A Decentralised Electricity System: Definition and Current Trends in Europe

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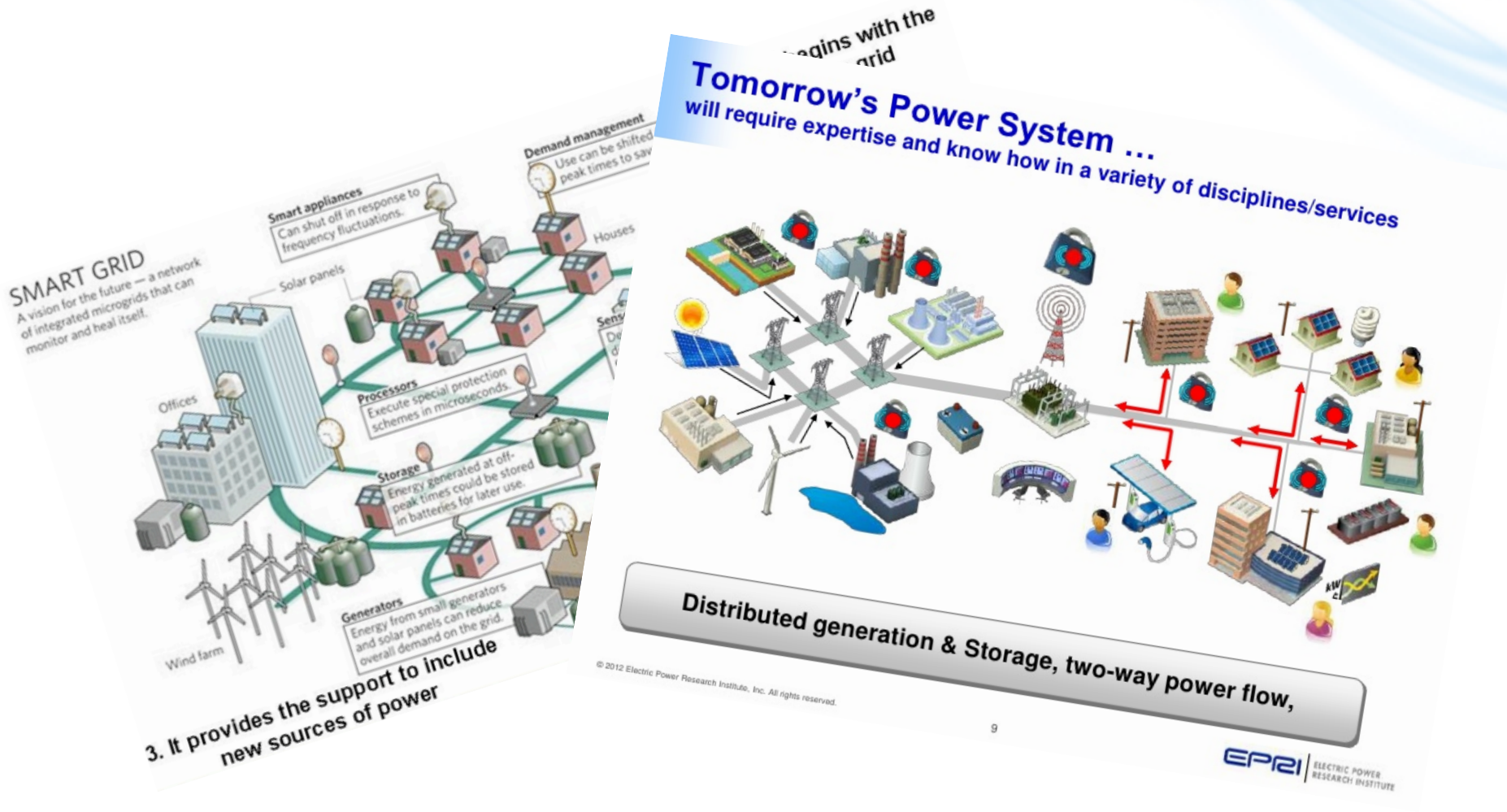
WHAT IS DISTRIBUTED GENERATION?



WHAT IS DISTRIBUTED GENERATION?

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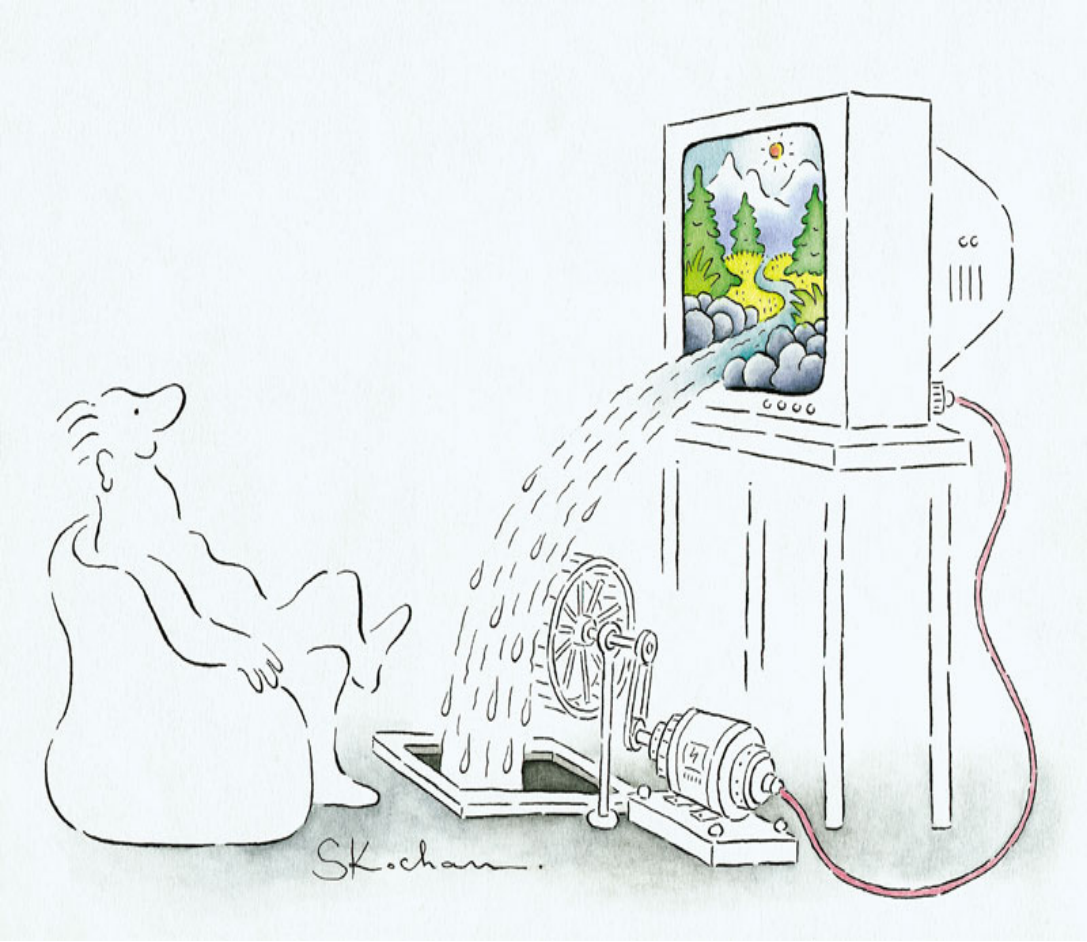

WHAT IS DISTRIBUTED GENERATION?

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Existing Definitions

Electric Power Research Institute:

DG is generation from **“a few kilowatts up to 50 MW”**

Gas Research Institute:

DG is **“typically [between] 25 kW and 25 MW”**

Cardell:

DG is generation **“between 500 kW and 1 MW”**

WHAT IS DISTRIBUTED GENERATION?

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Old Definitions developed by Authorities:

Old English Market:

DG with **less than 100 MW** is not centrally dispatched and

DG with **less than 50 MW** -> no trade via the wholesale market required

-> often referred to embedded generation

Old Swedish Legislation:

DG = maximum generation capacity of **up to 1,500 KW**

(Wind farm = maximum size of each unit 1,500 kW)

MY DEFINITION

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Definition is defined by the following parameters:

A. Purpose
B. Location
C. Rating
D. Power delivery area
E. Technology
F. Environmental impact
G. Mode of operation
H. Ownership, and
I. Penetration of distributed generation

A. PURPOSE

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A 1:

The **purpose** of distributed generation is to provide a source of **active** electric power.

B. LOCATION

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B 1:

The **location** of distributed generation is defined as the installation and operation of electric power generation units connected **directly to the distribution network or connected to the network on the customer site of the meter**.

B 2:

In the context of competitive electricity market regulations, only the **legal definition of transmission and distribution systems provides a clear distinction between the two systems**.

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C 1:

The **rating** of the DG power source is not relevant for the definition we suggest.

Comment:

Possible rating of DG depends on the capacity of the distribution system.

Each distribution system is unique, therefore, no general definition of the maximum generation capacity that can be connected to a distribution system can be given.

- **Micro** distributed generation: ~ 1 Watt < 5 kW
- **Small** distributed generation: 5 kW < 5 MW
- **Medium** distributed generation: 5 MW < 50 MW
- **Large** distributed generation: 50 MW < ~300 MW

D. POWER DELIVERY AREA

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D 1:

The **area of the power delivery is not relevant** for the definition of DG we suggest.

Comment:

The term **embedded distributed generations** is more appropriate to describe the fact that the power output of the distributed generation source is only used locally.

E. TECHNOLOGY

E 1:

The technology used for DG is not relevant for the suggested definition.

Comment:

- **Renewable** distributed generation
- **Modular** distributed generation
- **CHP** distributed generation

TECHNOLOGY

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Technology	Typical available size per modul
Combined Cycle Gas T.	35 MW – 400 MW
Internal Combustion Engines	5 kW – 10 MW
Combustion Turbine	1 MW – 250 MW
Micro-Turbines	35 kW – 1 MW
Fuel Cells, PhosAcid	200 kW – 2 MW
Fuel Cells, Molten Carbonate	250 kW – 2 MW
Fuel Cells, Proton Exchange	1 kW – 250 kW
Fuel Cells, Solid Oxide	250 kW – 5 MW
Stirling Engine	2 kW – 10 kW

TECHNOLOGY BASED ON RENEWABLES

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Technology	Typical available size per modul
Small Hydro	1 MW – 100 MW
Micro Hydro	25 kW – 1 MW
Wind Turbine	200 Watt – 8 MW
Photovoltaic Arrays	20 Watt – 100 MW
Solar Thermal, Central Receiver	1 – 10 MW
Solar Thermal, Lutz System	10 – 80 MW
Biomass Gasification/Combustion etc.	100 kW – 40 MW
Geothermal	5 MW – 100 MW
Ocean Energy	100 kW – 1 MW
Stirling Engine	2 kW – 10 kW

F. ENVIRONMENTAL IMPACT

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F 1:

The **environmental impact** of DG is not relevant for the suggested definition.

Comment:

The analysis of the environment of impact is too complex, to be included in the suggested definition

G. MODE OF OPERATION

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G 1:

The **mode of operation** of distributed power generation is **not relevant** for the suggested definition.

Comment:

There are large variations in the international regulations regarding the operation of electricity networks (dispatch etc.)

H. OWNERSHIP

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H 1:

The **ownership** of DG is not relevant for the suggested definition.

Comment:

Different international experience regarding the ownership of distributed generation;

ownership of DG could be mentioned, for example, **independently-owned distributed generation**.

I. PENETRATION

I 1:

The **penetration level** of DG is not relevant for the suggested definition.

Comment:

The definition of the penetration level itself is problematic.

The amount of DG must be put into relation to an area, e.g. local distribution system or nation-wide power network.

DEFINITION DISTRIBUTED GENERATION

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Distributed generation is an electric power source connected directly to the distribution network or on the customer site of the meter.

WHAT ARE DISTRIBUTED RESOURCES?

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According to Moskovitz distributed resources are:

"demand- and supply-side resources that can be deployed throughout an electric distribution system (as distinguished from the transmission system) to meet the energy and reliability needs of the customers served by that system. Distributed resources can be installed on either the customer side or the utility side of the meter."

DISTRIBUTED RESOURCES CONSISTS OF TWO ASPECTS:

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- **Distributed generation**, located within the distribution system or on the customer side of the meter, and

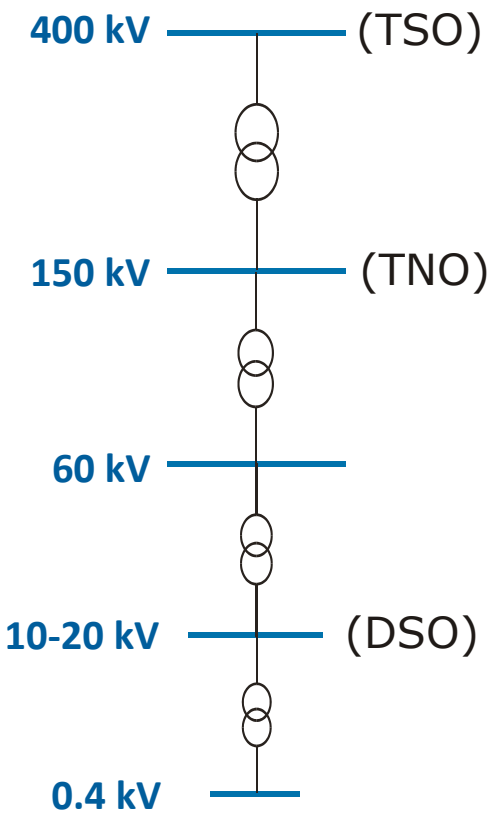
- **Demand-side resources**, such as load management systems, to move electricity use from peak to off-peak periods, and energy efficiency options, e.g. to reduce peak electricity demand, to increase the efficiency of buildings or drives for industrial applications or to reduce the overall electricity demand.

WHAT IS DISTRIBUTED CAPACITY?

Distributed capacity includes all aspects of distributed generation and distributed resources plus reserve capacity, e.g. stand-by generators or load management, to minimize the requirements for overdimensioning of transmission/ distribution system.

EUROPEAN EXAMPLES

PRODUCTION UNITS/VOLTAGE LEVEL WESTERN DENMARK (STATUS 2013)

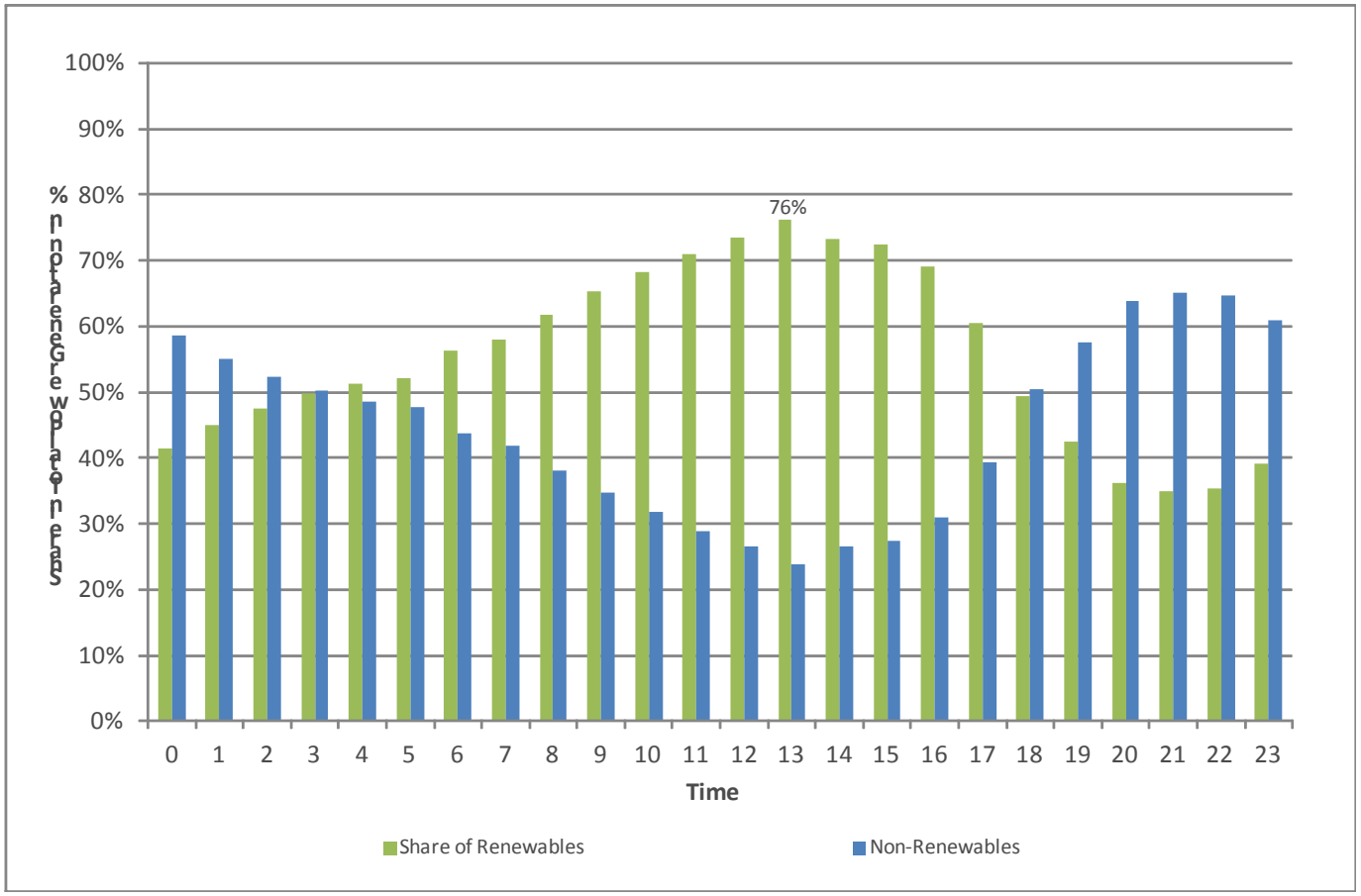


Capacity	Capacity Sum	Units
1,488 MW		4 Primary Power Stations
1,914 MW		5 Primary Power Stations
160 MW		80 Wind Turbines
	3,562 MW	
589 MW		16 CHP (18 Gen)
41 MW		34 Wind Turbines
1,093 MW		543 CHP (734 Gen)
2,179 MW		4,047 Wind Turbines
2 MW		1,000 PV Units
	3,904 MW	
	7,466 MW	

Source: ENERGINET.DK / National Danish TSO

SHARE OF DG IN GERMANY – PART 1

11 May 2014 at 13:00: 76 % Power Supply through Renewables



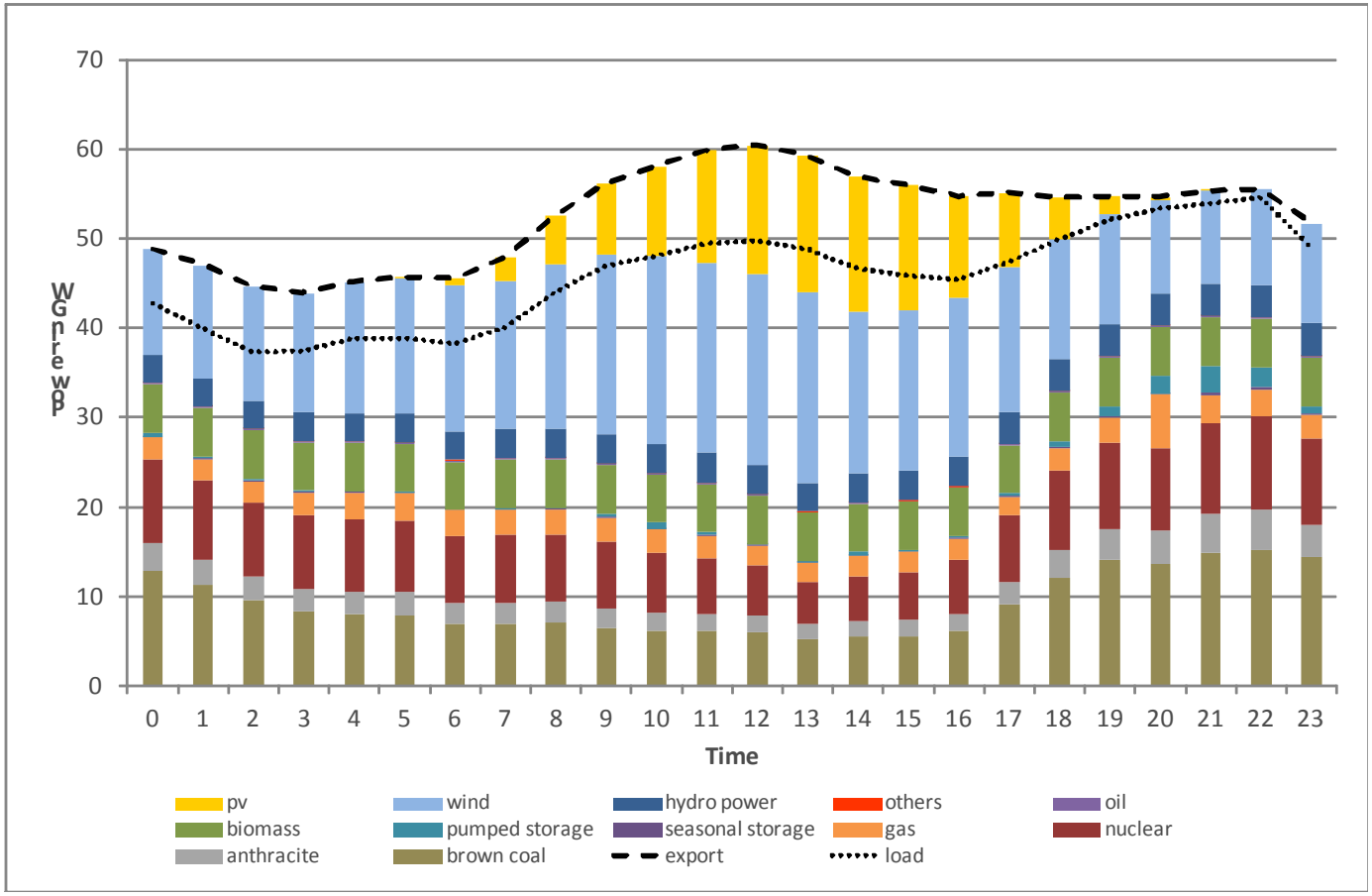
- The share of renewables on this day amounted to 76% at 1:00 pm with 45,12 GW of power supply

Figure: Percentage of renewables and non – renewables on total power generation.

* Difference due to methodological approach: press release - data of Agora - Energiewende, here: data from the Fraunhofer ISE and own calculations
Source : EEX, ISE Fraunhofer, own diagram, last downloaded on 04.08.2014

SHARE OF DG IN GERMANY – PART 2

11 May 2014: Share of DG at 13:00 – approx.: 65%



- Power generation exceeds the load
- Surplus is exported to neighboring countries (export - commercial)

Figure: Vertical load of the transmission system operators as well as wind- and PV-power-generation.

Source : Tennet, 50 Hertz, Amprion, TransnetBW, own diagram, last downloaded on 05.08.2014

THE POWER GRID

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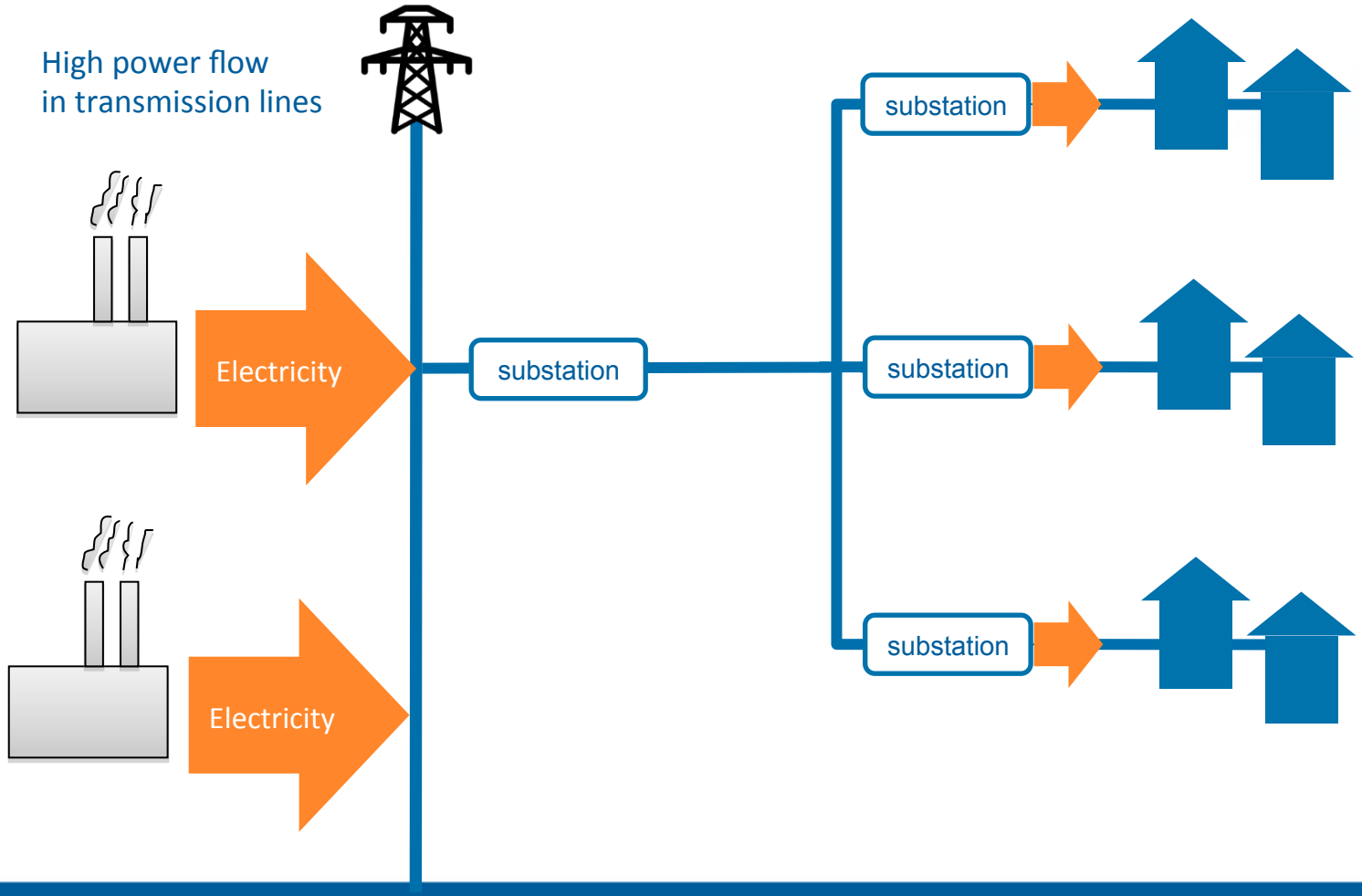
Classic model



THE POWER GRID

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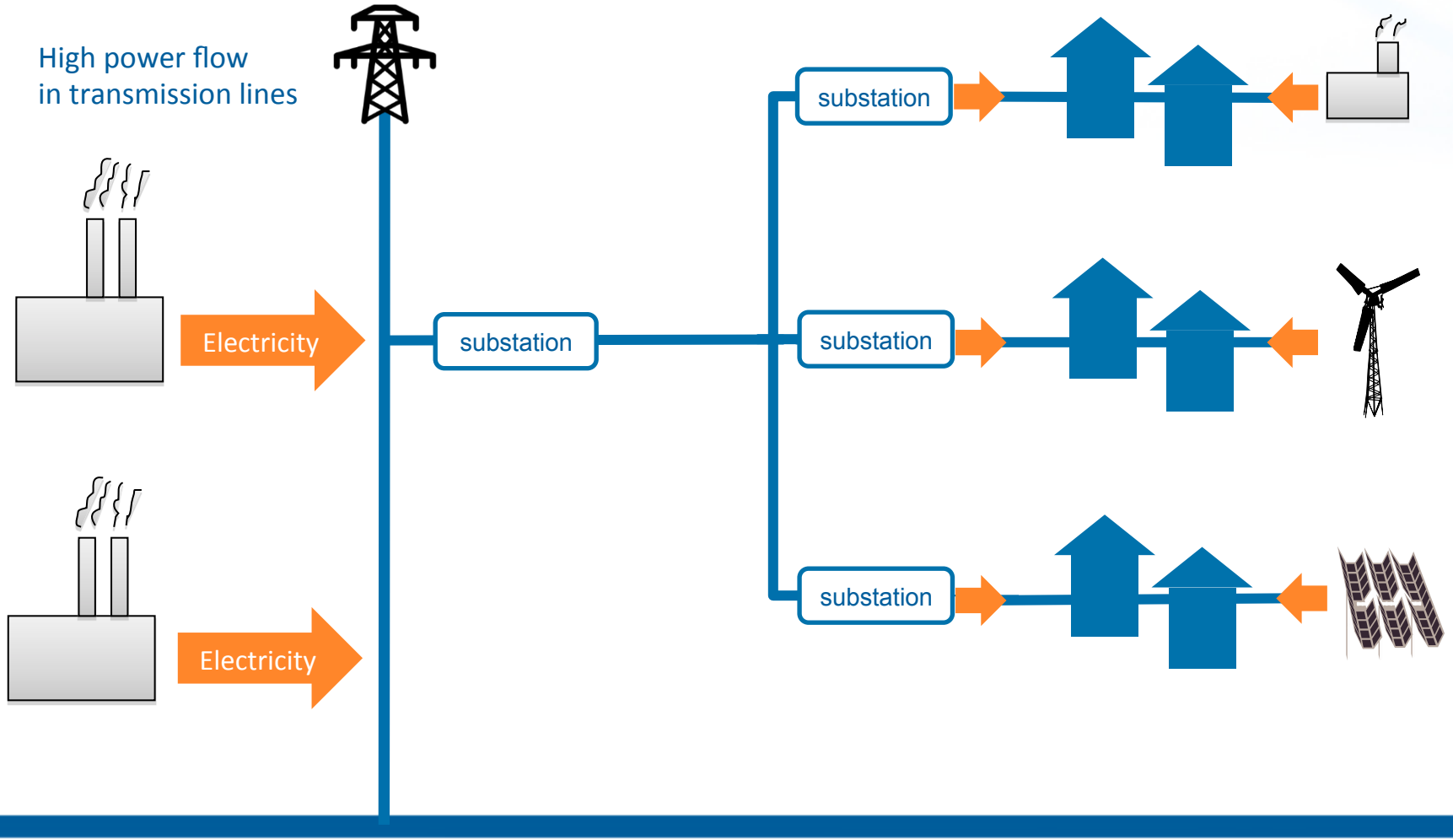
With small amount of distributed generation



THE POWER GRID

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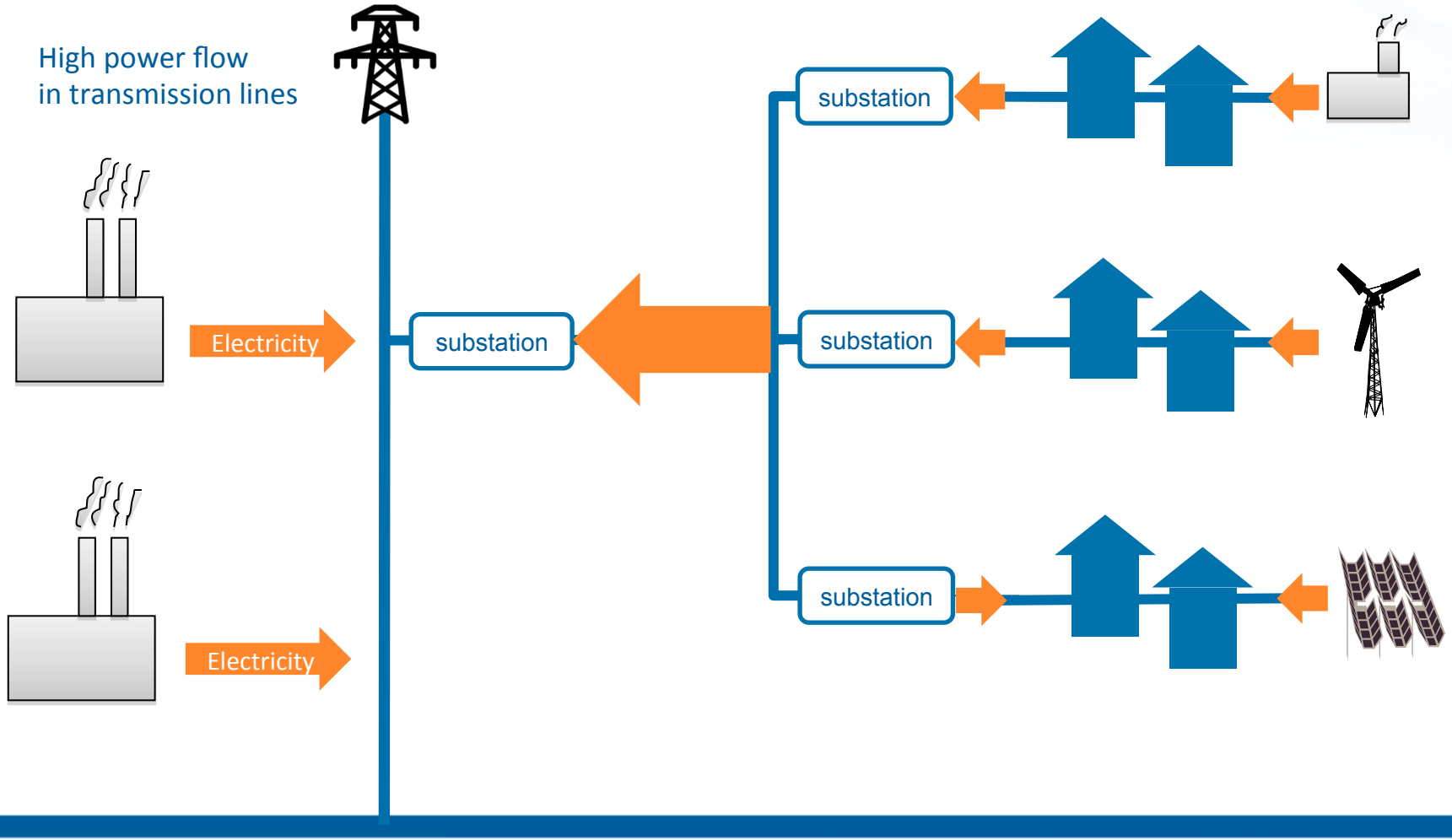
With large amount of distributed generation



ECONOMIC SITUATION OF DG

THERE IS GOOD NEWS AND BAD NEWS FOR THE COST OF DISTRIBUTED RENEWABLE GENERATION.

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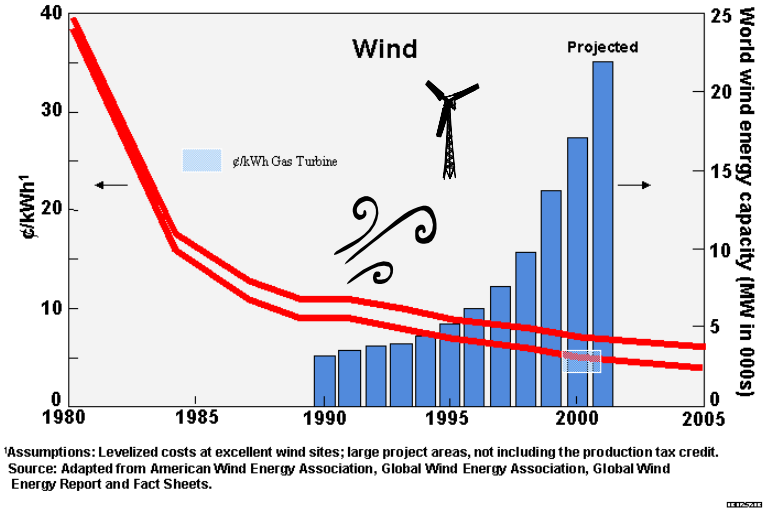
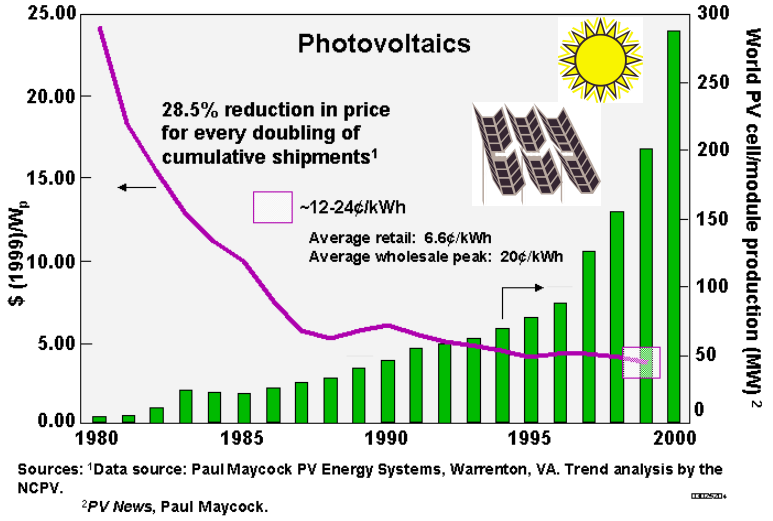
Historic Cost Curves



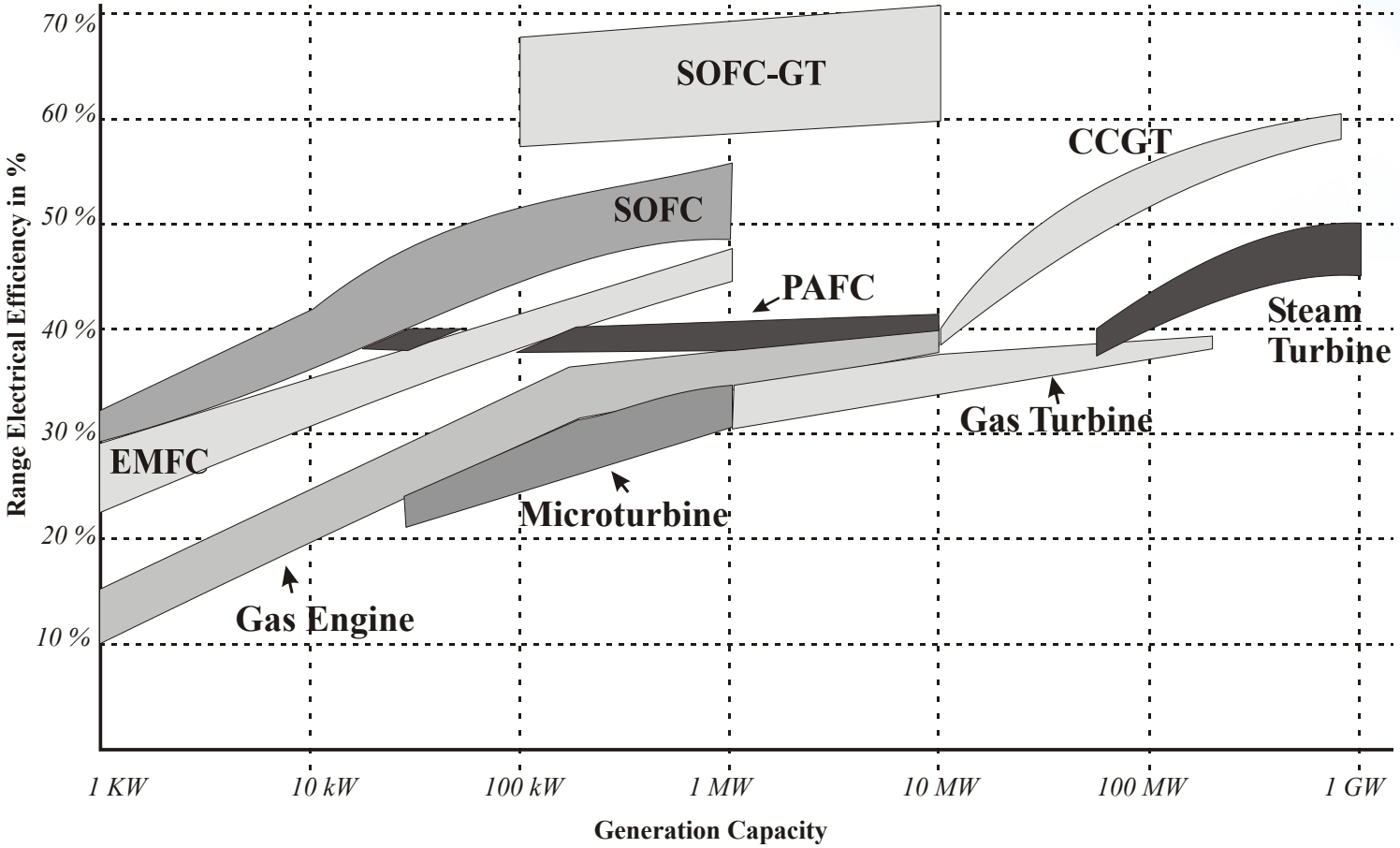
[1]Assumptions: Levelized costs at excellent wind sites; large project areas, not including the production tax credit.
Source: Adapted from American Wind Energy Association, Global Wind Energy Association, Global Wind Energy Report and Fact Sheets.



Sources: [1]Data source: Paul Maycock PV Energy Systems, Warrenton, VA. Trend analysis by the NCPV.
[2]*PV News*, Paul Maycock.

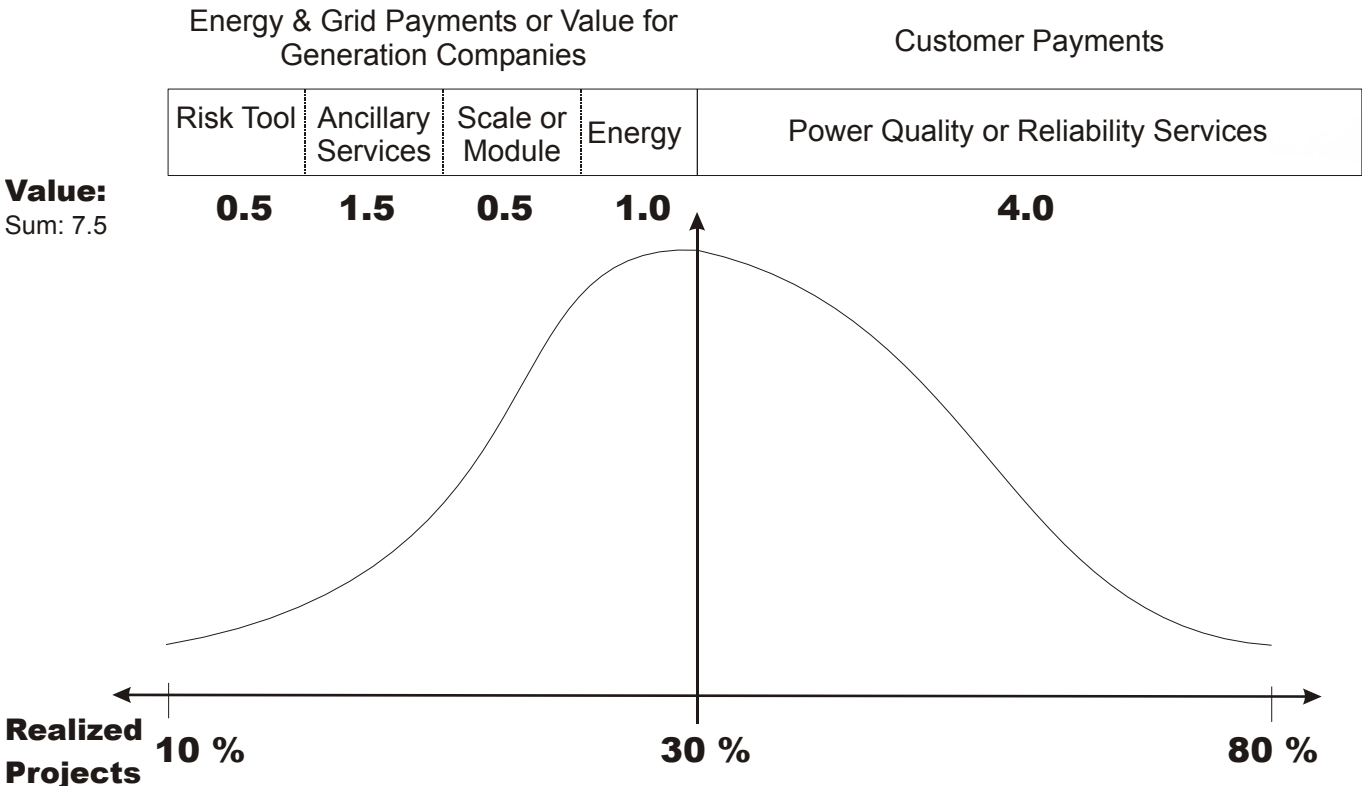
The costs of renewables have steadily decreased over the last few decades, but so have the costs of other energy forms...

EFFICIENCY DG TECHNOLOGIES



SOFC = Solid Oxide Fuel Cell

SECOND – REVENUE STREAM NON RENEWABLE DG



SECOND REVENUE STREAM FOR COMBINED HEAT AND POWER

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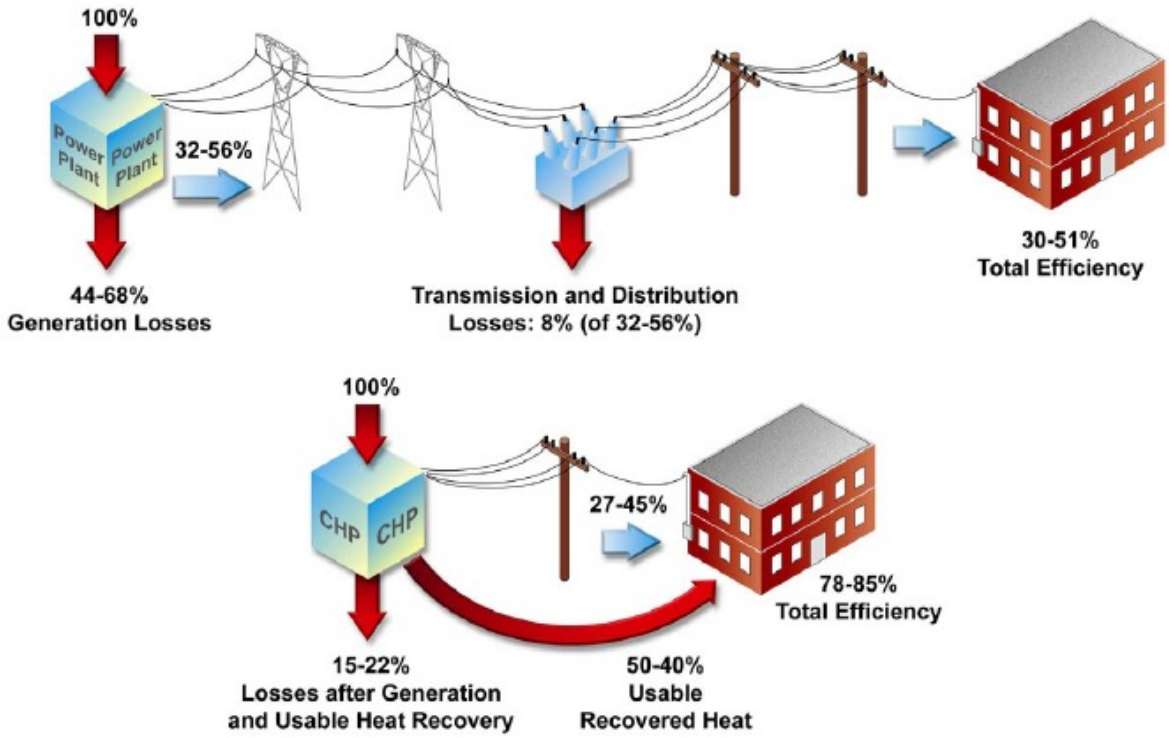

CONCLUSION

DG WILL SCRAP MANY OLD ASSUMPTION REGARDING GRIDS AND ENERGY DELIVERY

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THANK YOU FOR YOUR ATTENTION!