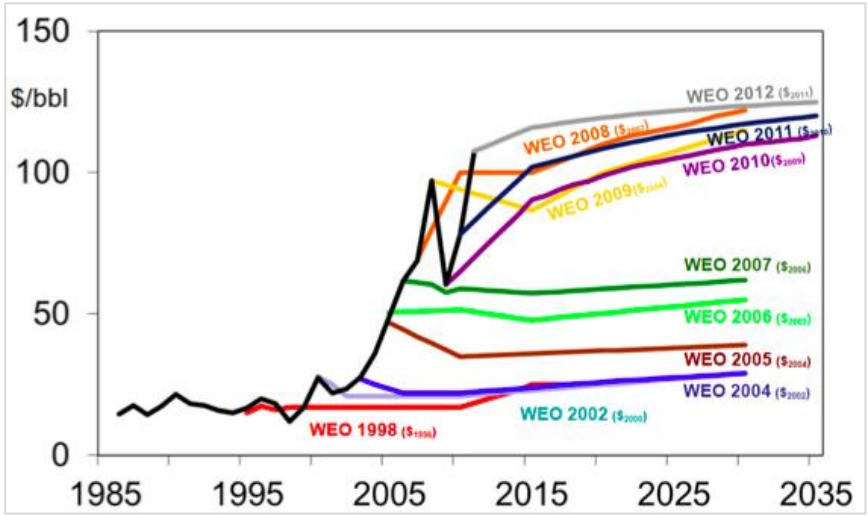
“My interest is not data, it's the world. And part of world development you can see in numbers.”

- Hans Rosling

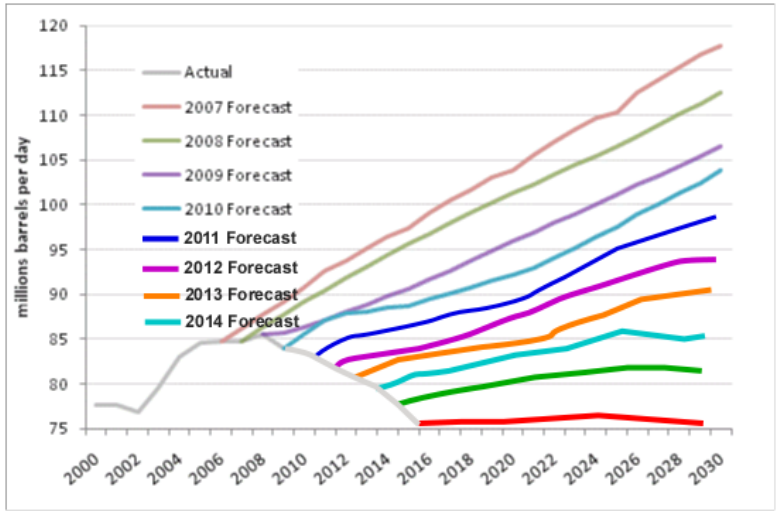
BUSINESS CASE OR BUSINESS LOGIC?

If you can't predict numbers, don't pretend you can…

IEA: Oil price forecast 1998-2012



US-EIA: Oil production volume forecast 2007-2016



…or at least don't base you actions on the model answering "43"…

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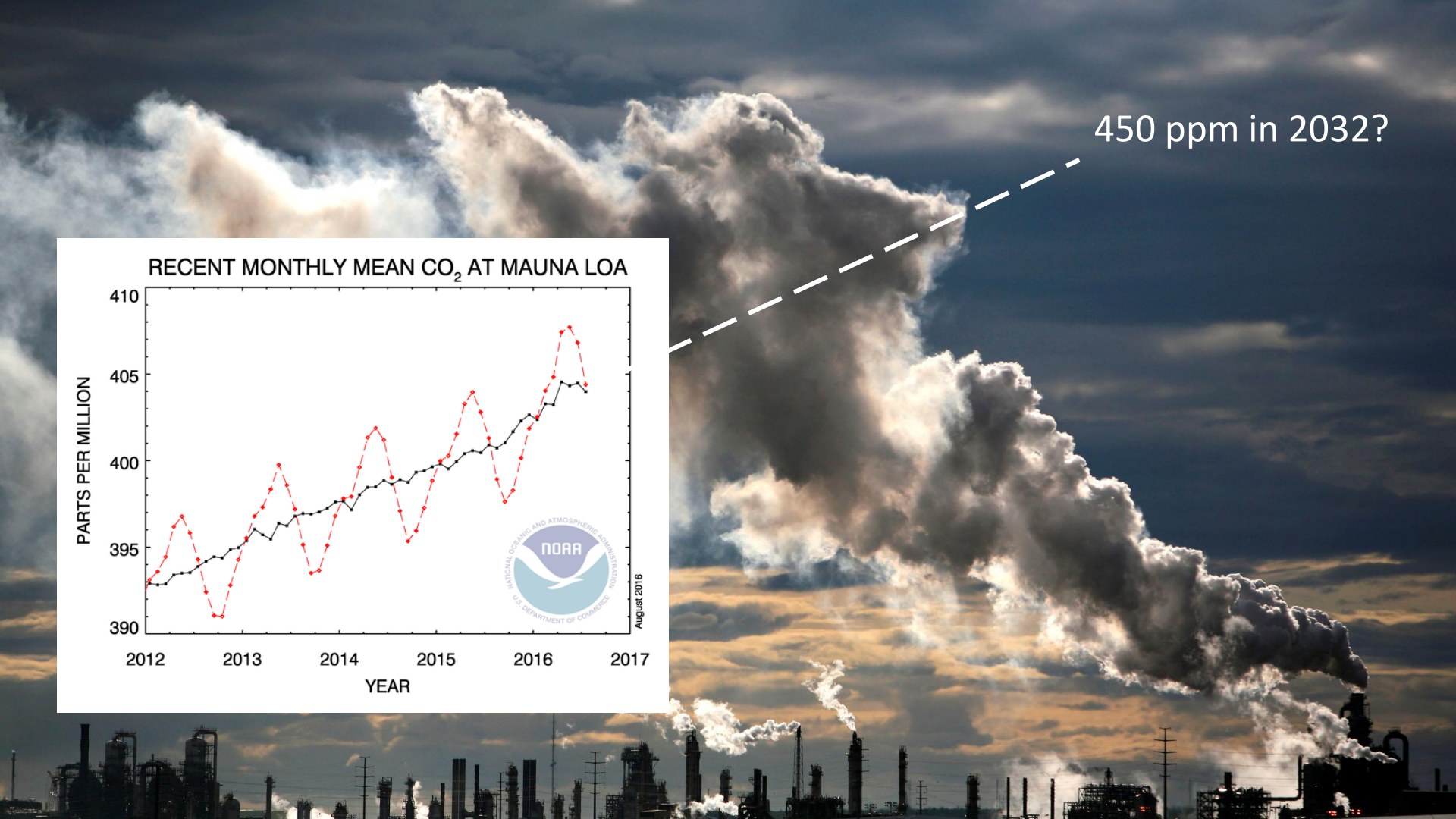
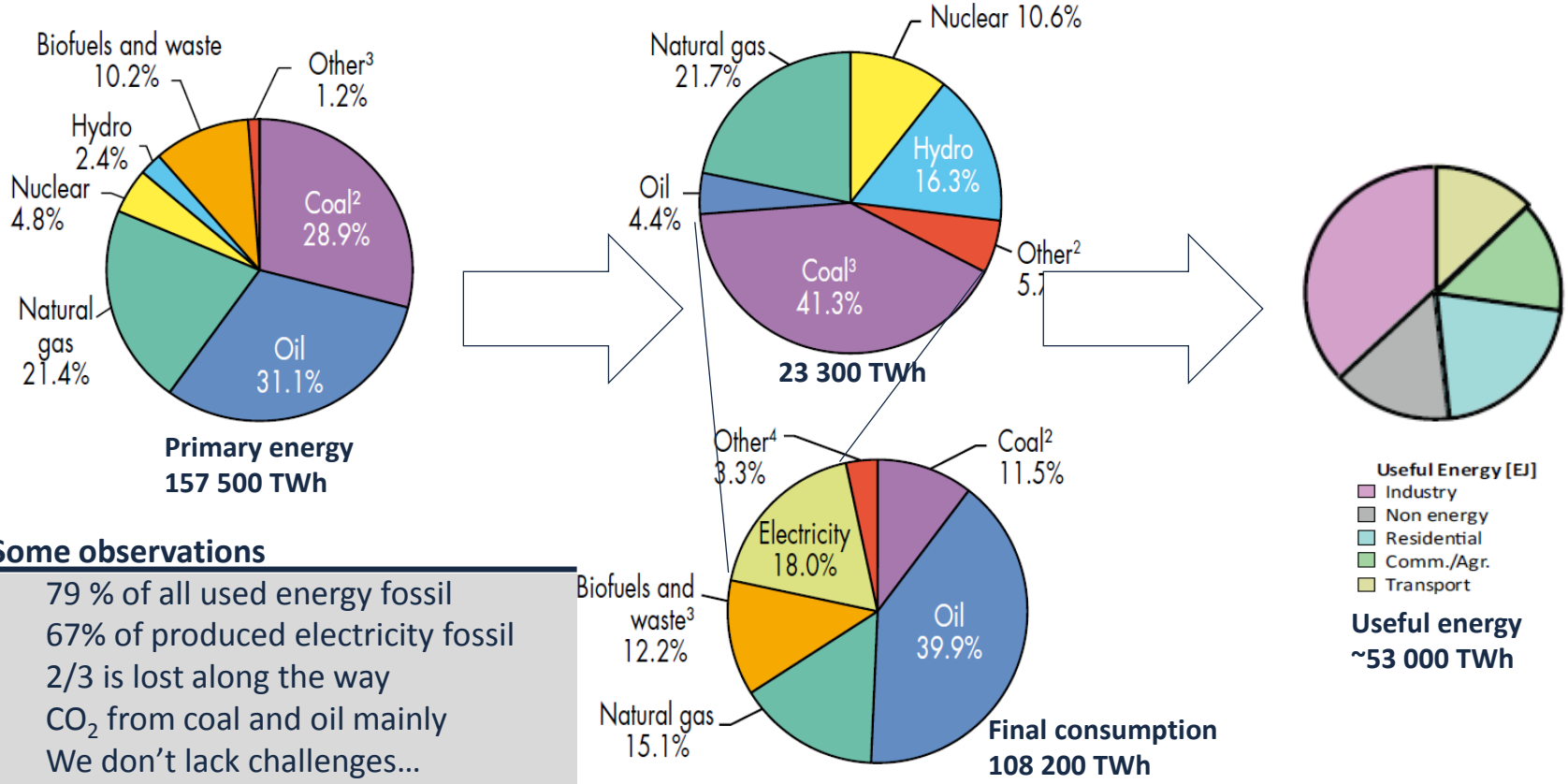

450 ppm in 2032?
RECENT MONTHLY MEAN CO_2 AT MAUNA LOA
PARTS PER MILLION
410
405
400
395
390
2012
2013
2014
2015
2016
2017
YEAR
NOAA
August 2016

GLOBAL ENERGY SUPPLY AND DEMAND



Some observations

- 79 % of all used energy fossil
- 67% of produced electricity fossil
- 2/3 is lost along the way
- CO_2 from coal and oil mainly
- We don't lack challenges…

Source: Key world energy statistics (IEA), GEA

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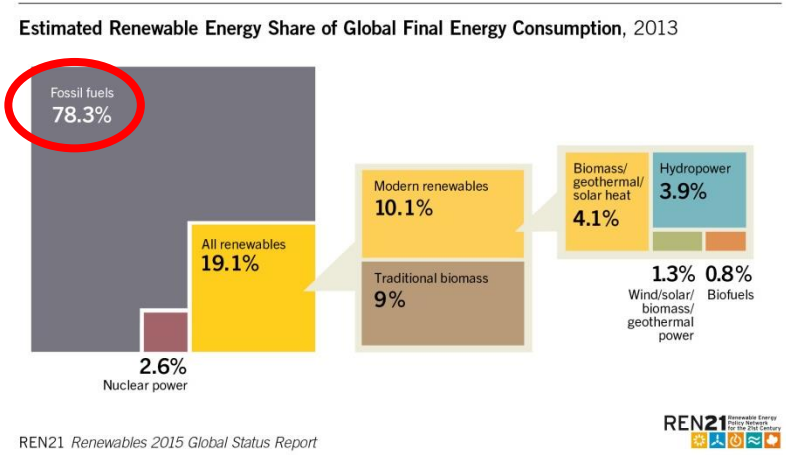
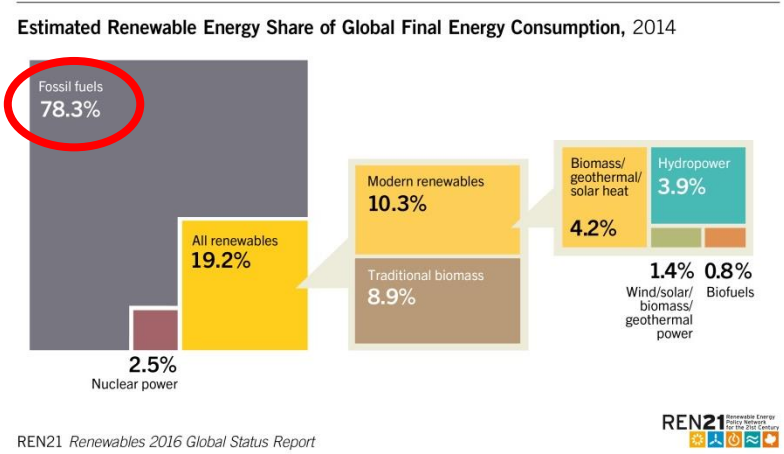
THE MOST DEPRESSING PICTURE EVER?



2013



2014

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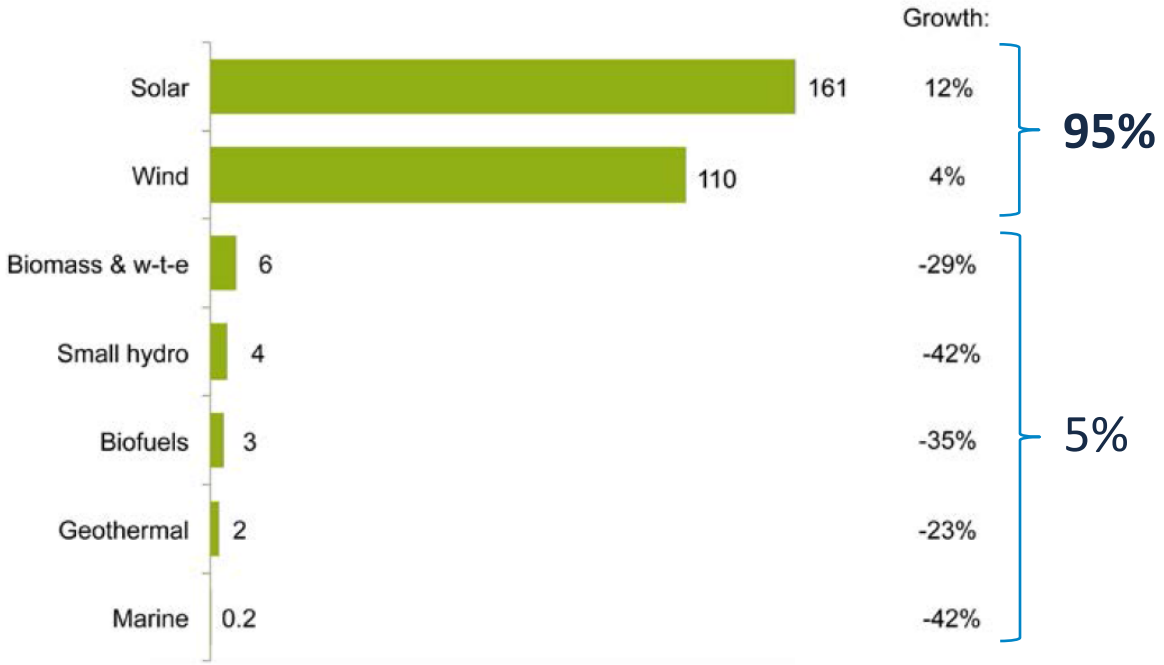
FROM 10.1% TO 10.3% COSTS 286 BN$ (2015)



Source: UNEP/BNEF (2016)

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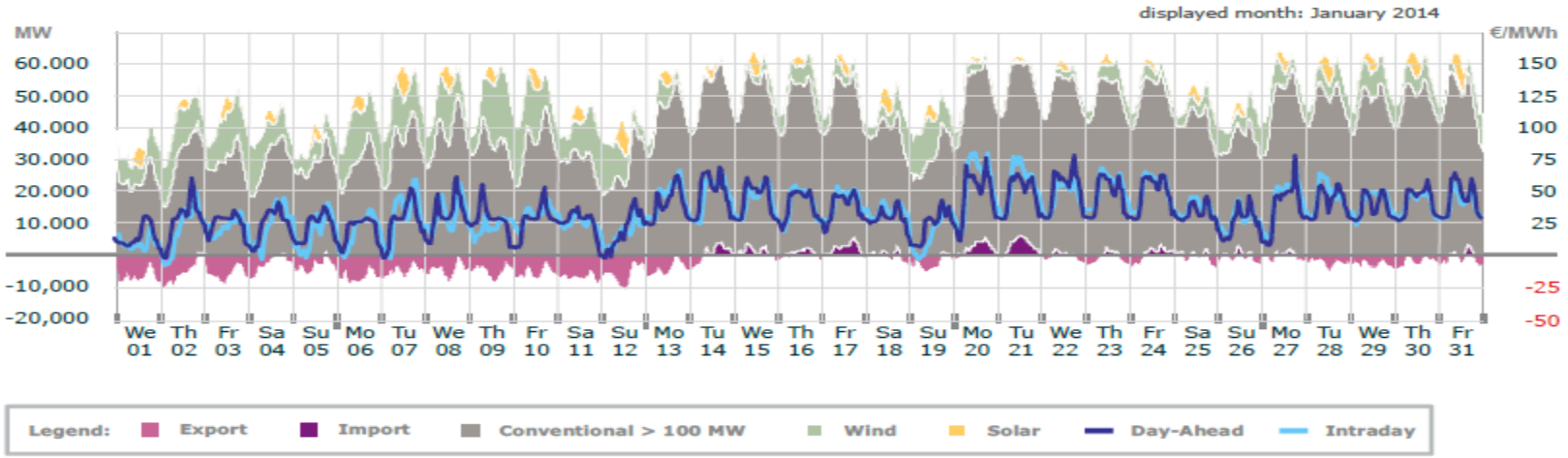
INTERMITTENT GENERATION – EXAMPLE



Some observations

- Wind and PV production linked to price
- Flexible generation and transmission counteract on variability

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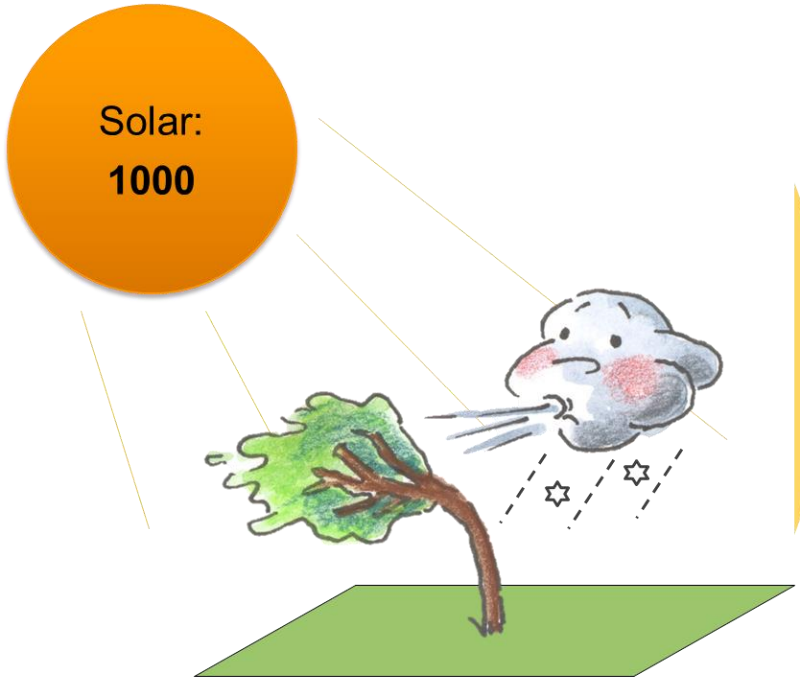
HARVESTING RENEWABLE ENERGY - WHAT CAN YOU SQUEEZE OUT FROM A SQUARE METER?



Solar PV:	**30-150**
Wind:	**17-20**
Hydro:	**0.6**
Bio:	**0.3**

All numbers in kWh/m²/year

Source: Kraftpojkarna, Arise, Vattenkraft.info, Skogsstyrelsen

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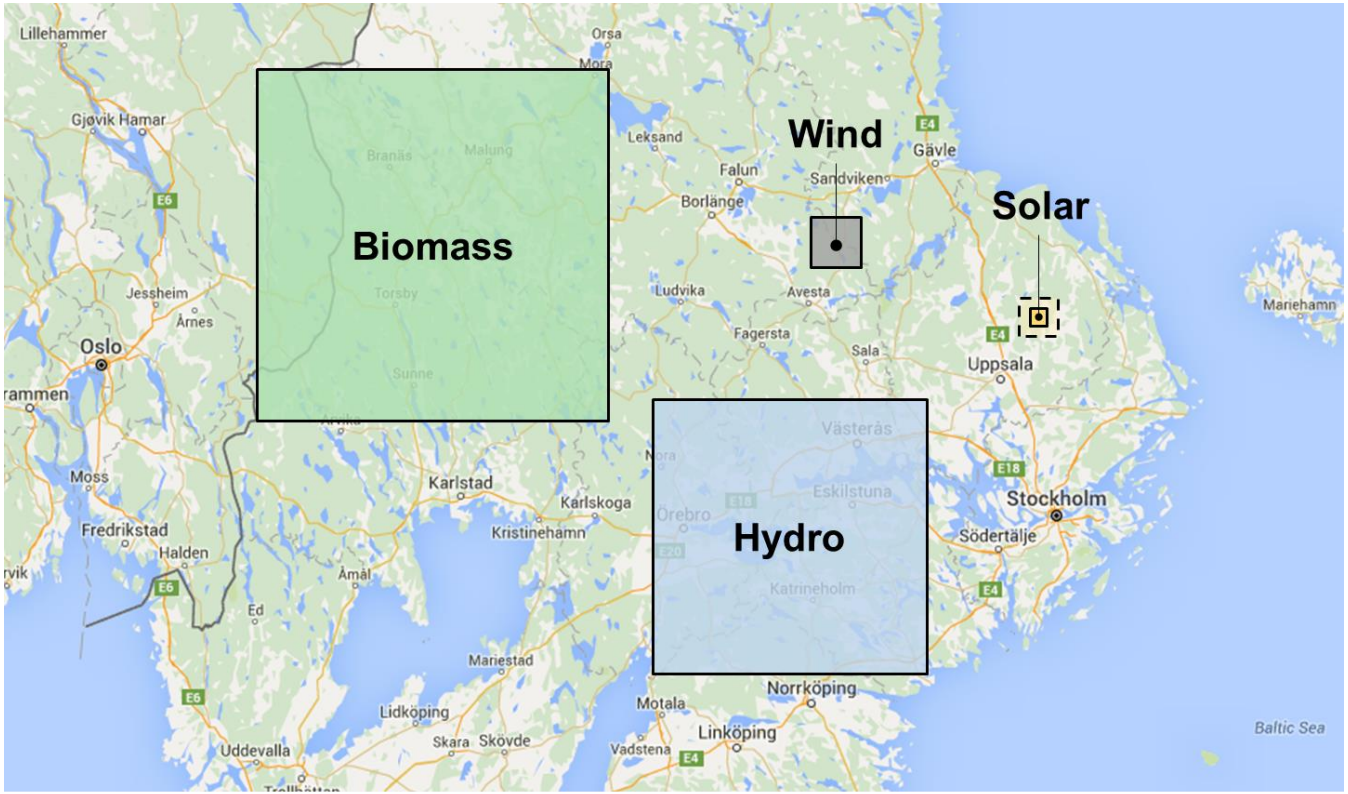
10 TWH PER YEAR FROM…



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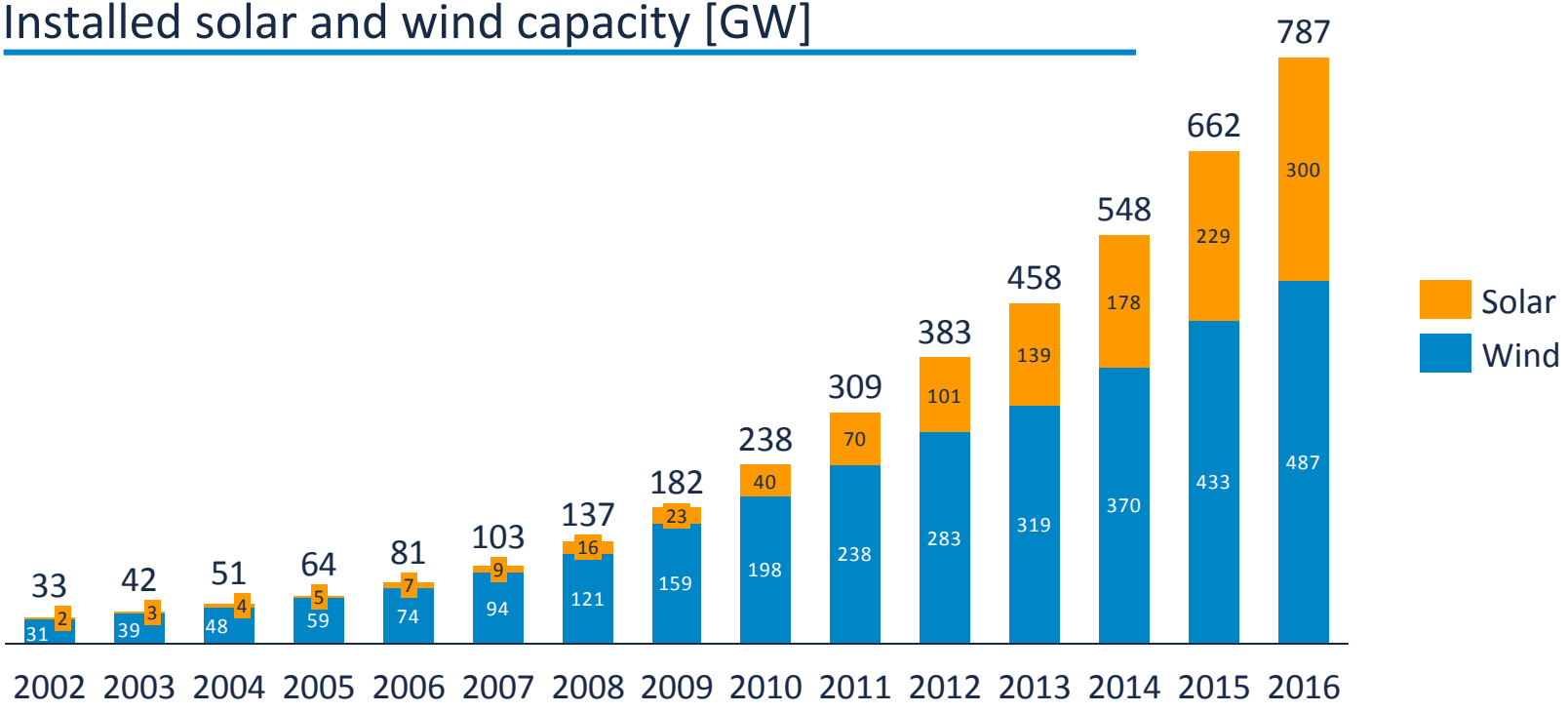
SO THAT'S WHY…

Installed solar and wind capacity [GW]



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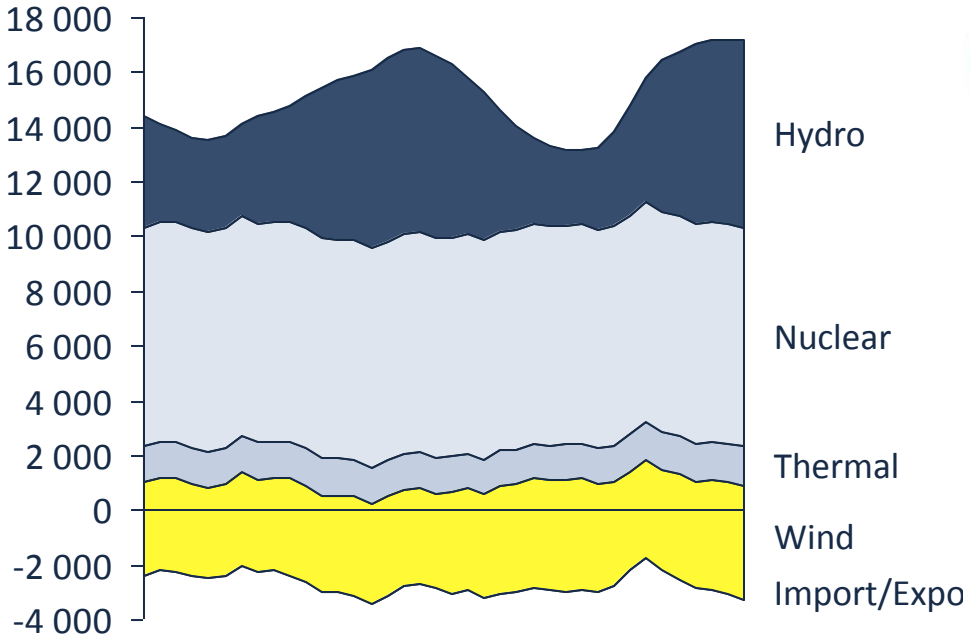
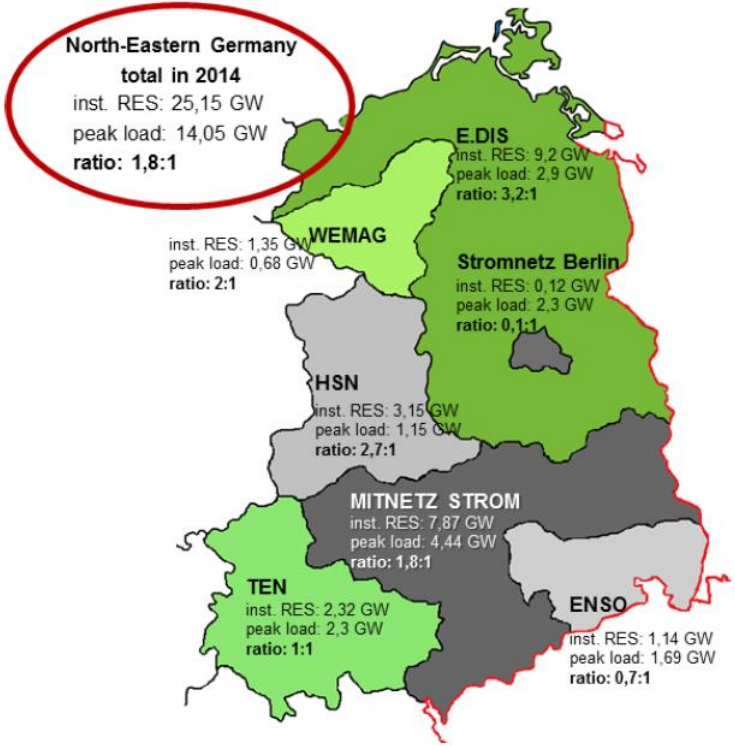
VARIABILITY AND VARIABILITY - THE DIFFERENCE



Sweden



Germany

Source: SvK, Gridlab/Vattenfall (2016)

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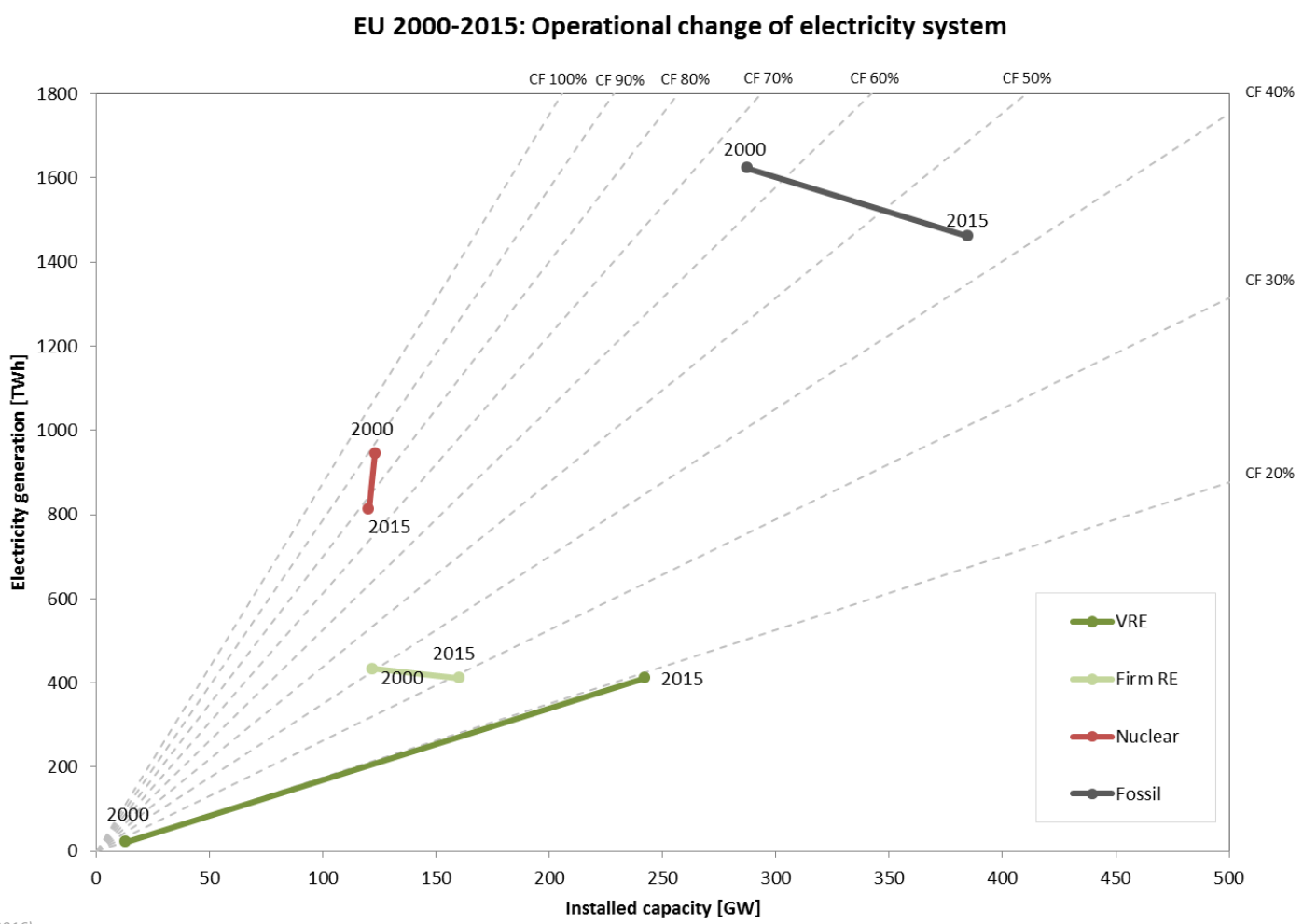
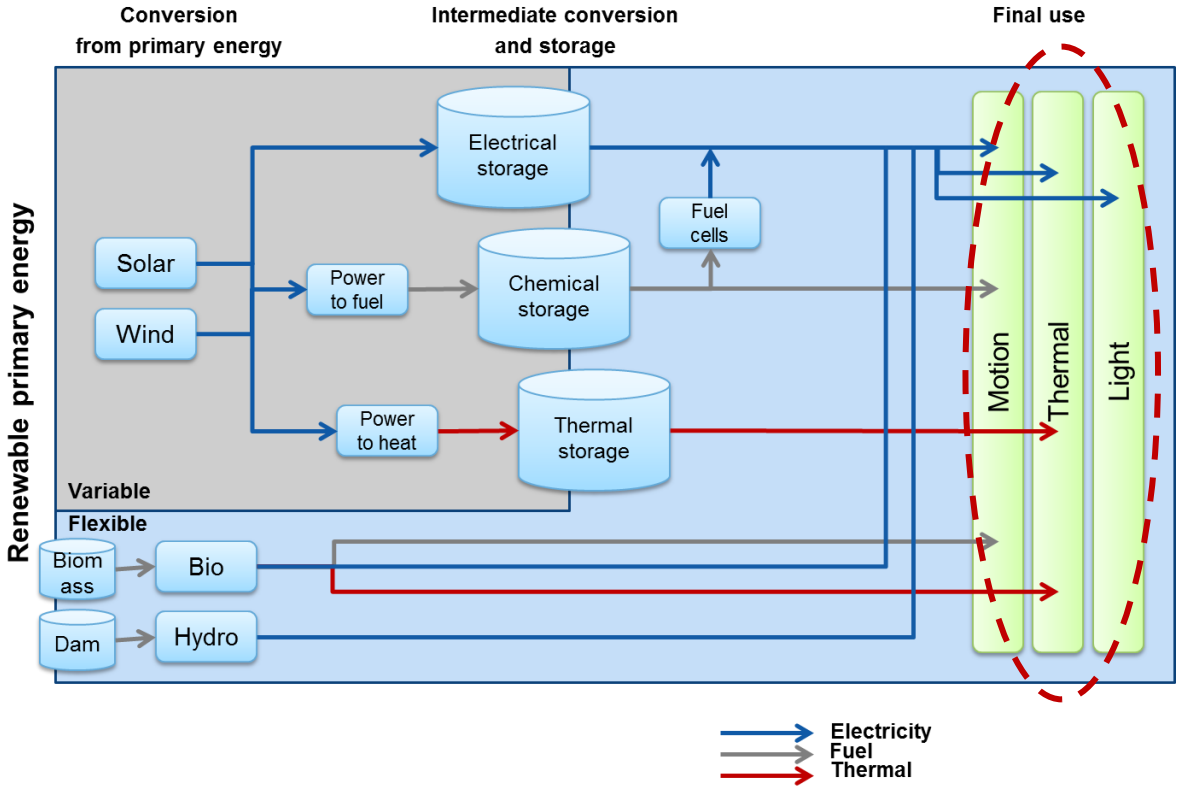


Source: Eirostat, EWEA (2016)

FUTURE ENERGY SYSTEM NEEDS FLEXIBILITY



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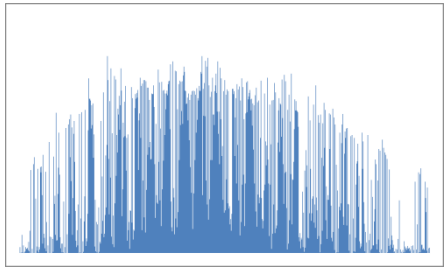
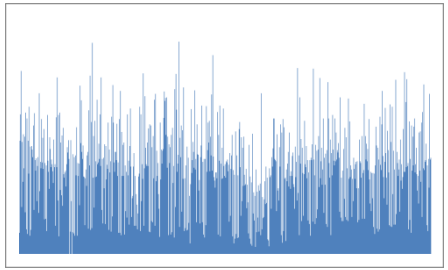
SOLAR: DEAL WITH VARIABILITY AT THE SOURCE

Generation (PV)



Consumption



Capacity factor: 8-12%

Correlation: -0.1

➔ Two, noisy, non-correlated grid burdens

Source: Energimyndigheten (2015)

ELECTRIFICATION IS AN ENABLER FOR SOLVING THE CLIMATE ISSUE

Vattenfall aims to play a leading role given our strong position in heating, renewable generation and our "Nordic" heritage coming from a low-emitting region

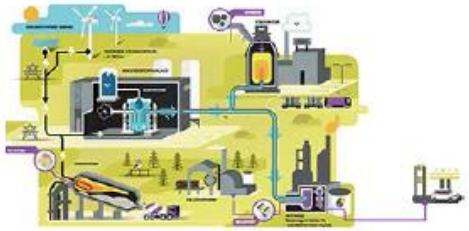
Electrification of the transport sector

- Supports e-mobility growth with resulting reduction of CO_2 as well as solving pollution and noise issues

Electrification of heating

- Energy efficiency achieved by switching from gas, oil or electric boilers to heat pumps or district heating
- Power to heat is an attractive solution to reduce the cost of heating

Electrification of the industry



- Greater use of electricity by industry can lead to fossil free steel, green concrete and boost the production of non-fossil diesel

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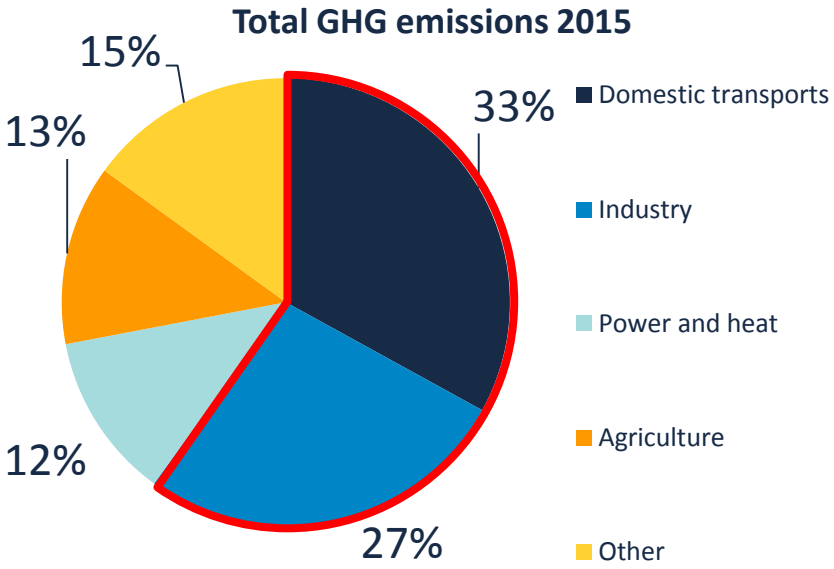
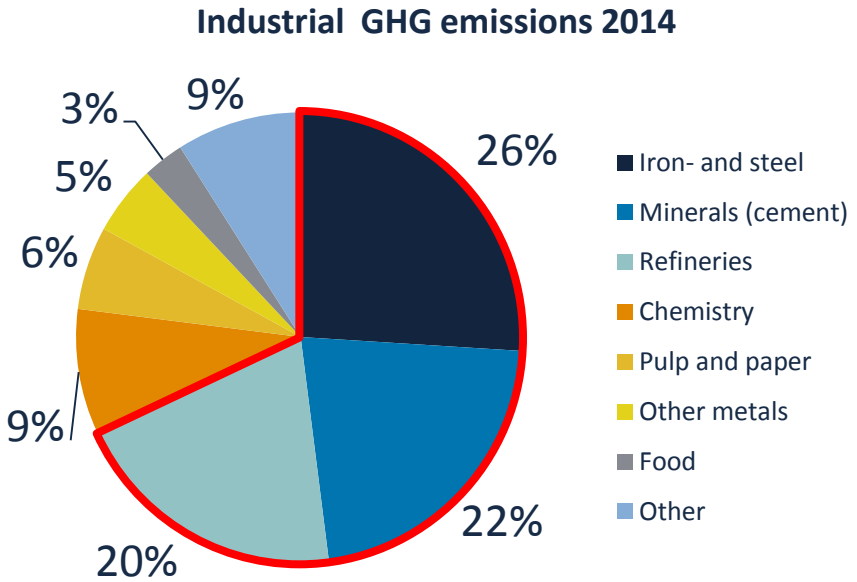
INDUSTRY AND TRANSPORT – THE MAJORITY OF SWEDISH GHG EMISSIONS



53.7 Mton



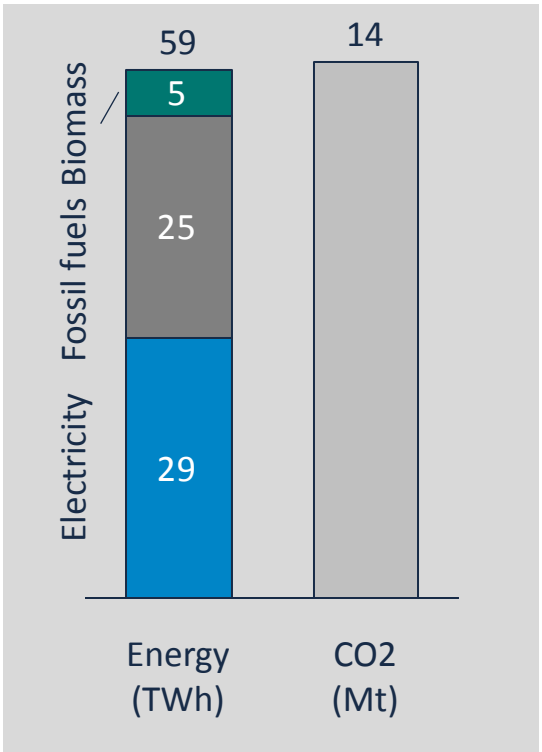
14.7 Mton

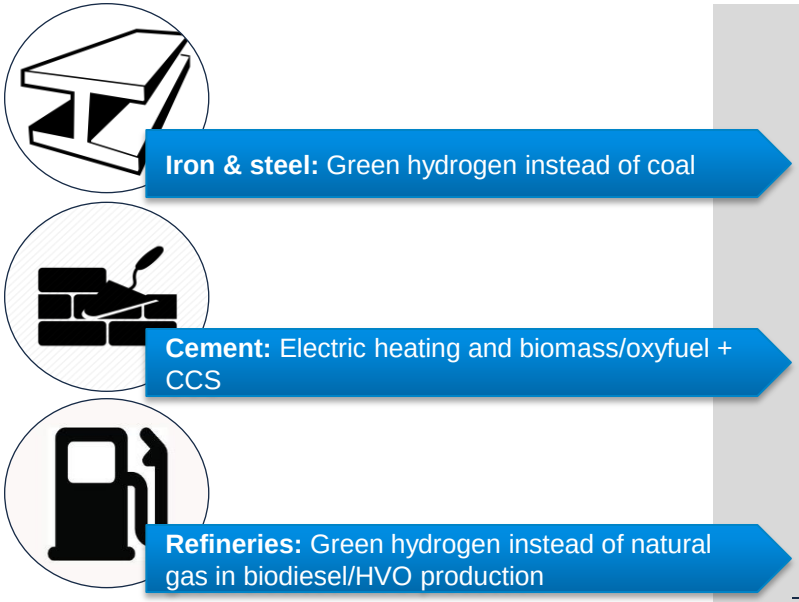
Source: Swedish Environmental Protection Agency

VATTENFALL

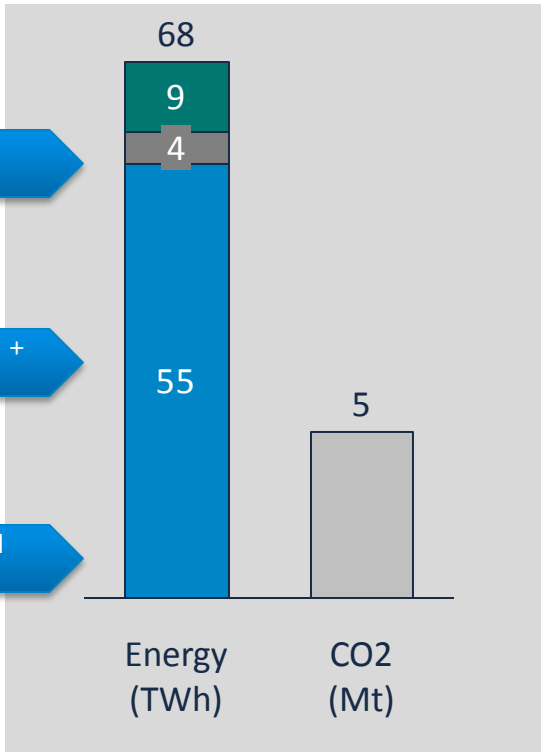
ELECTRIFICATION CAN ELIMINATE CO2 EMISSIONS FROM SEVERAL BASIC INDUSTRY BRANCHES

Today





Future (2030-2045)



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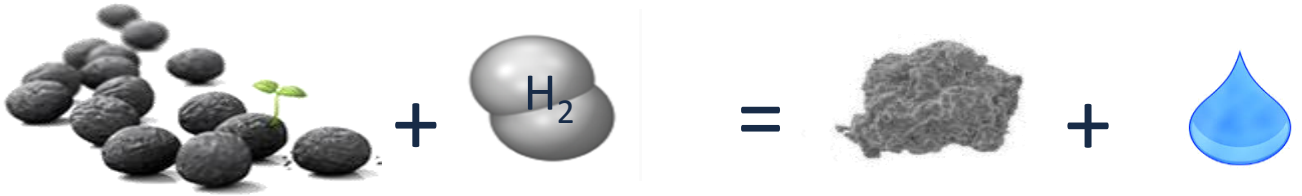
HYBRIT: **HY**DROGEN **BR**EAKTHROUGH **I**RONMAKING **T**ECHNOLOGY

- CEOs of SSAB, LKAB and Vattenfall launched on April 4, 2016, a joint development project that, if proven feasible, can solve the root cause of the steel industry's CO_2 challenge.

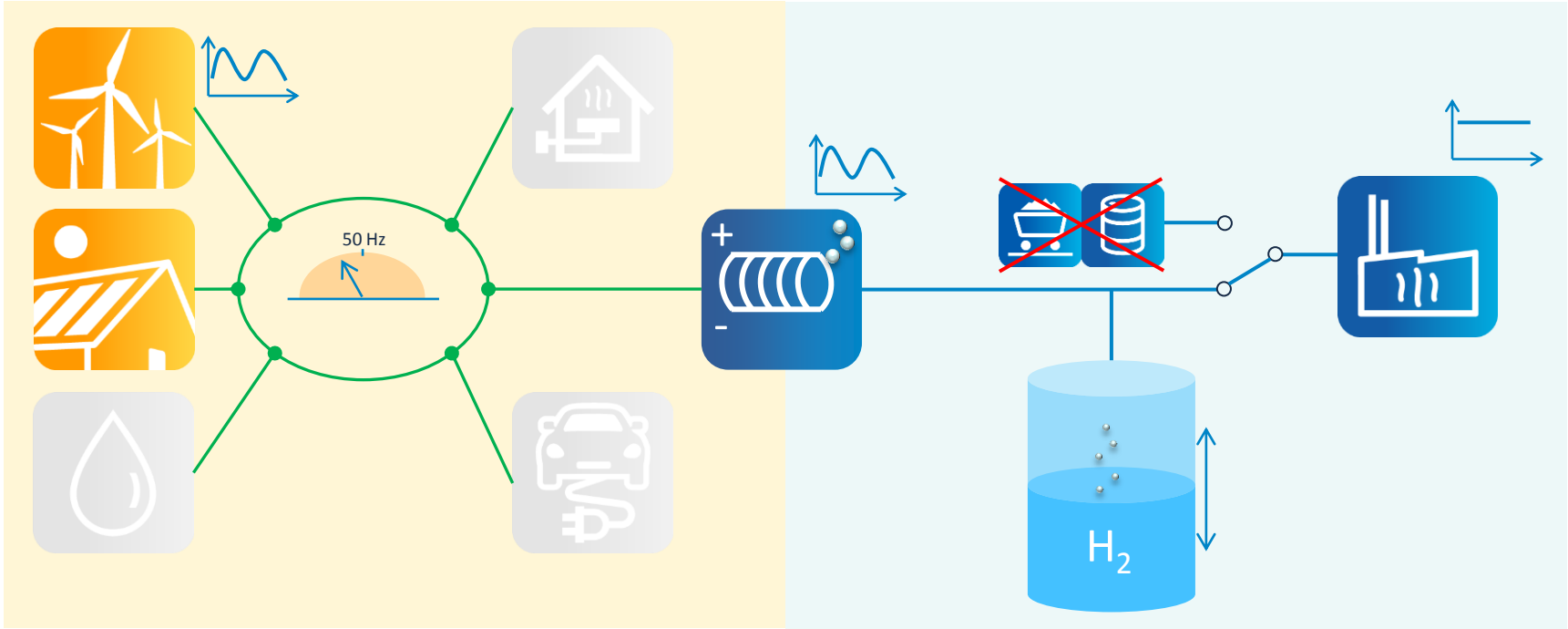
- The aim is to replace the blast furnace and eliminate CO_2 emissions from ironmaking, by using hydrogen produced from "clean" electricity.

- The by-product from iron ore reduction would be **water**:



Iron ore pellets Hydrogen Sponge iron Water

HYDROGEN – REDUCING CARBON FOOTPRINT OF INDUSTRY WHILE BALACING WIND AND SOLAR ELECTRICITY



BASIC INDUSTRY AND VATTENFALL CAN COOPERATE TO DRASTICALLY REDUCE CO_2 EMISSIONS – WITH ELECTRICITY

Raw materials

Iron ore

Limestone

Biomass

Wind

Hydro

Solar

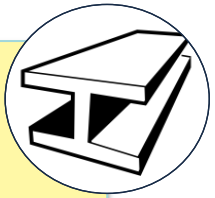
Renewable energy

Natural resources

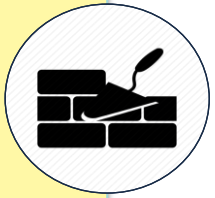
Processing

Renewable electricity (hydrogen)

High performing steel



High performing cement



Renewable liquid drop-in fuels

Products
with close to no carbon footprint

Target: 70% of Sweden's industrial CO_2 emissions

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Thank you

mikael.nordlander@vattenfall.com

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