A vision of sustainable energy future: A multi-energy concept of smart energy systems

Central European Student and Young Professionals Congress

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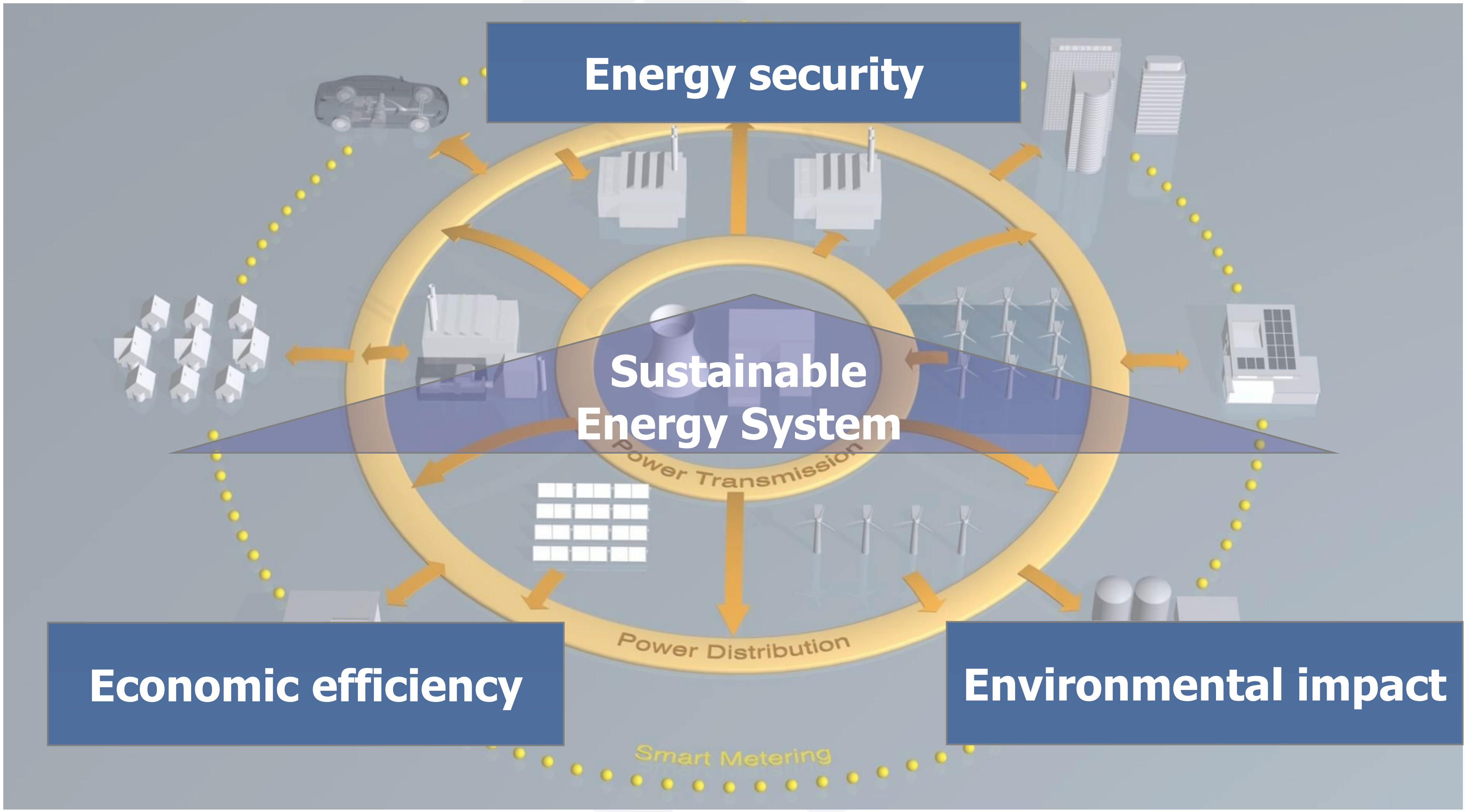
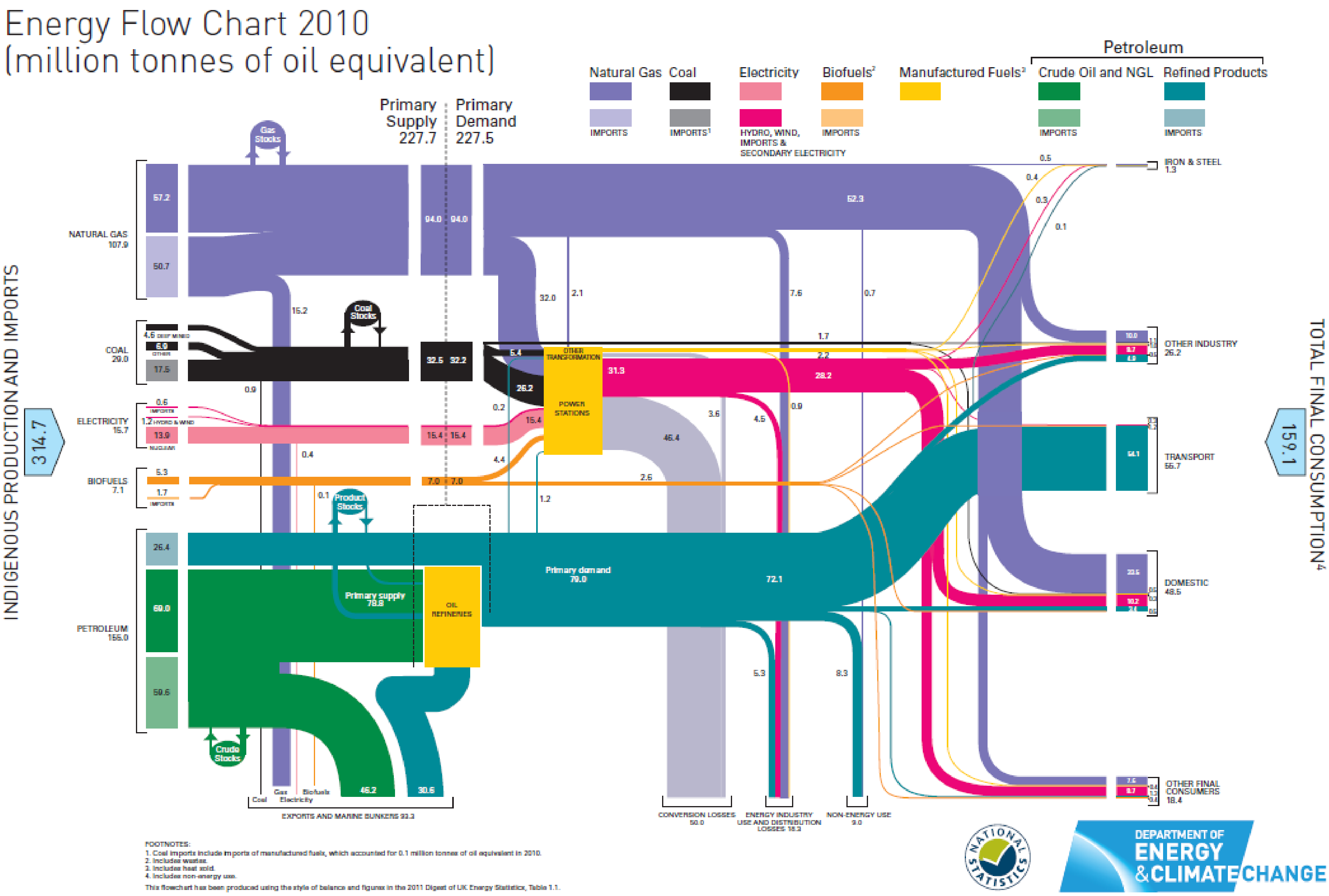
SUSTAINABLE ENERGY FUTURE



CHALLENGES

- Reducing carbon intensity
  - Today: electricity CO_2 share ≈ 30% (USA 35%, UK 33%)
  - Today: heat CO_2 share ≈ 50% (EU average)
  - 14200 million tons of CO_2 emissions annually
  - > 400 ppm CO_2 in 2013
- More Renewable Energy Sources (RES)
  - 20% energy from RES by 2020. - EU 20-20-20(10)
  - 100% energy from RES by 2050. (Denmark, Sweden, Germany, UK 80%)
- RES: clean but variable and uncontrollable generation
  - Forecasting methods can reduce the variations; no method is 100% accurate
  - To balance the system more reserve is needed

IT'S NOT ONLY ABOUT ELECTRICITY…

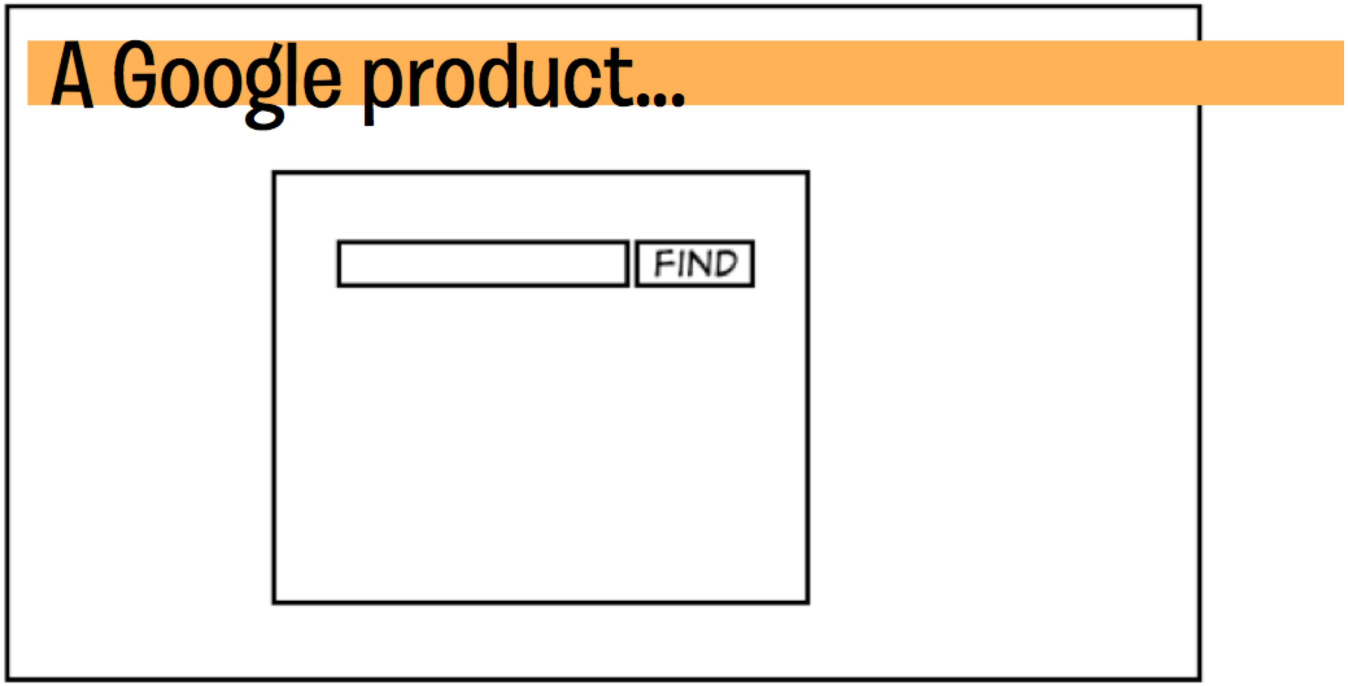


CHALLENGES

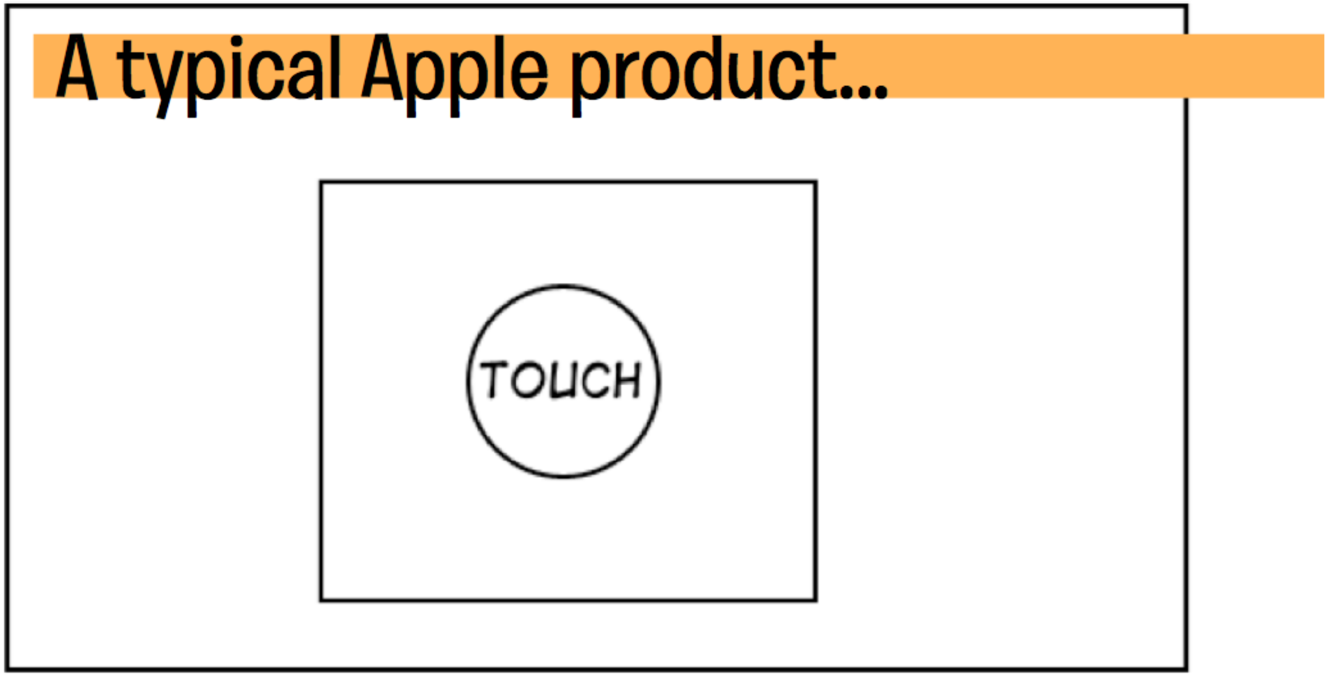
- Intelligent and efficient use of energy
  - How?
  - Shifting the consumption?
  - Energy savings?
  - How much does that cost (€) (ICT, meters etc)?
  - Consumer: What do I get for it (€)?
  - Is this the best solution solution?

Question: would you buy a Smartphone if it required from you to know how to program on Android/iOS in order to use it?

ENGAGING CONSUMERS – HOW?

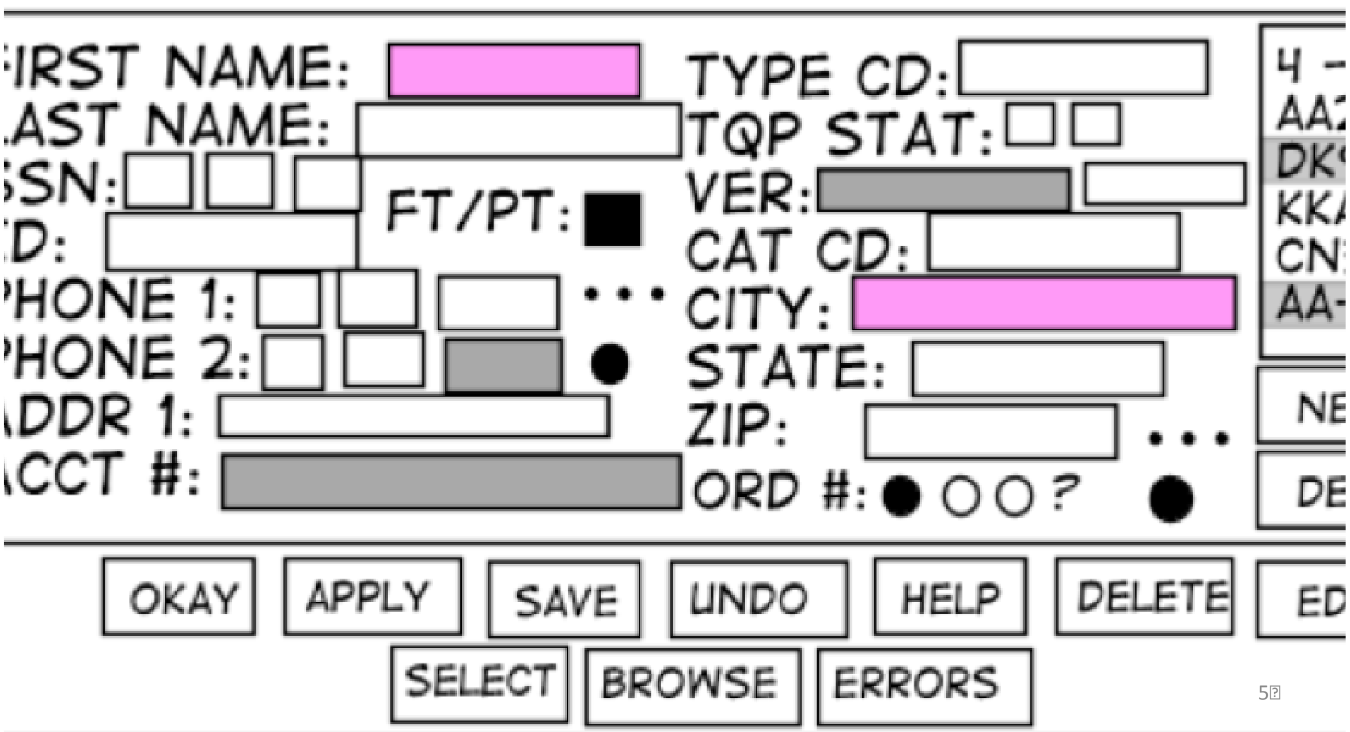


AESTHETIC, SIMPLE



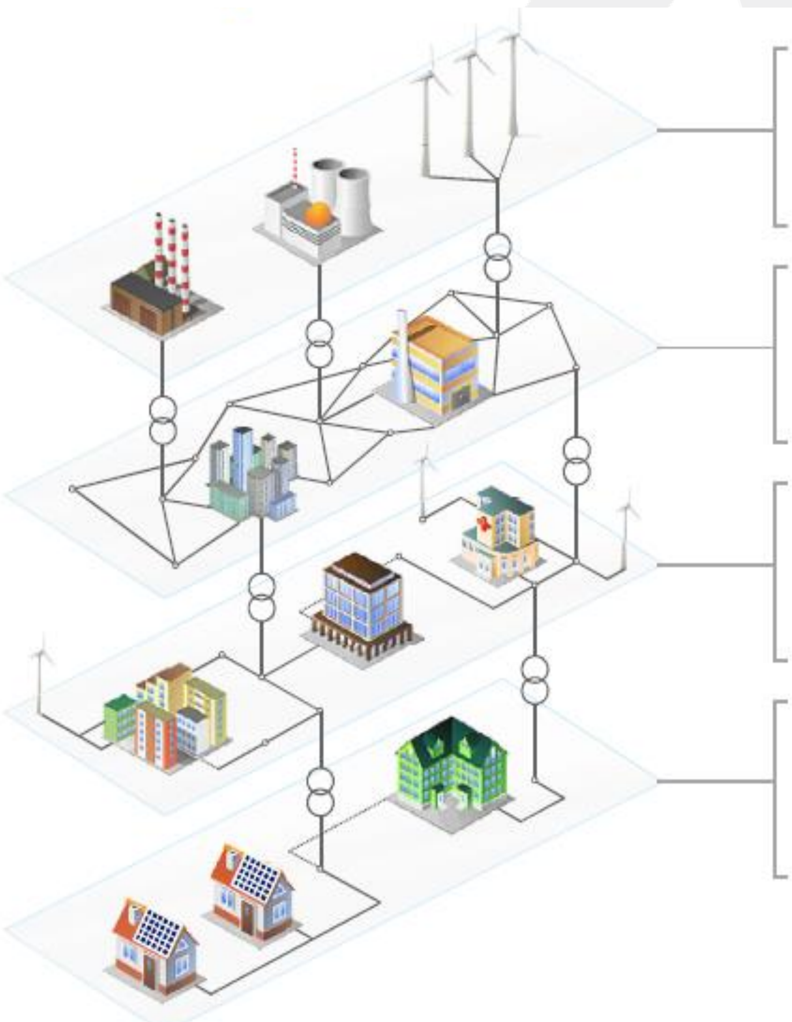
TYPICAL SMART METER

Your company's app...



IT SHOULD LIKE THIS!

HOW DOES IT WORK TODAY



Central Large Generation (small scale wind)
50 - 25000 MW

Transmission Network
Voltage levels 110 – 1200 kV (AC or DC)

Distribution MV System (6 – 35 kV)
Distributed Generation (RES included)
1 – 25 MW

Distribution LV System (110 – 1000 V)
Local Generation (RES included)
0.005 – 1 MW

HOW WILL IT WORK TOMORROW?

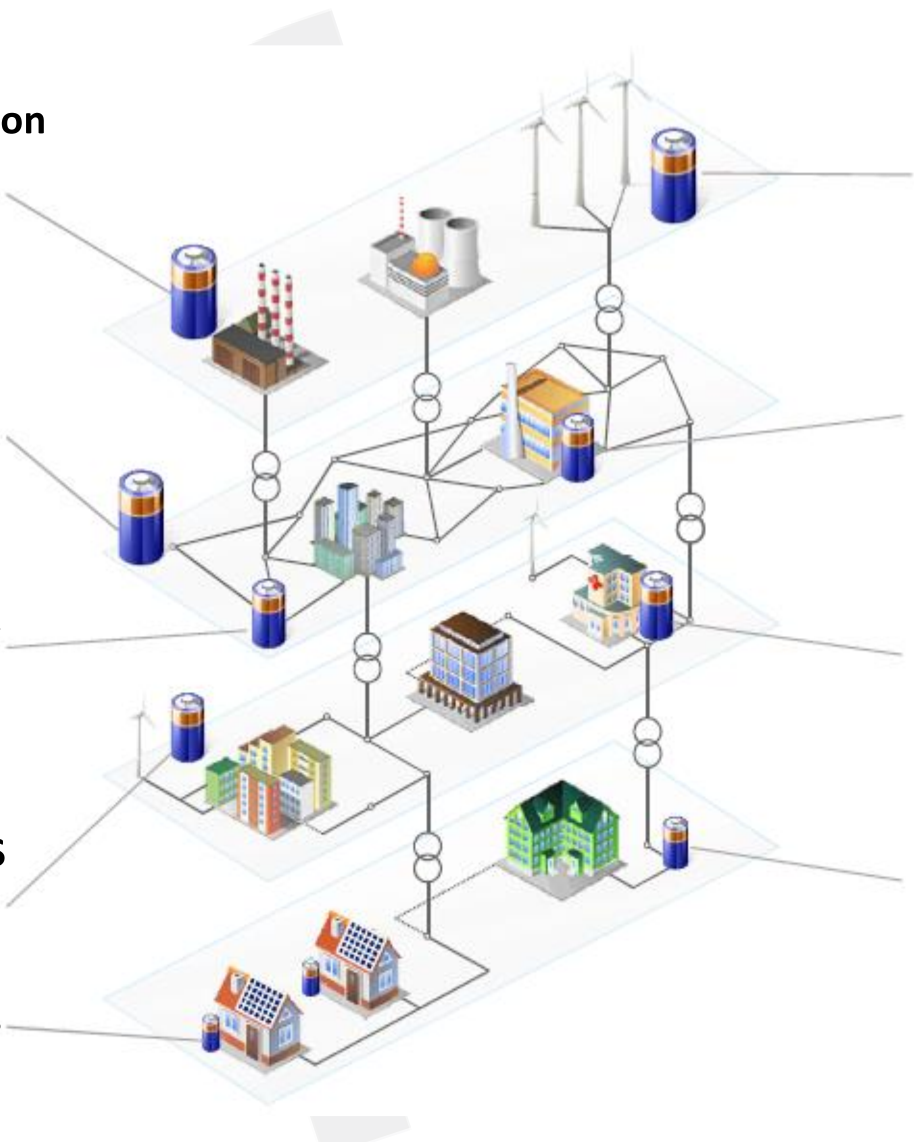
Balancing large generation
10-100 MW, 1-4 h

Balancing Transmission Network Requirements
10 – 100 MW, 1-4 h

Regulation of frequency
1-20 MW, 0.25-1 h

Balancing Local RES
1 – 10 MW, 1-6 h

Managing Smart Homes
1 – 10 MW, 1-6 h



Large Scale Renewable Energy (Wind, Solar)

Industry Prosumers (local generation)

Local Generation in Buildings (RES)

Smart Homes, Smart Buildings

HOW DO WE GET THERE?

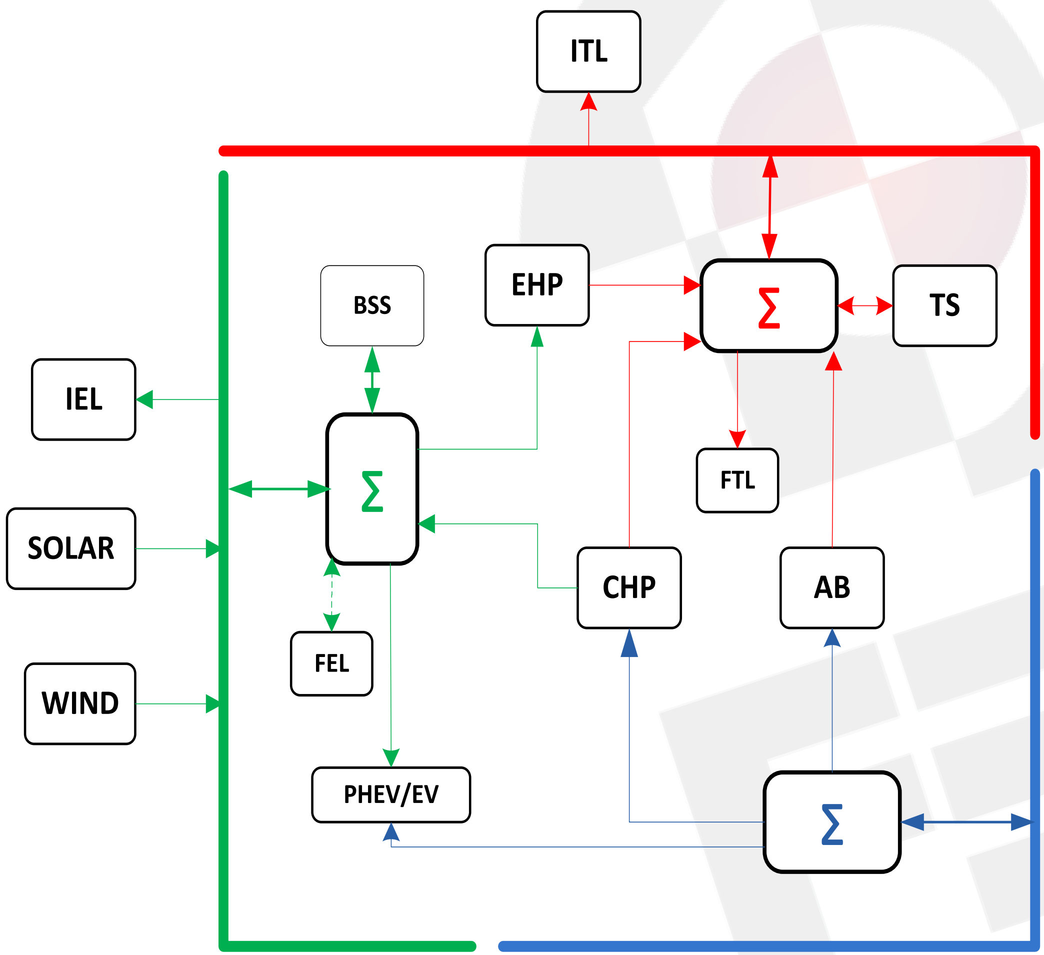
- Multi-energy concept
  - Transition concept towards „clean” energy system
- Integrated infrastructures
  - Different energy vectors are rarely interconnected today (cogeneration plants)
- Control of energy demand not done by a consumer
  - Consumer demands (energy) service and pays for it,
  - Controlable unit optimizes its operation to provide the cheapest service (makes profit),
  - Shiffting between energy vectors (gas,electricity) these units are capable of always selecting the lowest cost option
- Flexible multi energy producers
  - Cogeneration, trigeneration, multi-generation

MULTI-GENERATION CONCEPT

- Smaller units closer to the consumers
  - District heating, local CHP, local EHP.
- Coupling units – more efficient, more flexible
  - Cogeneration with thermal storage, cogeneration and electric heat pump.
- Optimal coordination between coupled units
  - Shifting between different energy vectors.
- Using the existing infrastructure
  - Gas networks for hydrogen (from RES).

INTEGRATED ENERGY SYSTEM

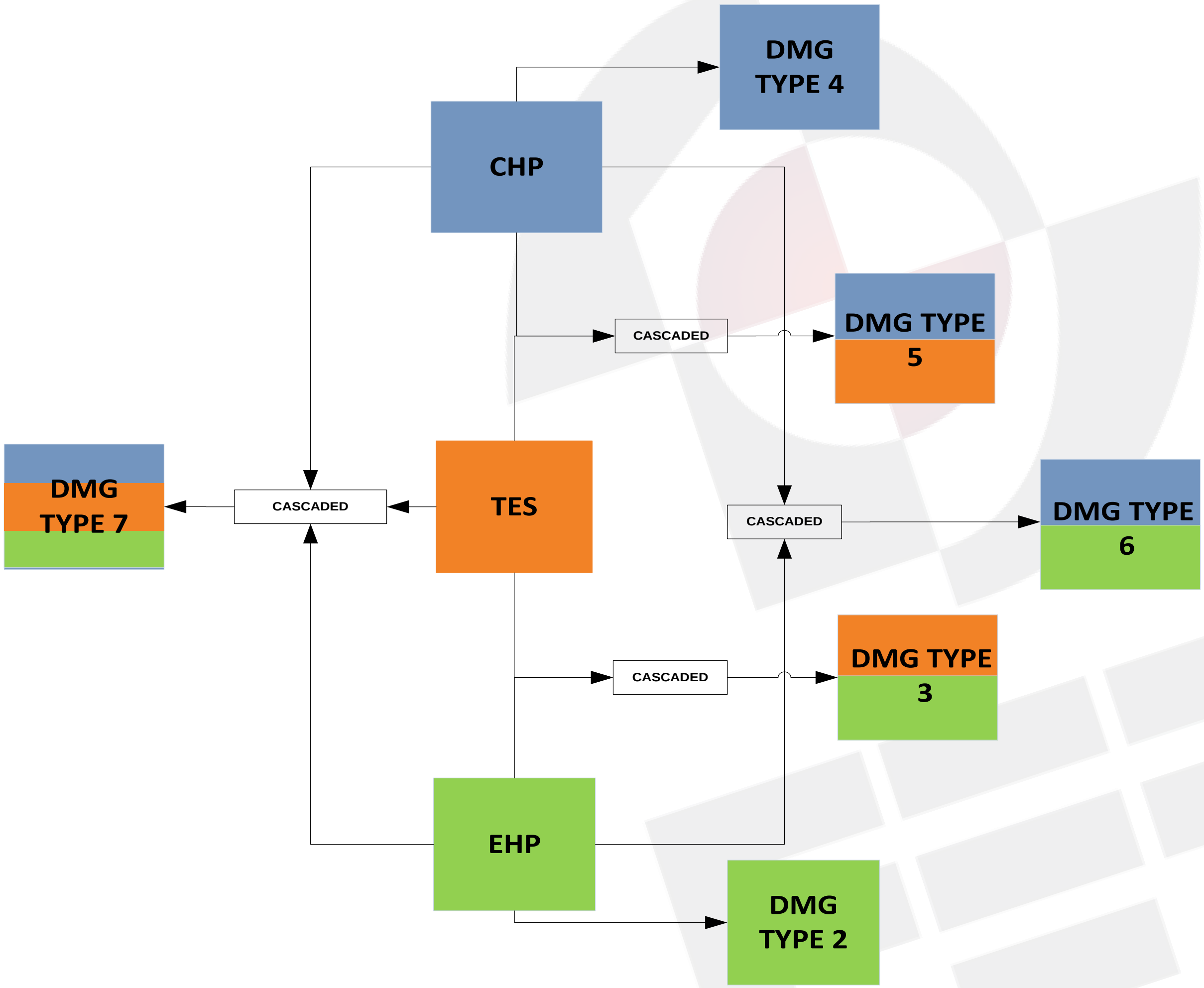
- Interactions between different systems



BSS		Battery Storage System
EHP		Electric Heat Pump
CHP		Cogeneration unit
FTL		Flexible thermal load
ITT		Inflexible thermal load
AB		Boiler
FEL		Flexible electric load
IEL		Inflexible electric load
PHEV/EV		„Plug-in” hybrid electric vehicle/Electric vehicle
TS		Thermal storage

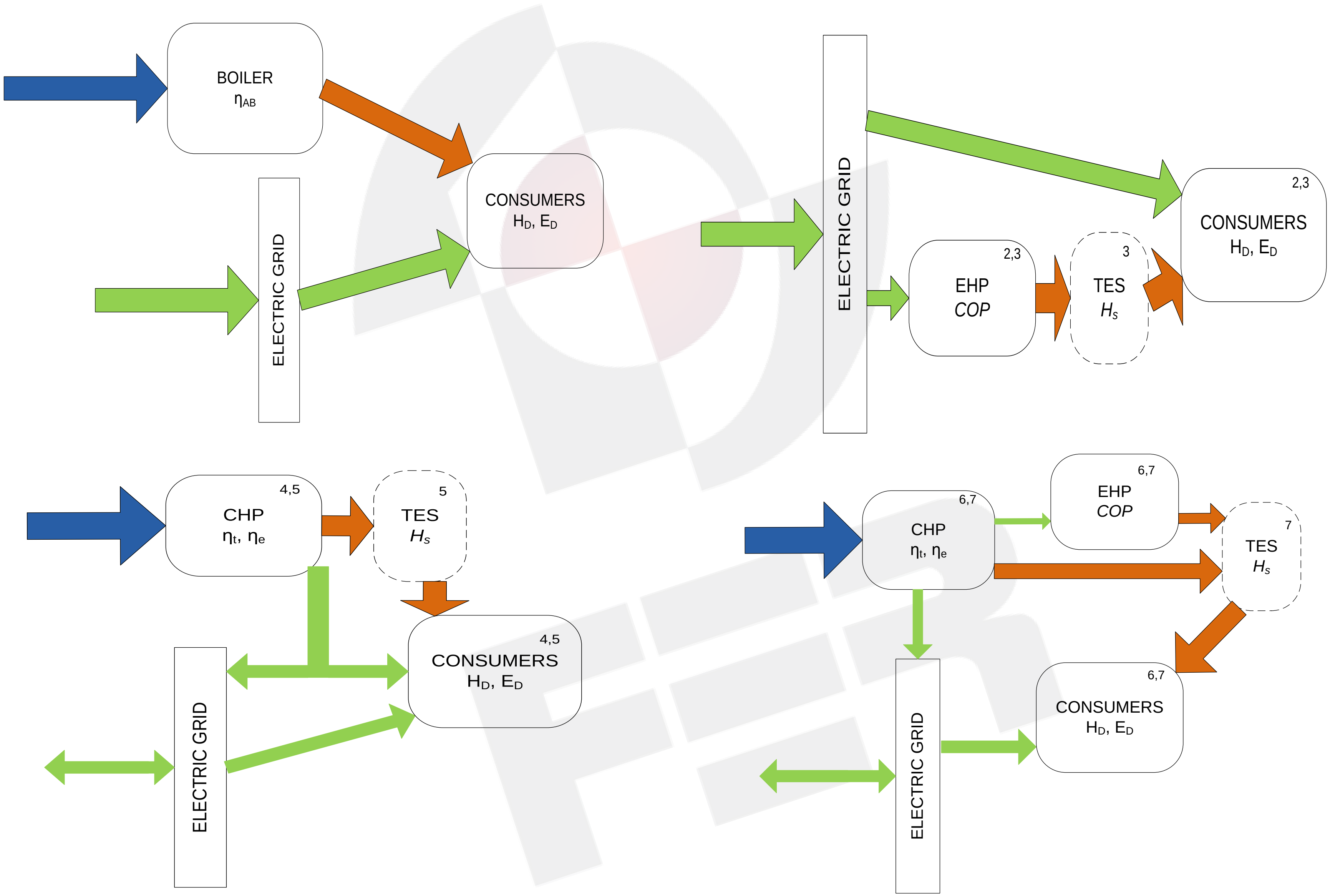
Heat
Gas/Fossil fuel
Electricity
Energy flow

SIMPLE DMG CONCEPT



- Defining different DH concepts – 7 types
- Building up from single unit types to complex interacting units

DMG DH CONCEPT



DMG TYPES

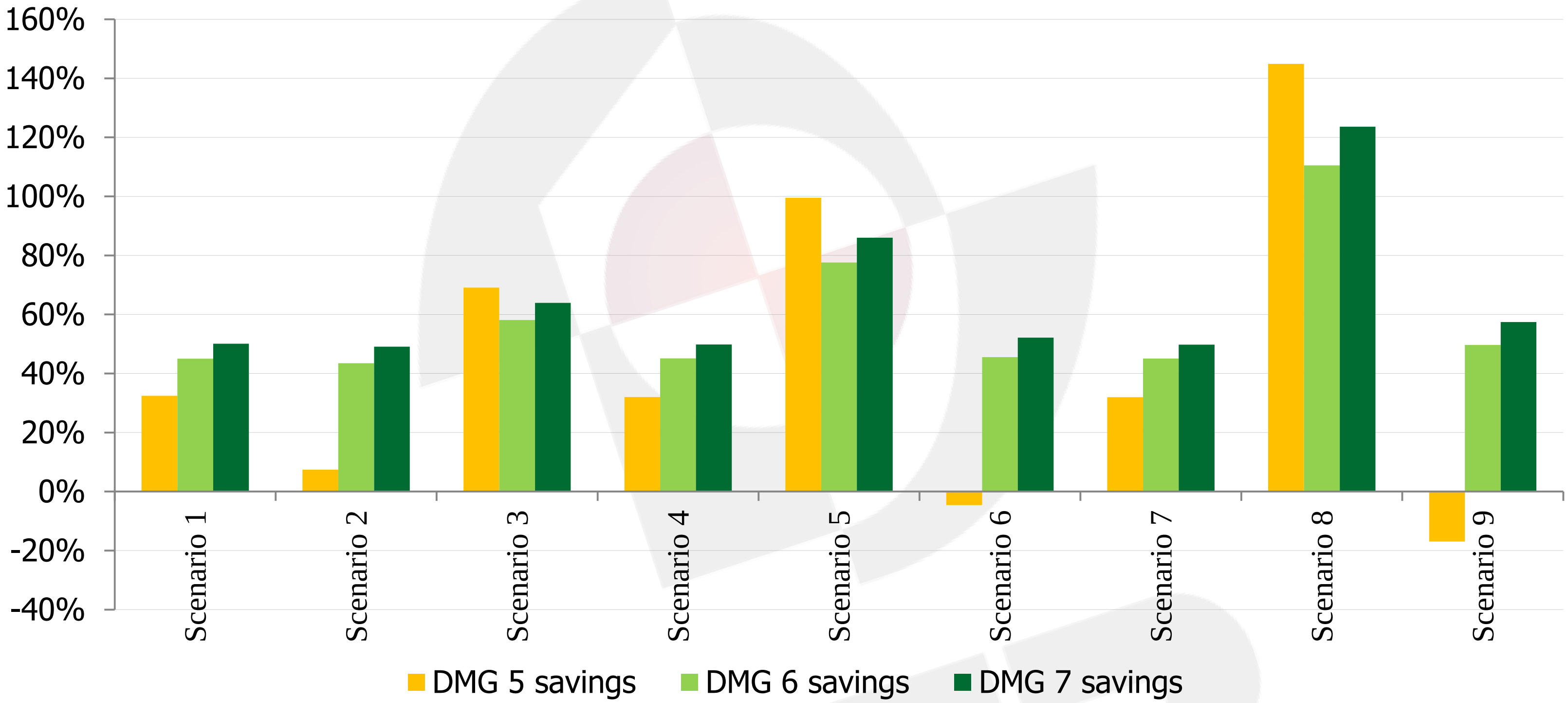
- Type 1: Separate energy vector production
  - How efficient is this? How flexible is this?
- Type 2 and 3: Electric heating as a solution
  - More efficient? How renewable is this?
- Type 4 and 5: Cogeneration, coupled with TES
  - Flexible response, depends on the size of the storage
- Type 6 and 7: Unit coupling
  - Using the best of units characteristics, flexible DMG, lower operation cost, shifting between different energy vectors

ECONOMIC ANALYSIS

Unit type	Operation cost (€/a)	Savings (%)
Boiler + Grid	625,440.00	-
EHP	479,599.00	-23.32
EHP + Storage	425,412.00	-31.98
CHP	462,691.00	-26.02
CHP+Storage	422,436.00	-32.46
CHP+EHP	342,684.00	**-45.21**
CHP+EHP+Storage	312,198.00	**-50.08**

- Operation cost for EHP based DMG types is 23% and 32% lower
- Operation cost for coupled DMG units (CHP+EHP) is 45% and 50% lower
- What happens under different market conditions (different gas and electricity prices)?

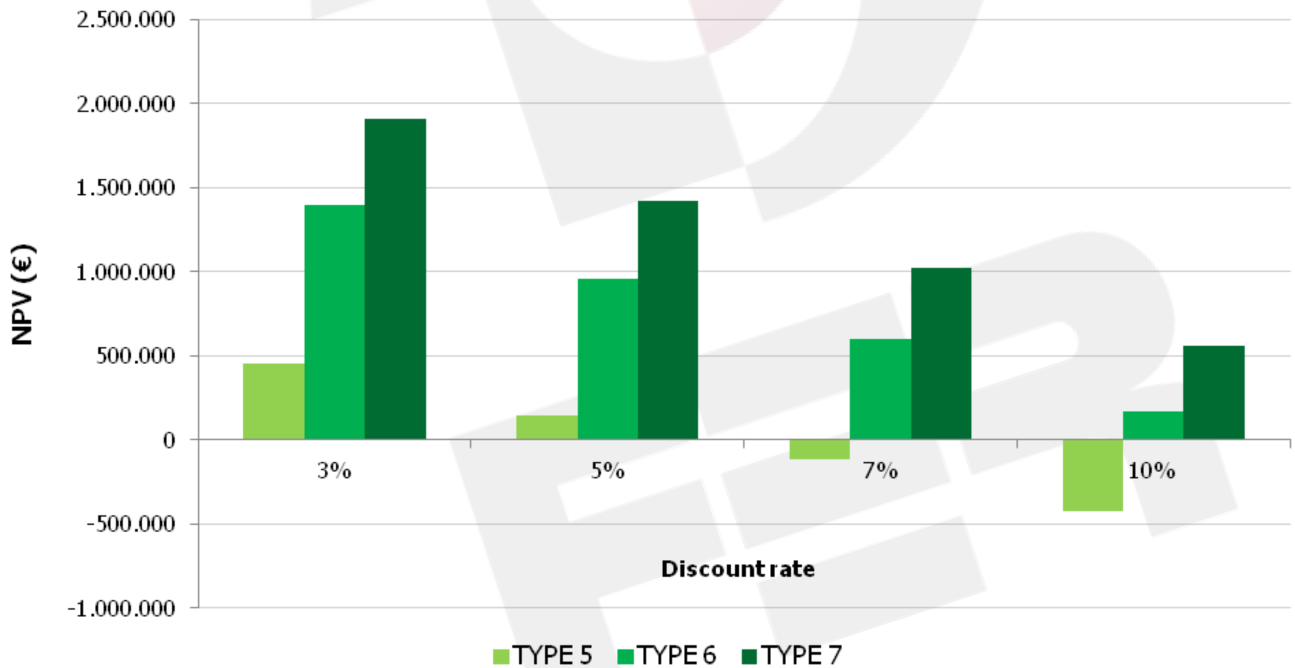
ECONOMIC ANALYSIS



- Sensitivity analysis - Changing gas and electricity prices ±50%
- Operation cost reduction for all cases, especially for DMG types combining CHP and EHP

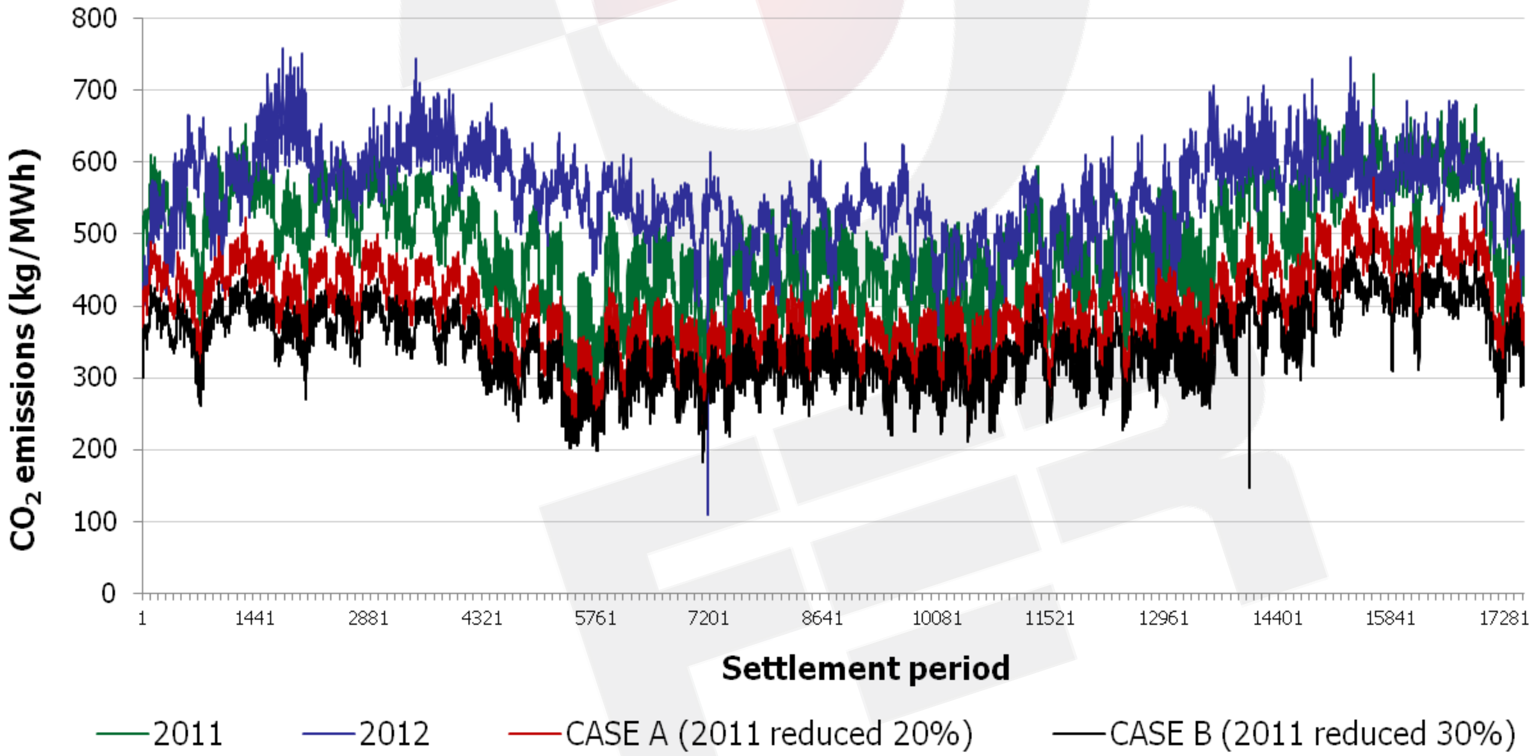
INVESTMENT ANALYSIS

- Higher NPV for type 6 and type 7 units
- Faster return of investment
- Less sensitive to higher discount rates



CO_2 EMISSIONS

- AEF (*Average Emission Factor*) is a calculated value of system level CO_2 emissions in each settlement period based on each power plants dispatch in that settlement period (real values for UK in 2011 and 2012)



CO_2 EMISSIONS

- DMG CO_2 emissions savings can be more than 40%
- Local production is treated as displacing emissions from central production
- EHP CO_2 emissions are highly dependable on the electricity production mix (AEF = average emission factor)
- Lower grid (system) average emission factor, lower CO_2 emissions by EHP

	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5	TYPE 6	TYPE 7
CO_2 savings (%)	0	9.9	10.1	36.9	42.4	34.1	34.2

LOCAL EMISSIONS

- Local emissions – relevant for DG options, close to consumers
- Limited range, around 100 km
- EHP is the most friendly option in terms of local emissions
- DMG type 7 does not increase local emissions of No_x
- Each fuel based option increases CO emissions between 3 and 8 times (DMG types 4 – 7)

	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5	TYPE 6	TYPE 7
NO_x (t/a)	3.151	0.196	0.117	6.932	7.555	3.34	3.150
CO (t/a)	0.630	0.039	0.023	3.607	4.097	1.86	1.791

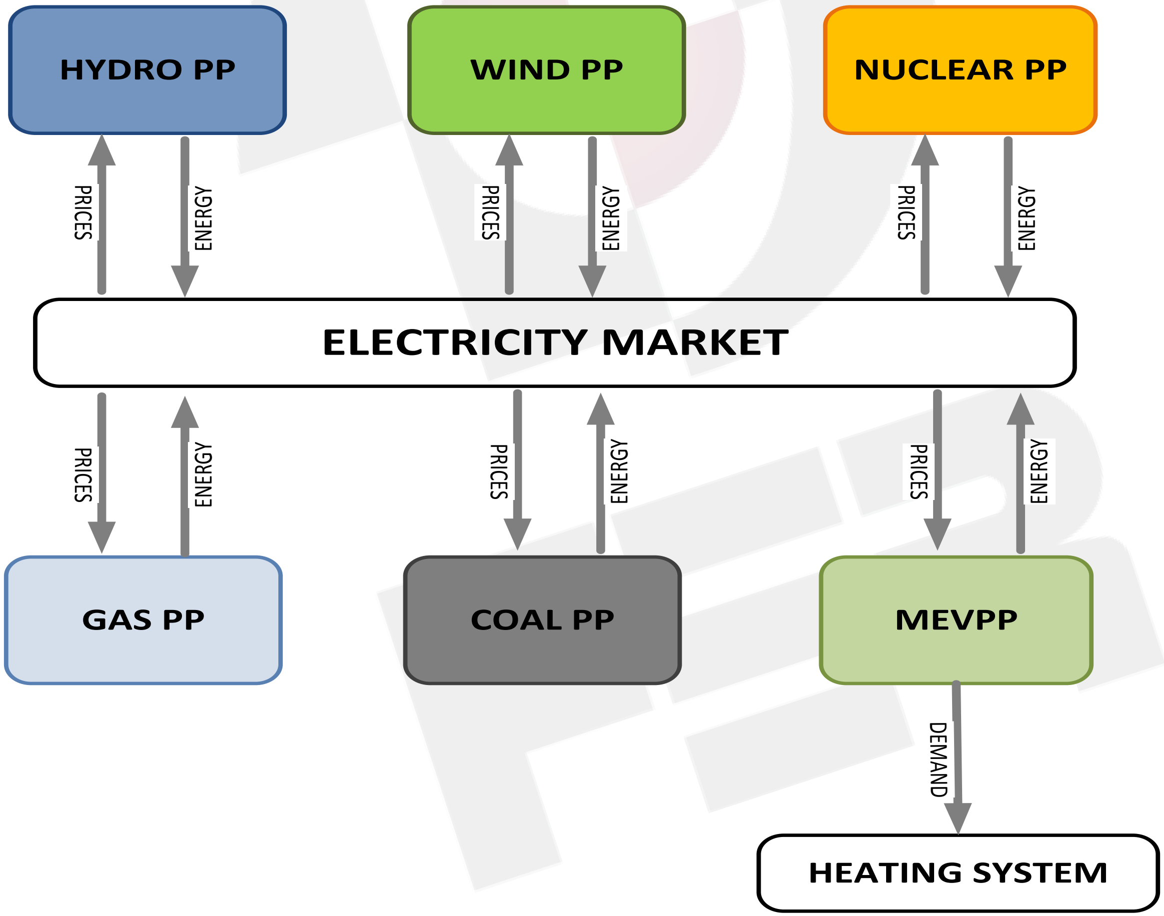
PRIMARY ENERGY SAVINGS

- Primary energy savings are extremely important
  - Energy Efficiency (EU says: 20% more efficient than today)
  - Dependency on „imported" fuel
- EHP based DMG have around 27% (8%) primary energy savings
- Primary energy savings of 40% (30%) for DMG type 7

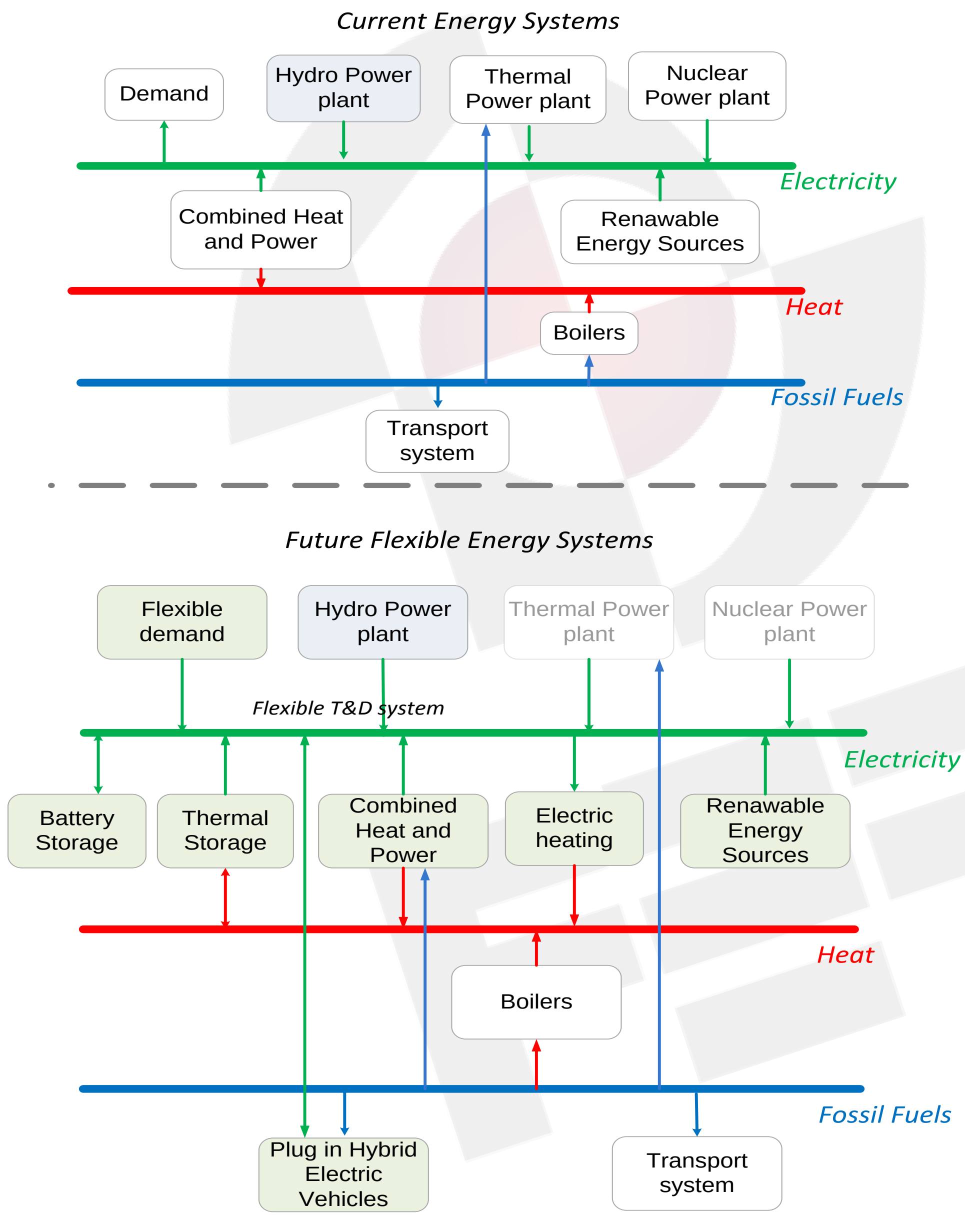
	PPES **(UK avg. 2012)**	***PPES*** **(CCGT)**
DMG TYPE 1	0.000	0.000
DMG TYPE 2	0.181	0.309
DMG TYPE 3	0.183	0.318
DMG TYPE 4	0.268	0.065
DMG TYPE 5	0.286	0.079
DMG TYPE 6	**0.386**	**0.284**
DMG TYPE 7	**0.403**	**0.310**

VIRTUAL MULTI-ENERGY POWER PLANT

- *Virtual Multi-Energy Power Plant* (VMEPP) is a cluster of flexible multi-generation units supplying local heat demand and participating in electricity market as a single entity.



VISION OF FUTURE OF ENERGY



CONCLUDING REMARKS

- Multi-energy as low carbon „transition” concept
  - Expandable (EV, batteries) – additional value
  - Modular – e.g. type 7 to type 3 in future 100% renewable system
- Operational cost savings
  - Over 50%!!!
  - Imagine your energy bills „cut” in half!
- Primary energy savings
  - Over 40%
- Reduced global CO_2
  - Over 40%
  - By 2020 we should reduce them by 20% -long term good decision
- Distributed multi-energy systems as key component for low-carbon and energy efficient Smart District and Cities

CONCLUSIONS

- 2020?
- 2050?

CONCLUSIONS

- Act now
- But, think of the final goal

QUESTIONS AND DISCUSSION