Building Resilient & Sustainable Energy Supply Systems

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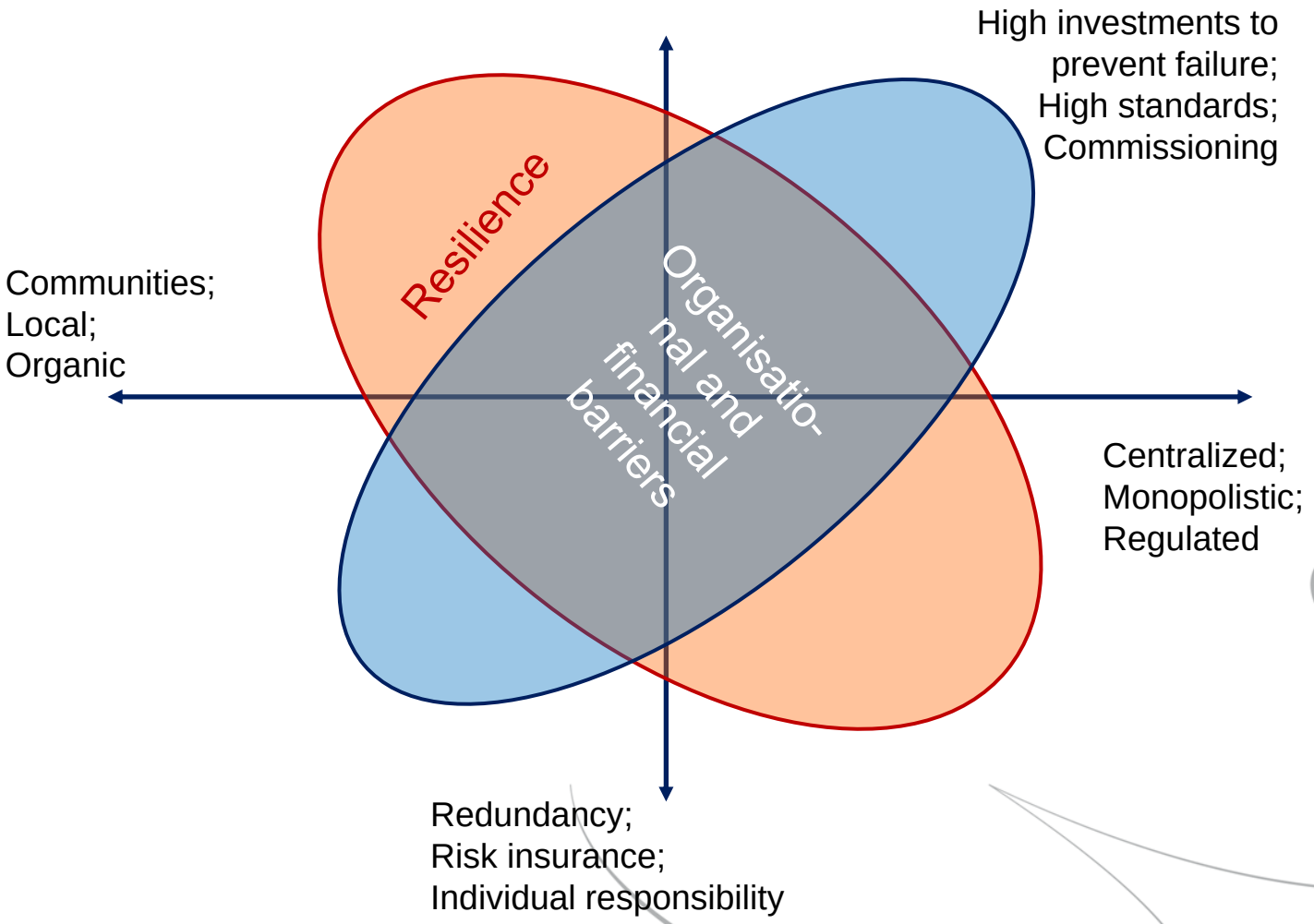
Stimulators for Enhanced Resilience

- Redundancy: In technical terms, this means that certain components or functions are duplicated, so that the whole will continue to function properly if a component fails – the costs of redundancy must be assessed against the risk of failure/disruption

- Diversification of sources and customer profiles: variety of functions (living, working, industry, commerce, recreation) gives a better distribution in time for the energy needed and increased opportunities for interchange

- Hybrid systems: a combination of centralized with local supply (bottom-up- or/and peer-to peer systems) gives fall back opportunities for local incidents and centralized infrastructure can be limited due to simultaneity advantage.

Resilient Urban supply: centralized or localized?



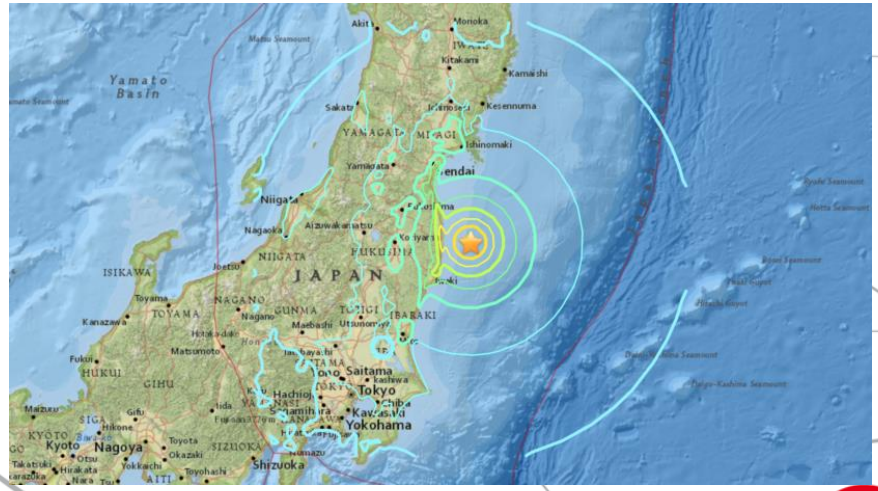
Failures in centralized infrastructure

Amsterdam Jan 2017, 340.000 households

Utrecht Feb 2017, 14.000 households

Fukushima March 2011

Is local the solution to this?



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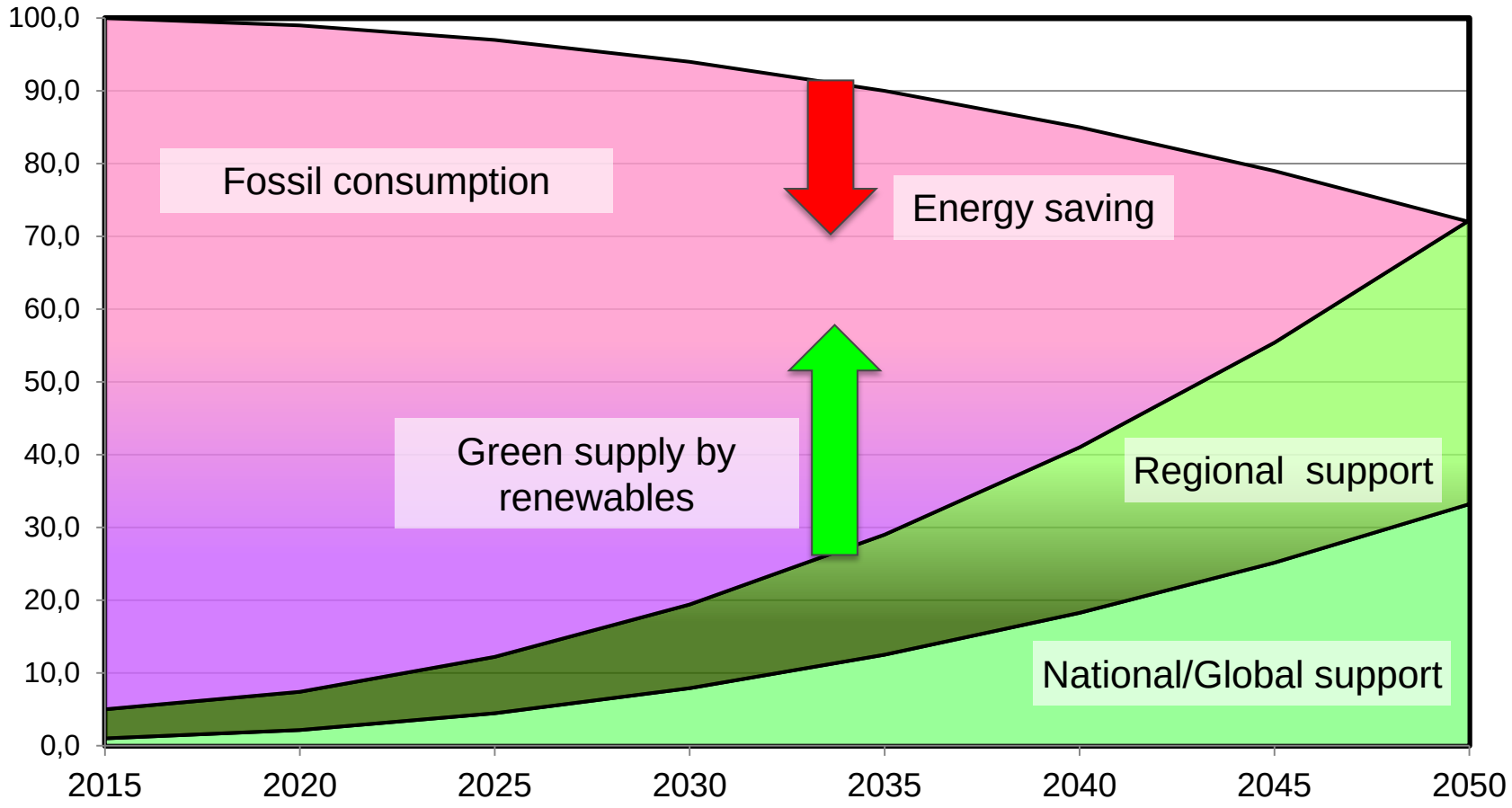
Resilient future energy scenario



Current roadmaps for greening the supply

There is a lot of effort in PV, wind, bio-energy, heat pumps and electric transport.

Problems (among other disadvantages):

- Hinderance (f.i. wind-turbines)
- Spatial restrictions (for biomass production)
- Fluctuating supply not matching demand (for solar, wind)
- Fine dust in cities
- Efficiency losses due to conversion and transport
- High dependency and loads on E-grid

The need for changing in building related energy supply

So, the challenge for the energy transition proces is to:

- Save or generate by RES: 2.900 PetaJoule
- Eliminate: 185 mill. tons CO_2 per year

Within a time period of 33 years

884 PJ of gas consumption is distributed by the national gas grid to end-users

410 PJ of fossils is converted to electricity and distributed by the electricity grid

70 % of building related energy demand concerns HEAT

1 petajoule = 1,3 million PV panels =
55.000 roofs covered by PV

Sustainable residential renovation concepts

PASSIVE HOUSE

Installations

- Balanced venting with heat recovery
- No cooling
- All electric

Unresolved:
architecture, high investment, high level of disturbance, overheating, bad CoP of HP's

PASSIVE <–> SOLAR
in common:

Measures envelope
- More/less insulation

Installations
- Heat pump on outside air
  - Floorheating
  - PV solar panels
- Optional: Infrared heating
  - Electric boiler

SOLAR PV

Installations

- Natural venting
- Energy delivering

Unresolved:
architecture (glazed roofs), overheating, bad CoP of HP's, disbalance on E-grid

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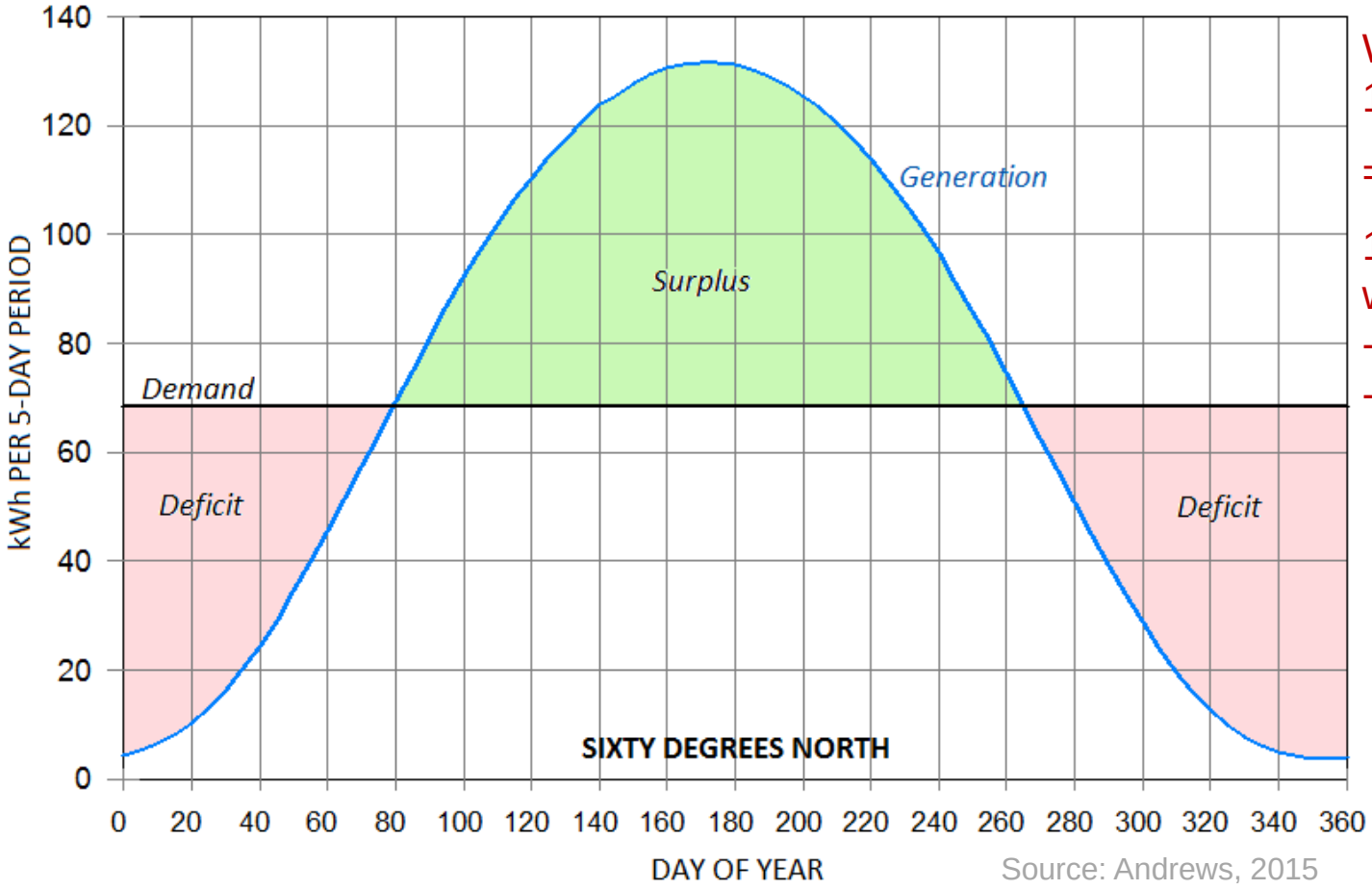
Thermal storage key technology to support decarbonisation



Source: Andrews, 2015

Winter deficit
1522 kWh buffering

=

153 Tesla 10kWh wall units
- costs: $535.500,-
- weight: 15.3 ton

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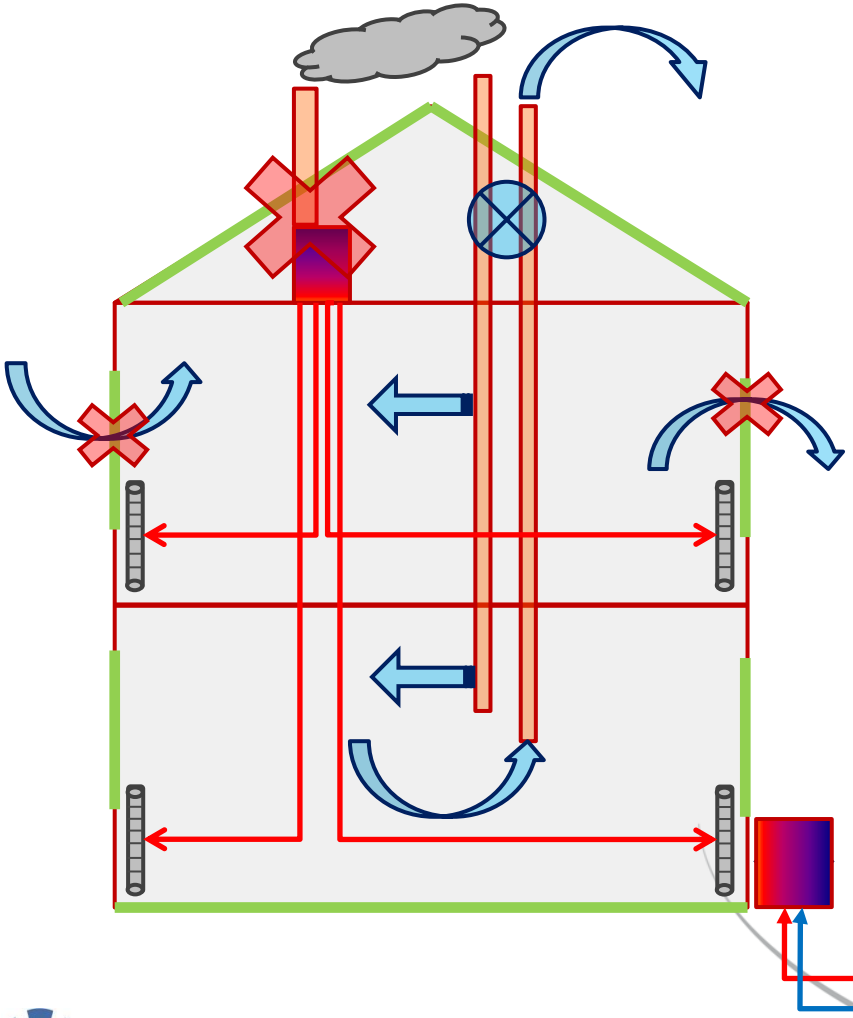
House renovation concept; existing dwelllings



DHC concept

1. Measures envelope
- HR++ Windows € 5.000,-
- Insulated roof and floor € 4.000,-

Label F -> C; $T_{radiator}$ from 90 -> 70 ºC

2. Installations
- Balanced venting with heat recovery € 5.000,-

Label C -> A; $T_{radiator}$ from 70 -> 50 ºC

3. Area energy support
- DHC source water 10 -> 30 ºC € 15.000,-
- Heat pump € 5.000,-
- Avoided CV-boiler - € 2.500,-

Label A -> energy neutral (A^{++++})

Supply energy: 5G DHC grid in operation in Heerlen

Due to low temperature grid gains from datacentres, greenhouses, solar collectors, etc. are utilisable leaving from 28 °C

industry

The only needed external energy is electricity (gasless solution) which can be derived from green generation

< 25-28 °C

Due to high temperature constant source the COP of Heat Pumps is 2-4 times higher than on ground water or outside air

electricity

Industry surplus

local green generation

dwellings

Shallow geothermal buffering stores energy unendless up to 30 °C with minimal losses

The gains from green generation are 10 % better utilisable due to sharing between mutiple users

Modern buildings need 35 % cooling energy (in thermal flow) against 65 % heating energy. The grid enables exchange of these flows in time.

commercial

(shallow) Geothermal

> 16-18 °C

Mid term buffering in the area stores energy for months up to 130 °C with < 10% losses

Including data centres, shops, etc.

Seasonal heat storage

MT Heat storage

MT Cold storage

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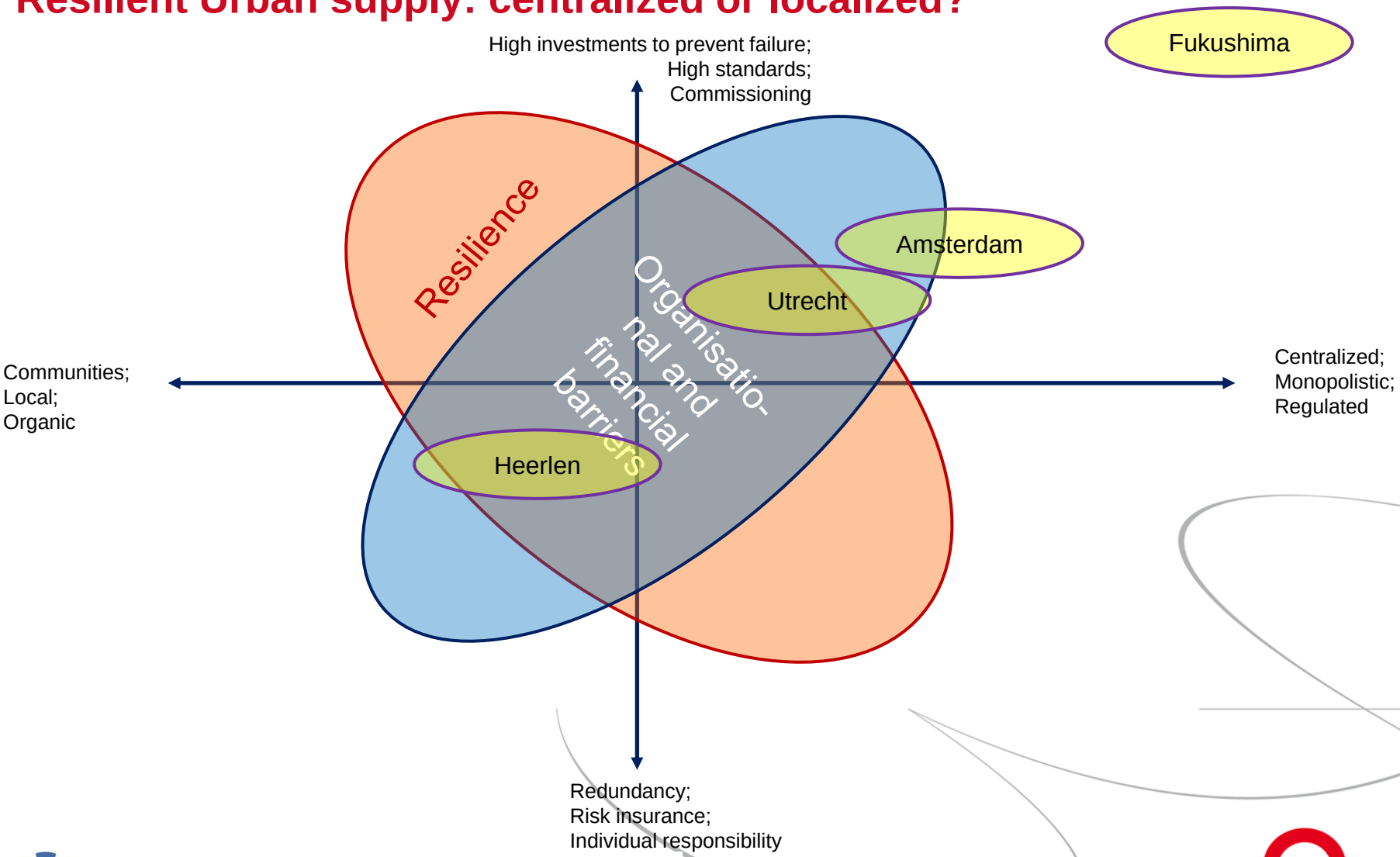

Resilience in Sustainable Urban Energy Supply Systems

Natural gas and other fossils are powerful and flexibel energy sources!

In order to maintain resilient supply, while phasing-out fossils, a number of considerations is to be applied:

- Small energy flows need **fast** reaction and **intelligent** controls;
- Build **redundancy** by exploiting multiple (green) sources and cloud-structured connections;
- Generate as much energy as possible **locally** as long as financially and spatial viable;
- Build **hybrid backup** on local energy clusters from national infrastructure
- Utilize **buffer** capacity of DHC-grids and connected buildings;
- Provide **cooling** capacity for high/well insulated buildings;
- Utilize optimal **cell balancing** (exchange of energy) by clustering multiple demand profiles and waste energy sources;
- Gain **low-hanging fruit** on building/area/regional/national levels;
- Promote **self-regulating** systems;
- Promote **end-user involvement**.

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Thanks for your attention

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