First Advisory Board Meeting
8 February 2018, Brussels

**H2FUTURE**
Green Hydrogen

# Embedding hydrogen into the energy system
## Perspectives for Austria
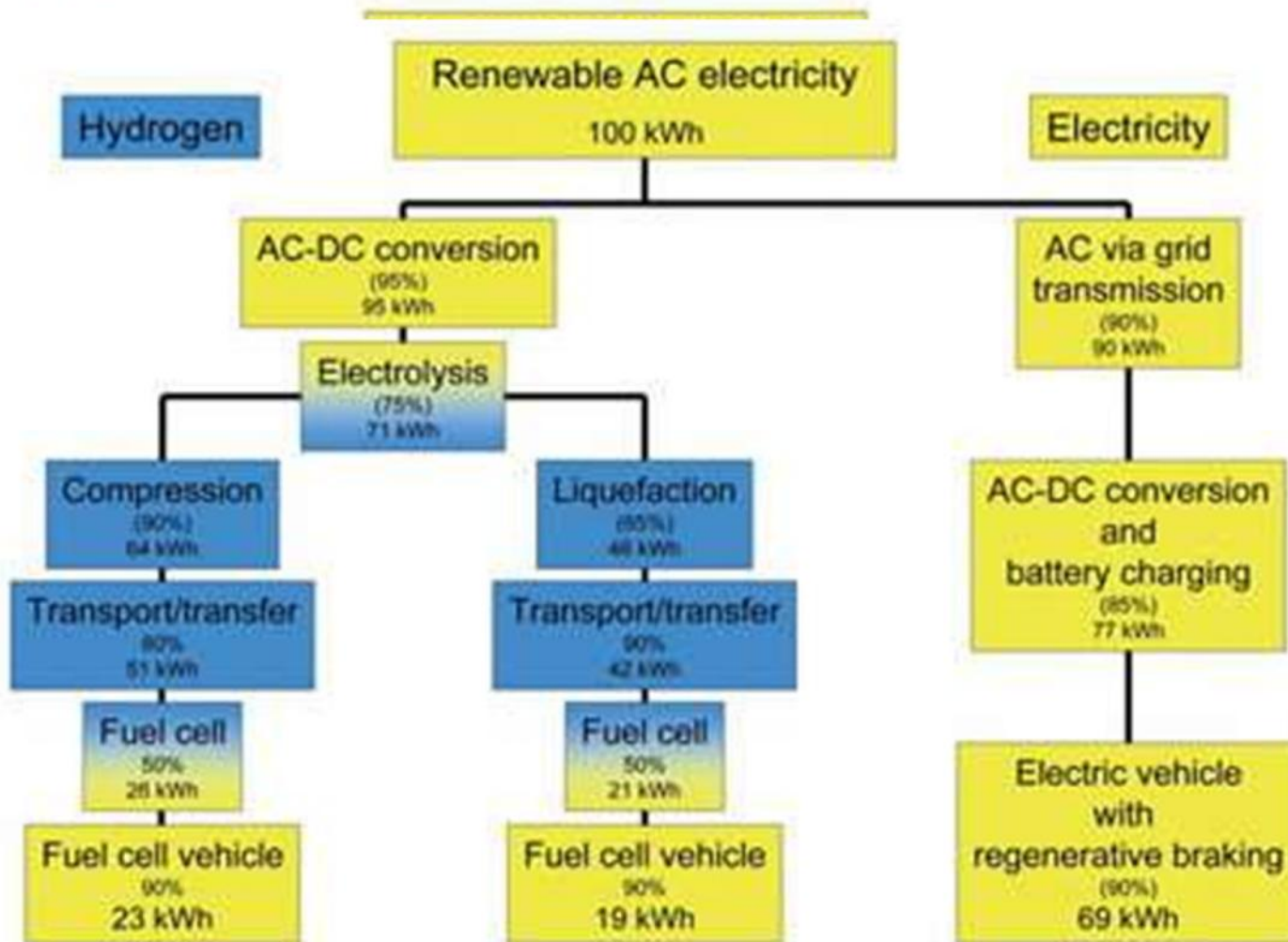
**Stefan P. Schleicher**
**University of Graz, Austria**
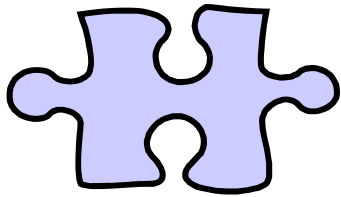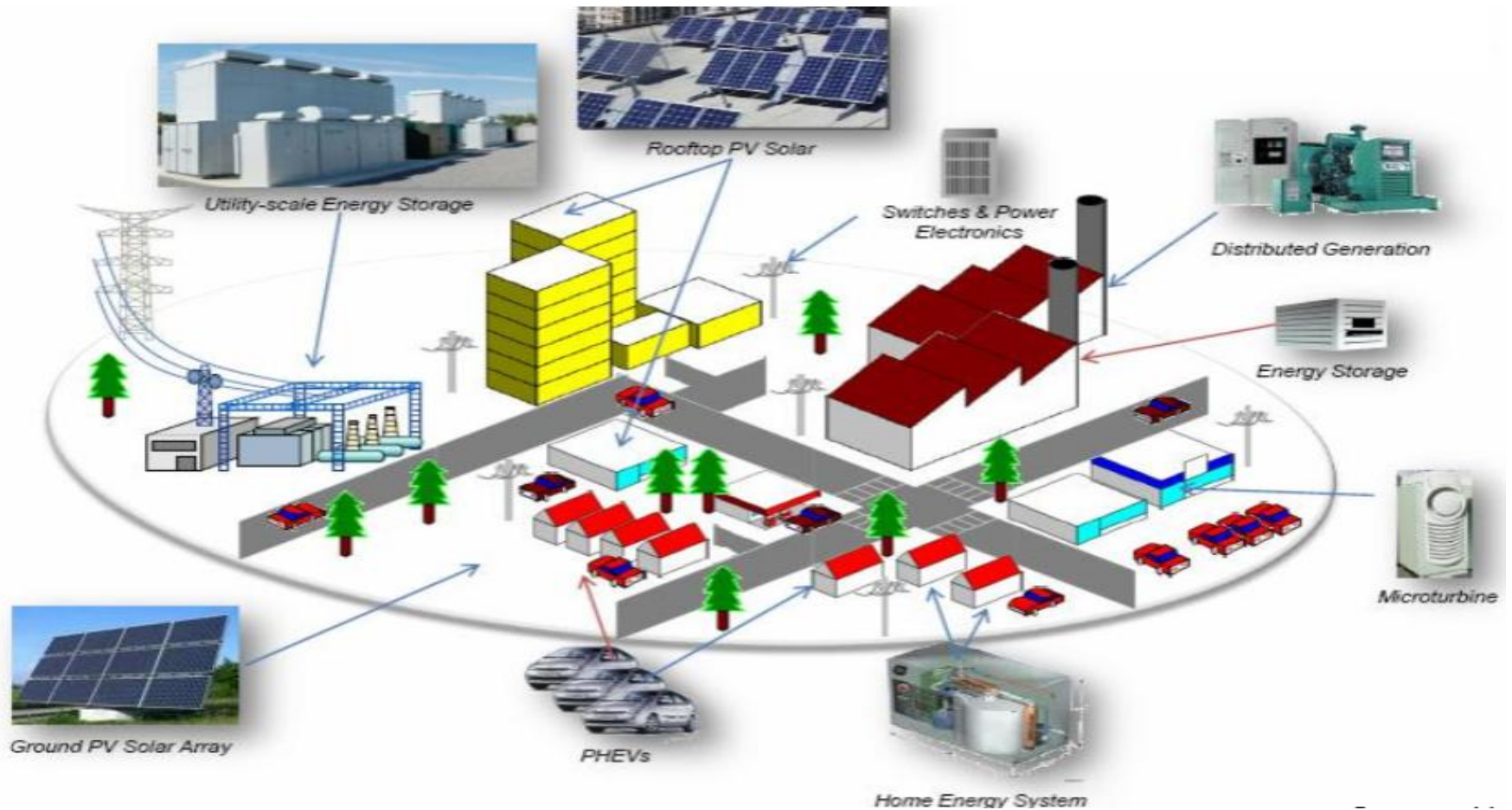
# The comeback of a hydrogen economy
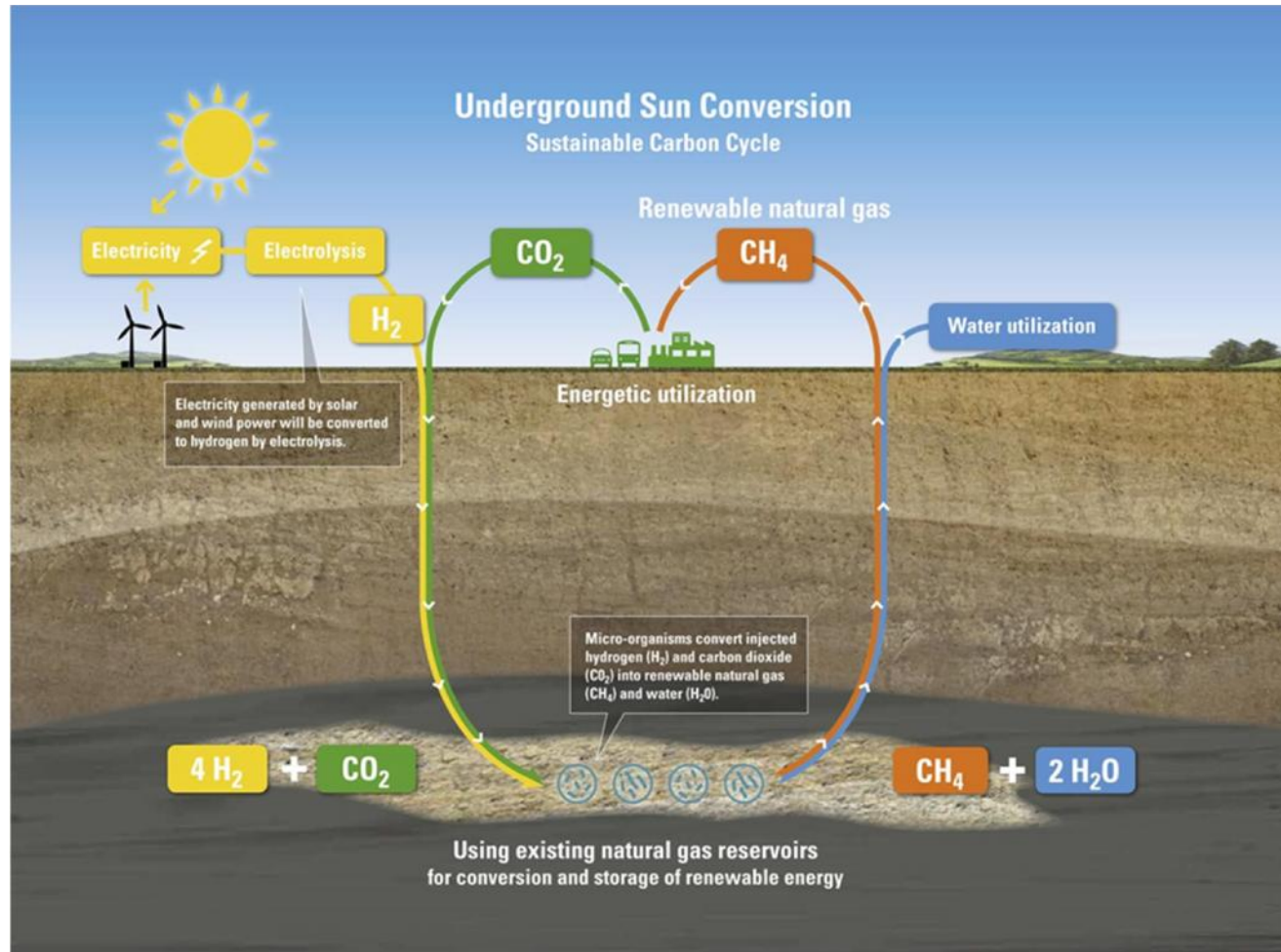
# 2006:
## "Why a hydrogen economy doesn't make sense"

# Emerging d-structures of energy systems
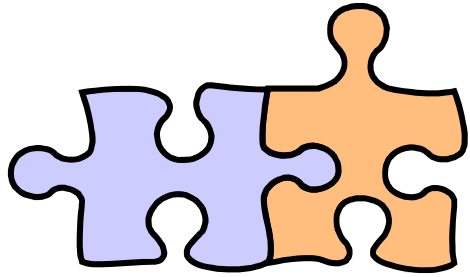## Decarbonized, decentralized, digitalized

# 20??:
# The RAG vision: Renewable natural gas

**The challenge:**
**Analyzing radical innovations**
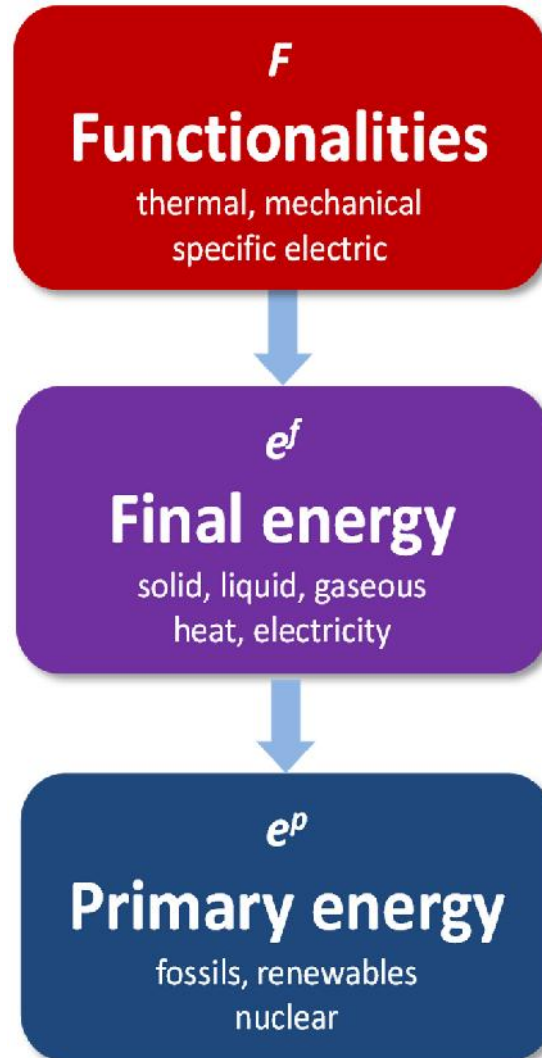
**The answer:**
**Deepened structural modeling**

**Tier 1:**
**The physical layer**

**Functionalities and energy flows**

# Step 1:
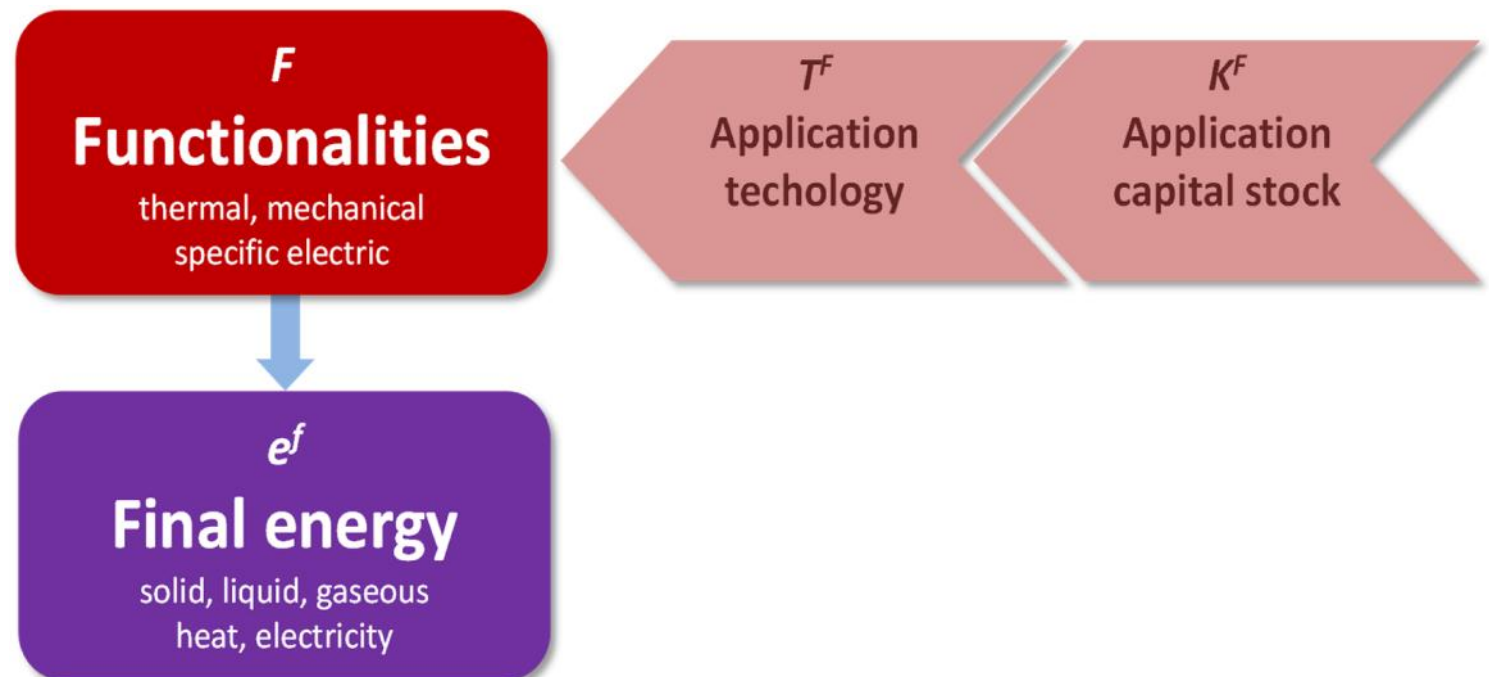## Consider the full energy value chain

$$F = T^F(e^f, K^F)$$
$$e^f = t^F(K^F)^{-1} \cdot F$$

$$e^f = t^T(K^T) \cdot e^p$$
$$e^p = t^T(K^T)^{-1} \cdot e^f$$

# Step 4: Link emissions to primary energy
## Fuel mix determines emissions intensities
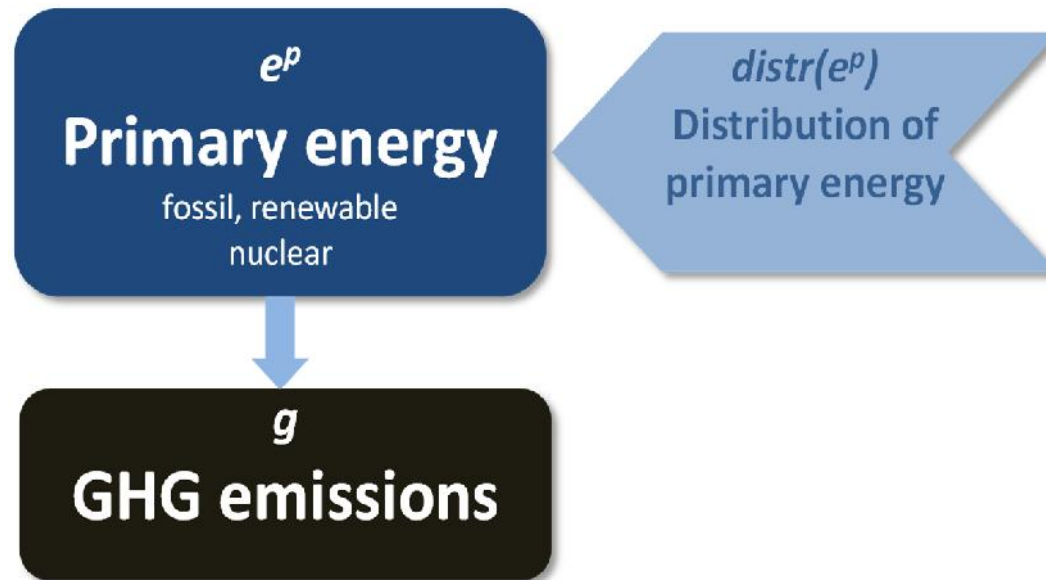
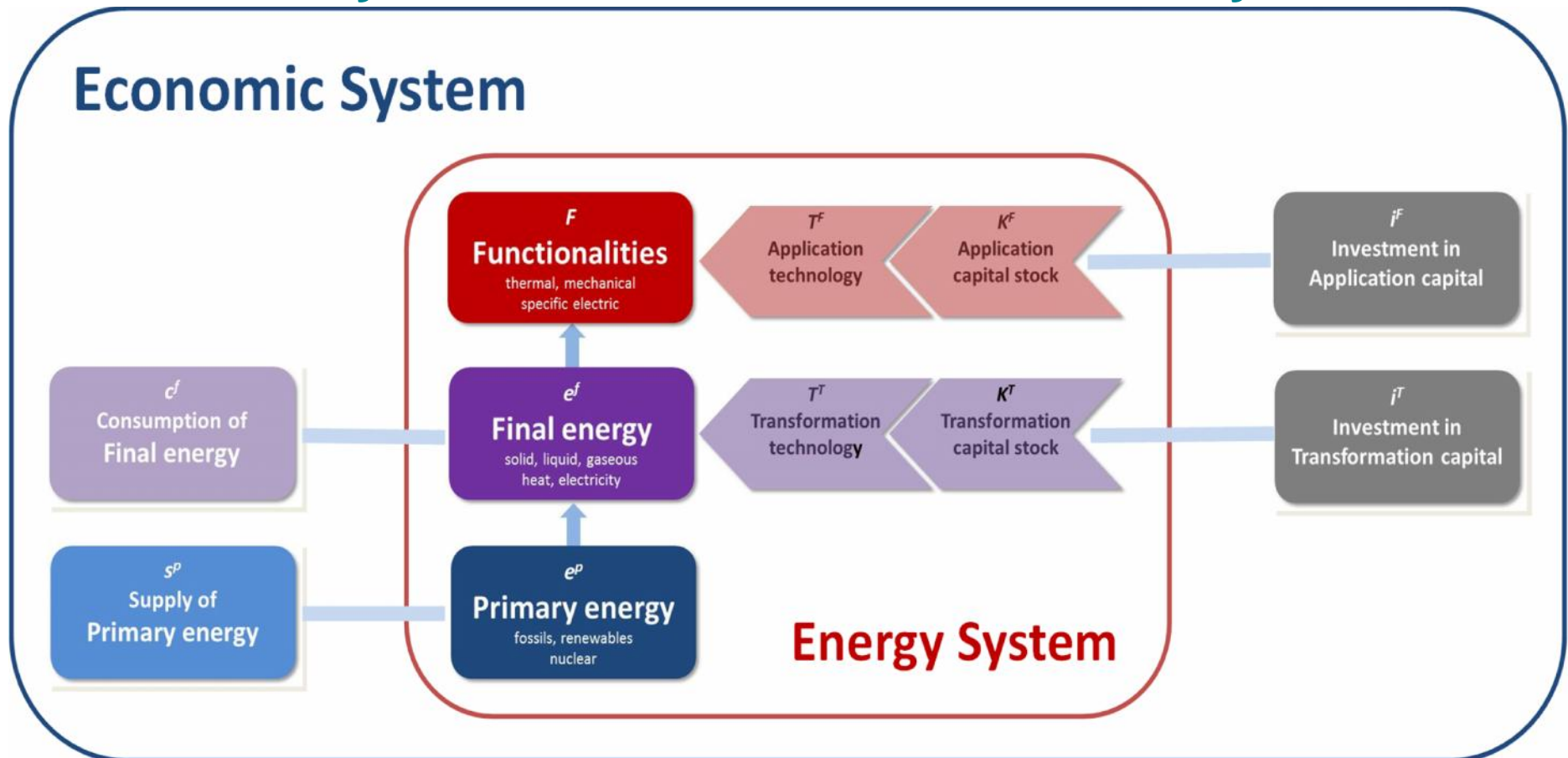$$g = g^{fos}(distr(e^{p,fos})) \cdot (1 - s^{p,fos} - s^{p,res} - s^{p,nuc}) \cdot e^p$$

# Tier 2:
# The economic layer

# Consumption of energy
# and investments in the energy system

# Step 5:
## Identity interactions with the economic system

**The energy system interacts with the economic system via the consumption of energy and investments into application and transformation technologies**
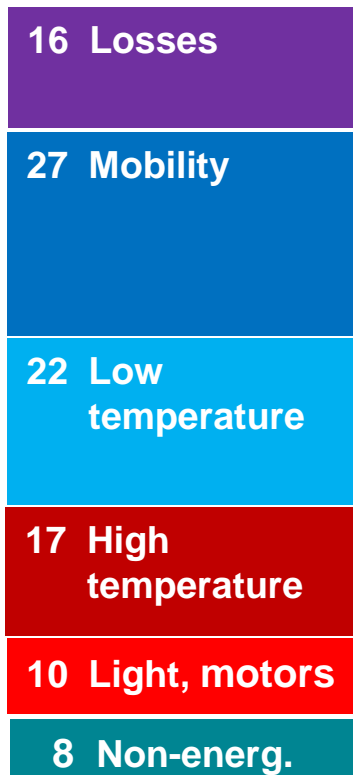
# Tier 3:
# Markets and institutions

## Price- and non-price determined mechanisms for coordination and incentives

# A low-carbon energy system by 2050
## Radical innovations along the energy value chain

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**2016**

| |
|---|
| 16 Losses |
| 27 Mobility |
| 22 Low temperature |
| 17 High temperature |
| 10 Light, motors |
| 8 Non-energ. |

**Web tool:**
**energyfutures.net**

**2050**

| |
|---|
| 5 Losses |
| 7 Mobility |
| 6 Low temp.. |
| 15 High temp. |
| 10 Light, motors |
| 7 Non-energ. |

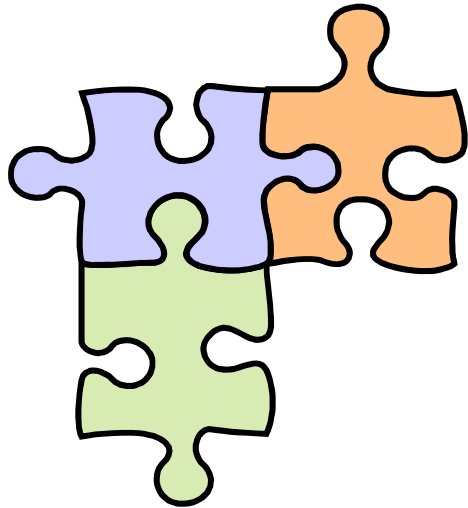**2050**

| |
|---|
| 10 Fossils |
| 40 Renewables |
| |

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**Hydrogen as a driver for radical innovations**

**The potential in industrial processes**

# A portfolio of low-carbon structures
## Enhanced innovation efforts

☐ **Multifunctional buildings**

    ☐ **Buildings are becoming part of the infrastructure of the new energy system**

☐ **Linked mobility**

    ☐ **Mobility is understood as access to persons, goods and locations**

☐ **Integrated grids**

    ☐ **The options for hydrogen in the new grid structures for electricity, heating and cooling, gas, information**

# Enhanced hydrogen structures
## High temperature functionalities

| | Total | Coal, Wast | Oil | Gas | Renewables | Electricity | Heat | |
|---|---|---|---|---|---|---|---|---|
| TJ | **243.539** | 26.630 | 11.553 | 93.040 | 51.094 | 48.838 | 12.383 | **2015** |
| | | Start Period Energy Mix | | | | | | |
| Index | 100 | 11% | 5% | 38% | 21% | 20% | 5% | |
| | | Change Energy Mix | | | | | | |
| Index | -3 | -10% | -4% | -33% | 32% | 13% | 2% | |
| | | End Period Energy Mix | | | | | | |
| Index | 97 | 1% | 1% | 5% | 53% | 33% | 7% | |
| TJ | **241.644** | 19.850 | 8.834 | 70.626 | 71.730 | 57.003 | 13.601 | **2030** |
| TJ | **237.347** | 2.219 | 1.765 | 12.350 | 125.746 | 78.452 | 16.815 | **2050** |

# Enhanced hydrogen structures
## High temperature functionalities
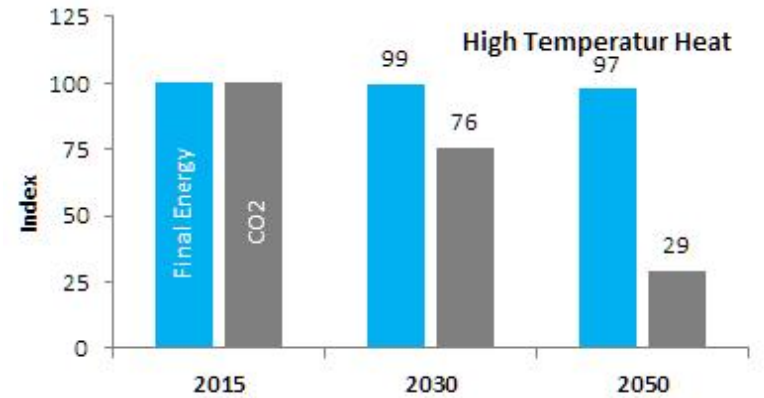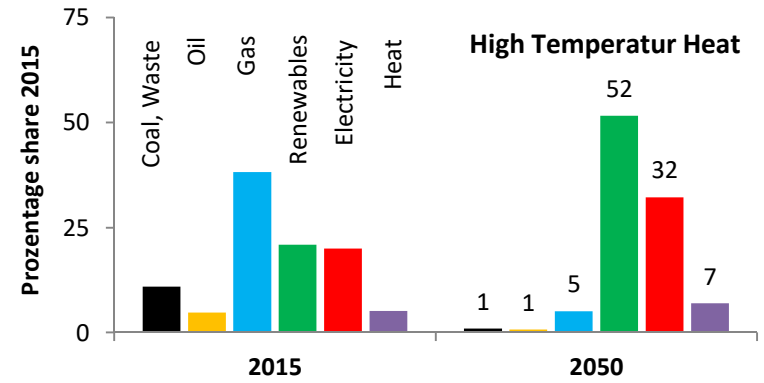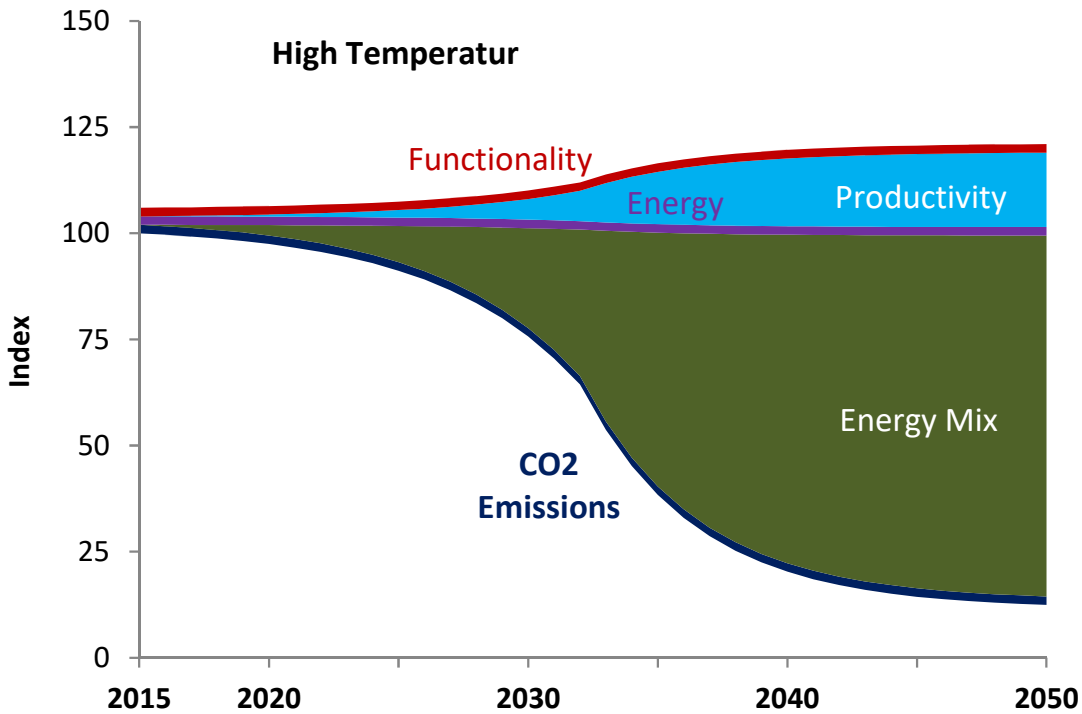
# Thank you.

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