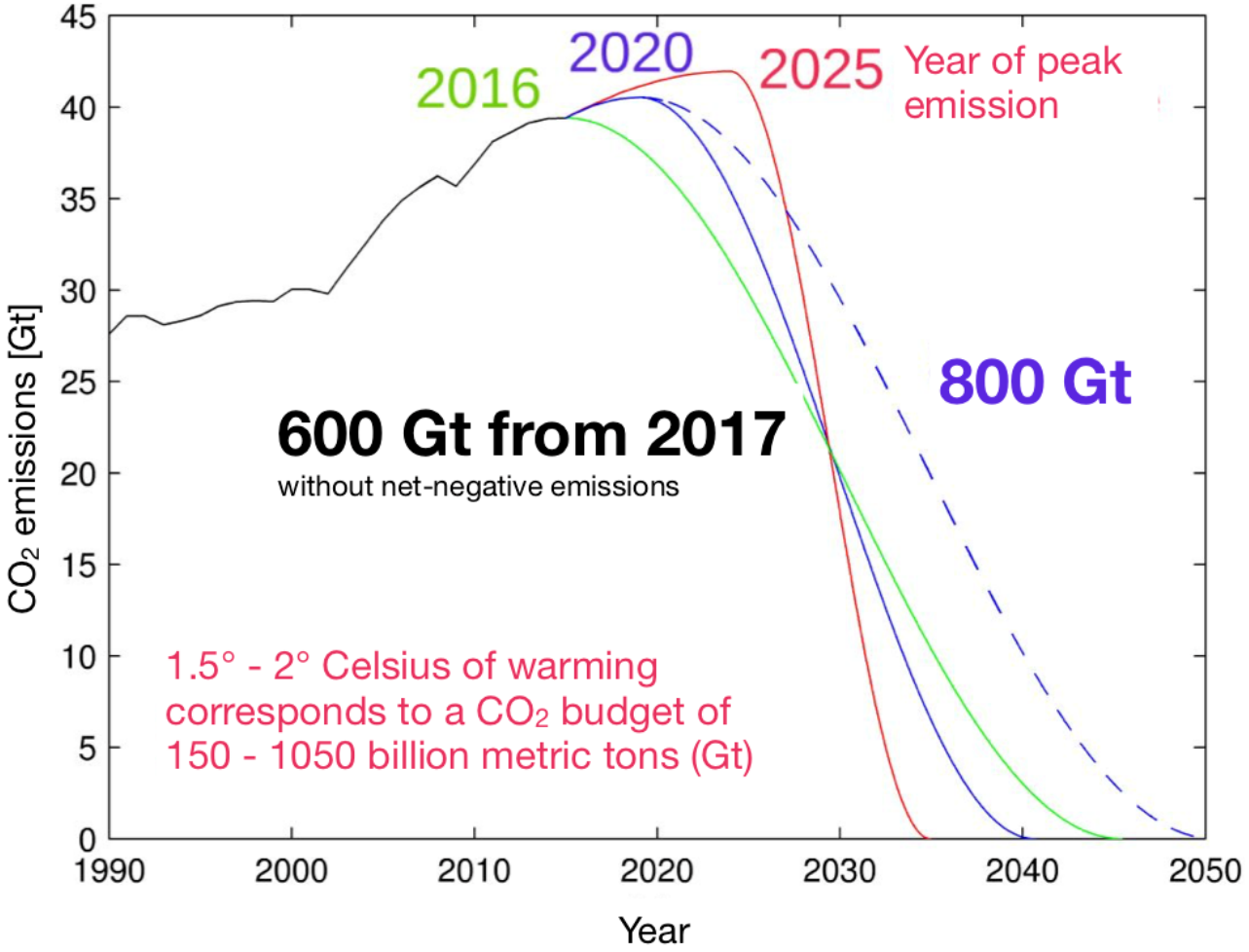
Energy efficient buildings in light of energy crisis - the example of Tyrol/Austria

Wolfgang Streicher
Arbeitsbereich Energieeffizientes Bauen
Universität Innsbruck

Why fossil free ?



*Figueres, Christiana; Schellnhuber, Hans Joachim; Whiteman, Gail; Rockström, Johan; Hobley, Anthony; Rahmstorf, Stefan (29 June 2017). "Three years to safeguard our climate". Nature. **546** (7660): 593–595.* **:**

What means fossil free ?

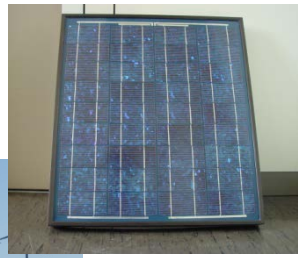


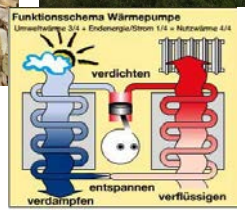

Fossil fuels like

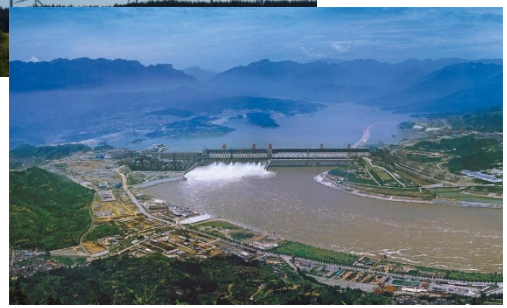
- Oil
- Natural gas
- Coal

have to be replaced by renewables i.e.

- Solar energy (photovoltaics, solar thermal)
- Wind energy
- Biomass, biogas, waste
- Hydro power
- Environmental heat/cold (heat pump)
- Deep geothermal heat

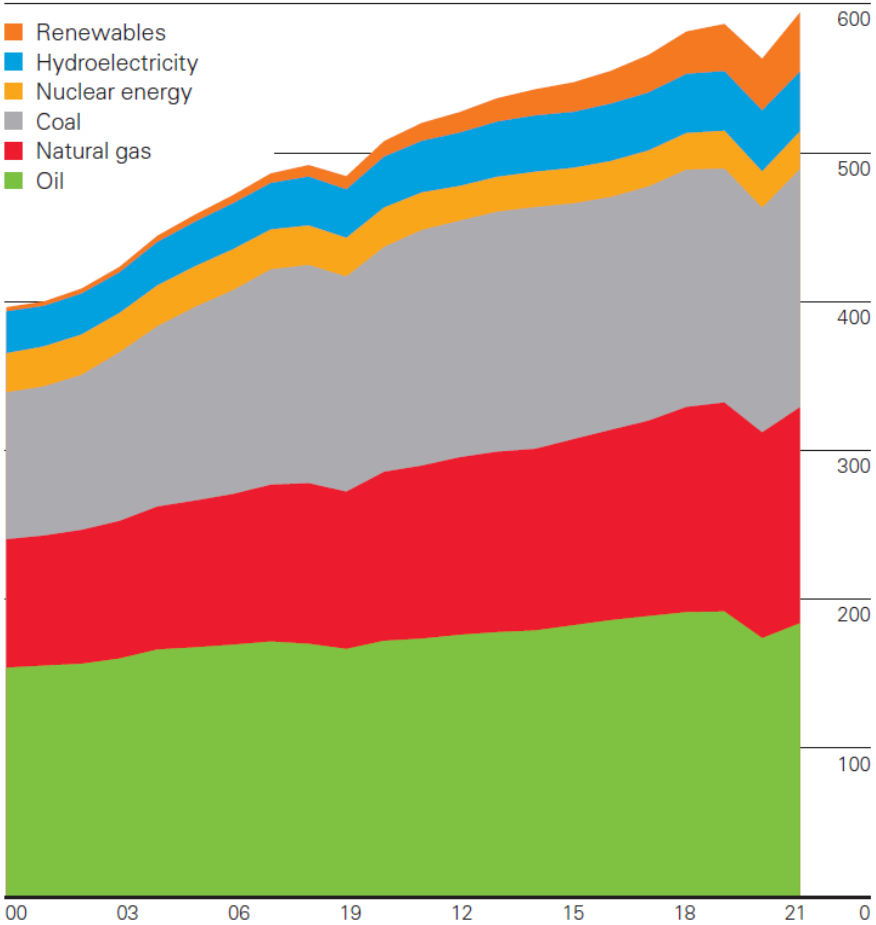


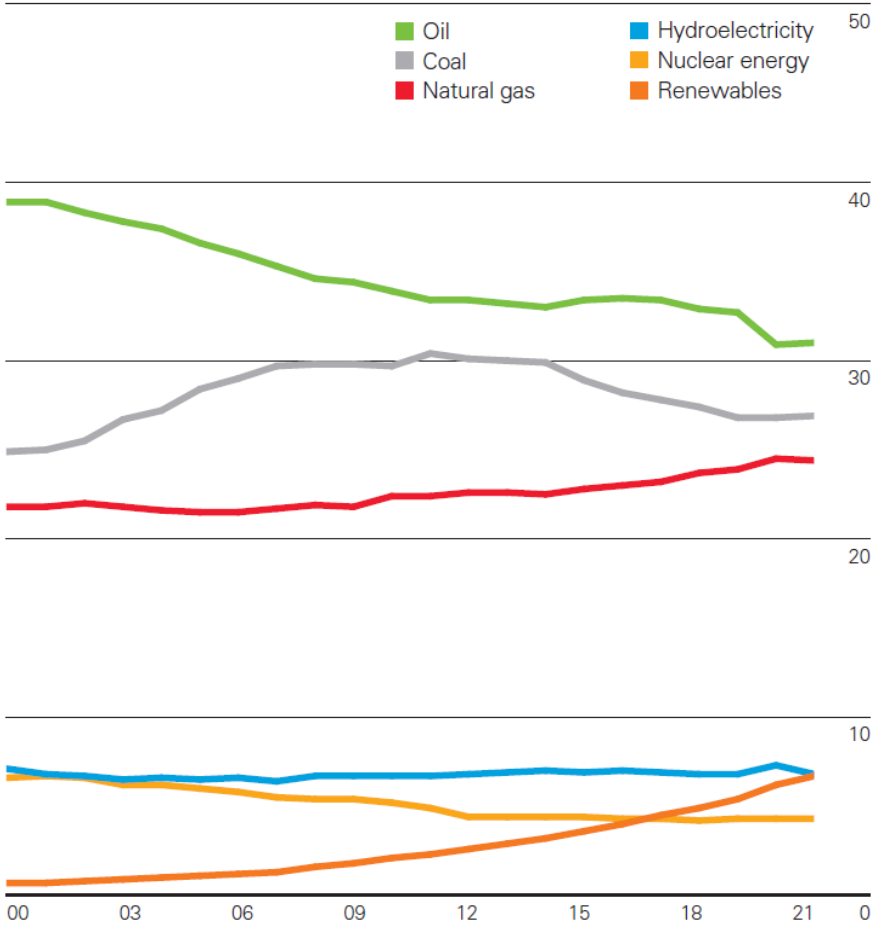


Sounds simple but … about 80 % of primary energy is fossil today

World consumption
Exajoules

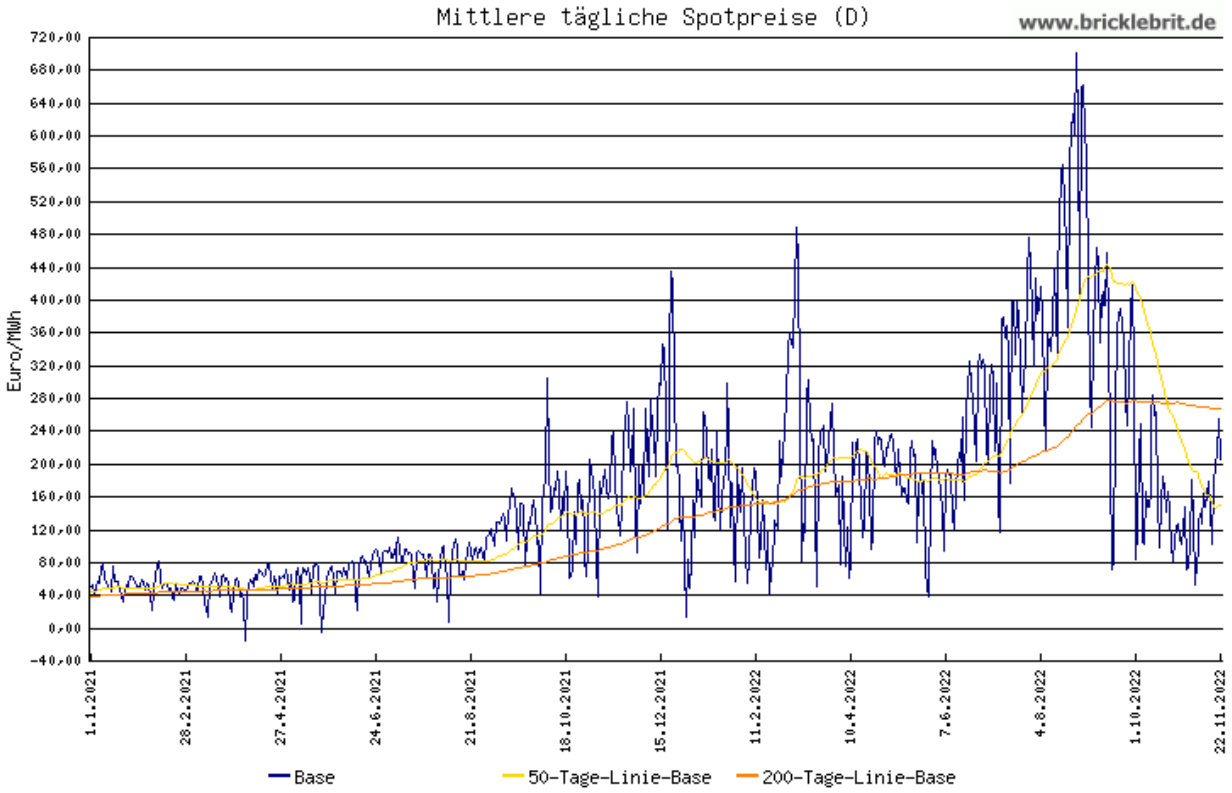


Shares of global primary energy
Percentage



universität innsbruck
Arbeitsbereich für Energieeffizientes Bauen

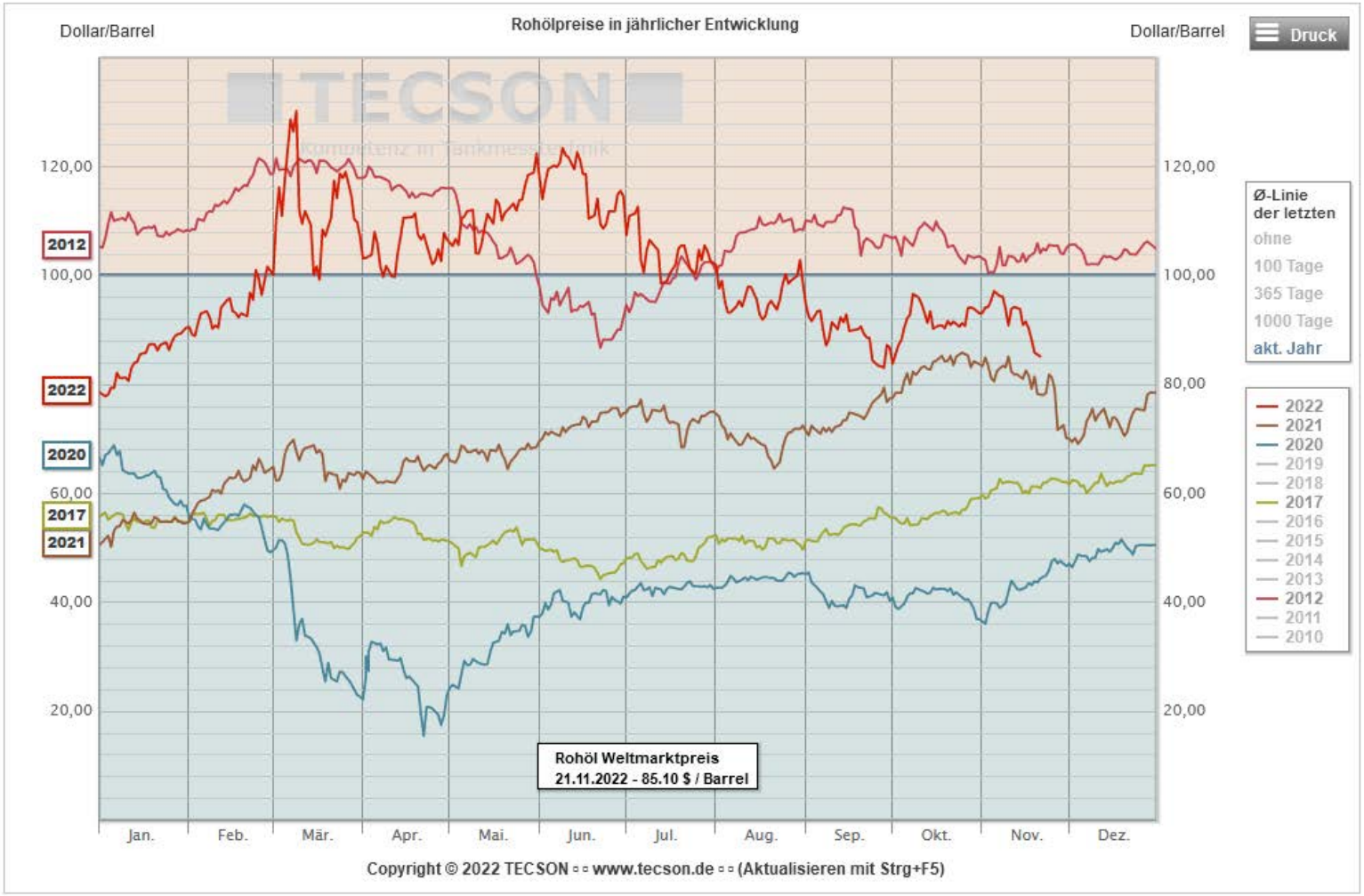
Energy crisis ?



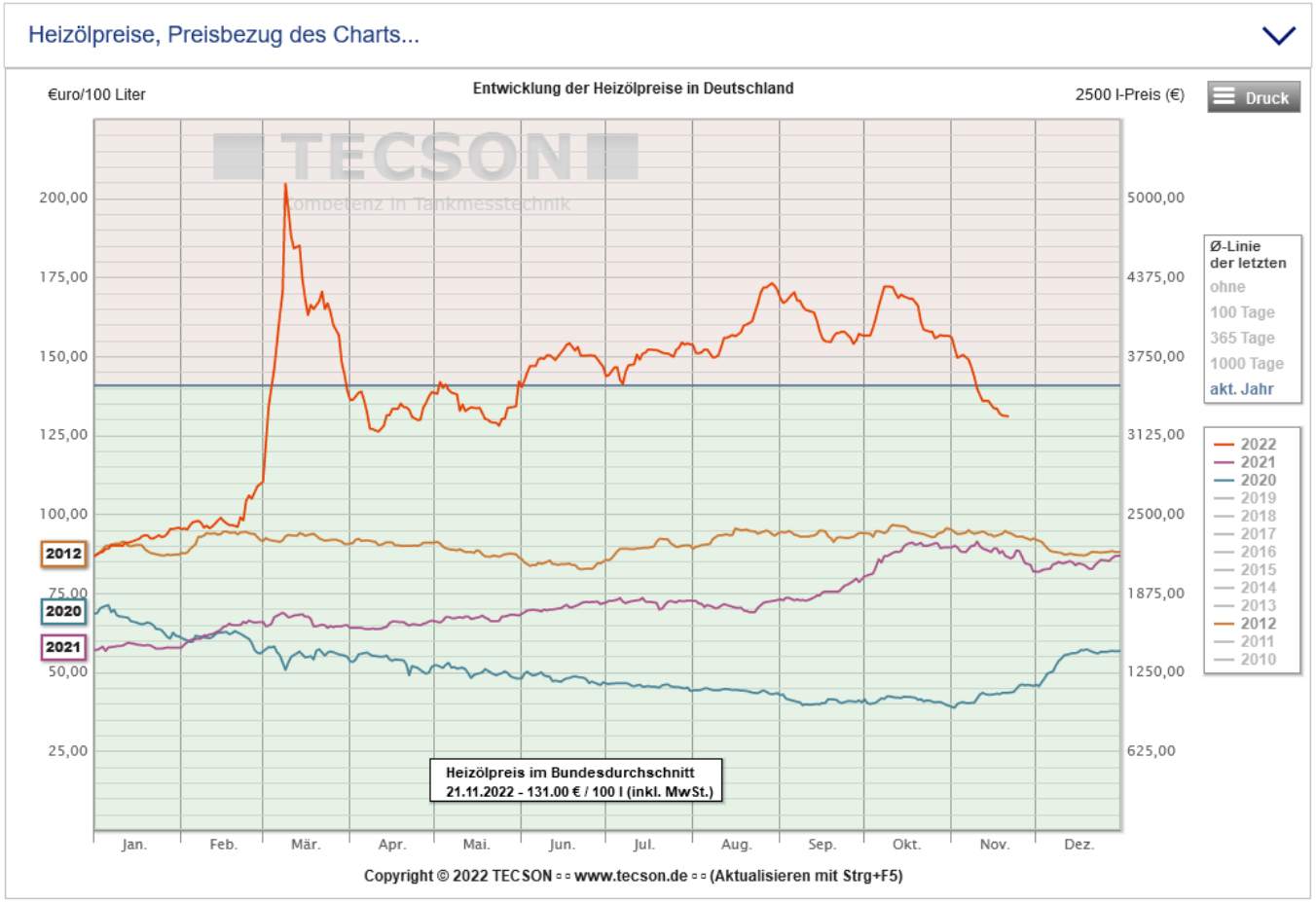
Energy crisis ?

Gas Storage Austria over 92 % filled
Intraday Gasprice €/MMBtu

Energy crisis – crude oil price?



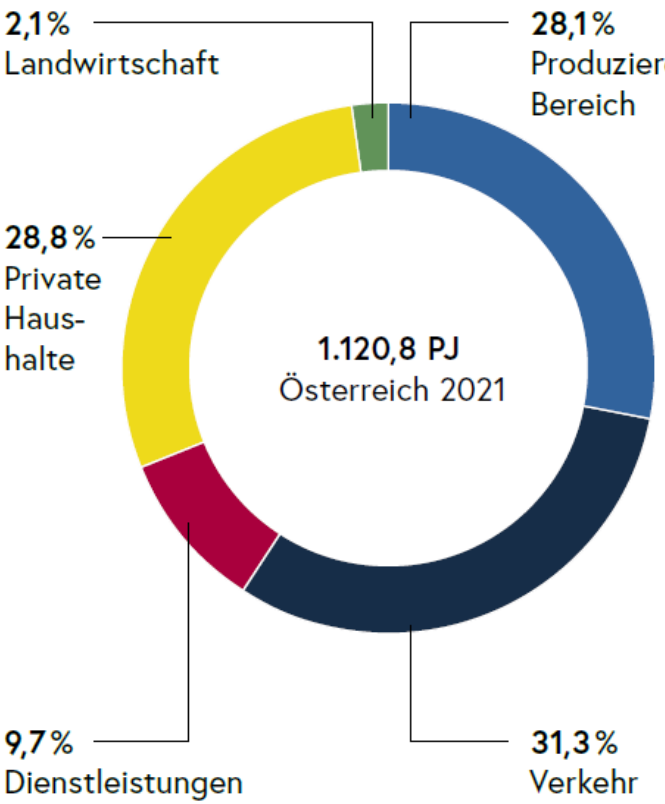
Energy crisis – heating oil price?

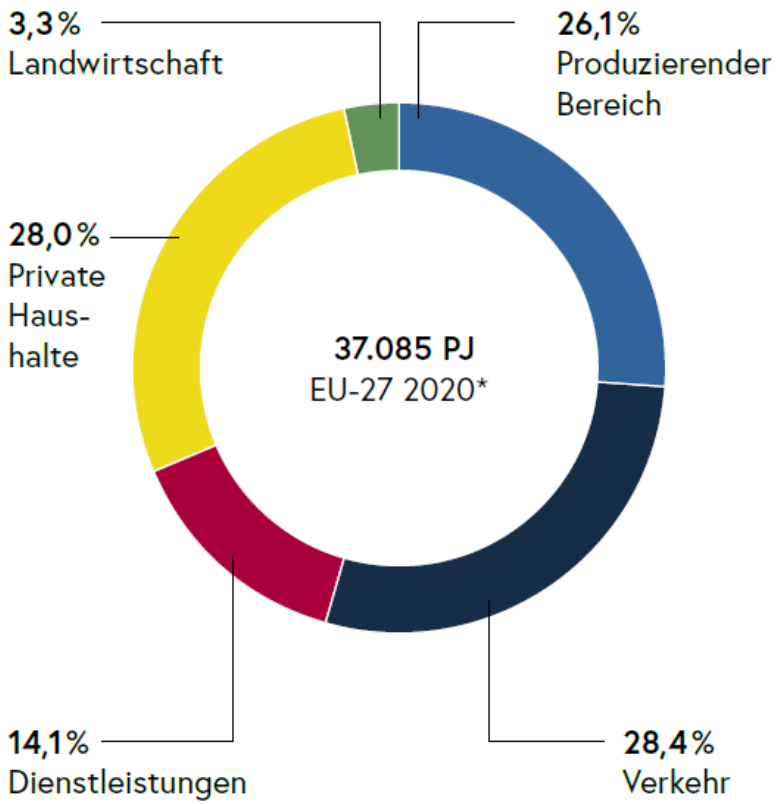


Durchschnittspreis 2500 l Heizöl schwefelarm, inkl. MwSt.

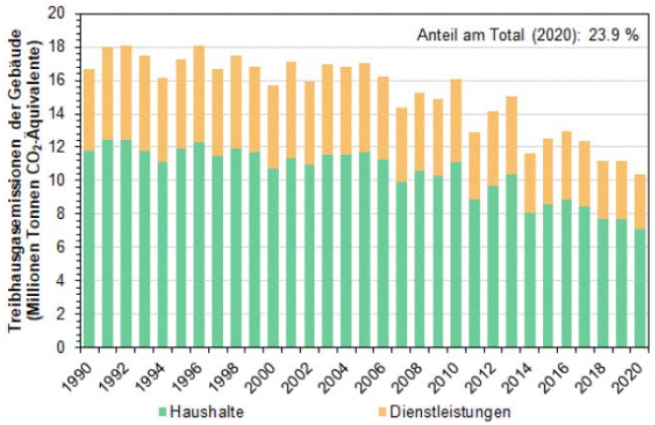
Structure of the energy demand in Austria

Abb. 17: Struktur des energetischen Endverbrauches in Österreich und EU-27
nach wirtschaftlichen Sektoren in Prozent



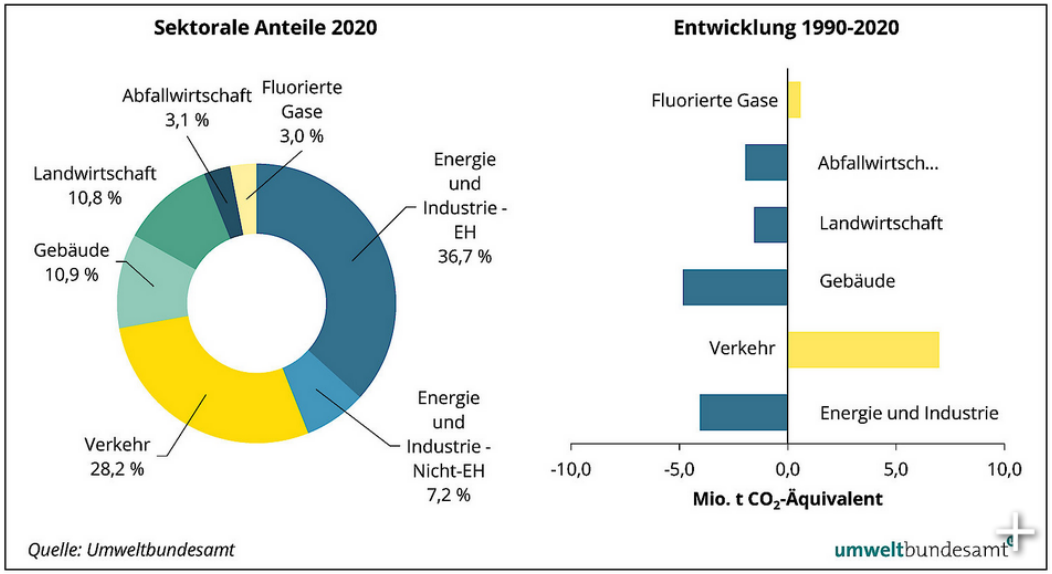


CO2-Emissions of Building sector in Switzerland and Austria



Treibhausgasemissionen des Sektors Gebäude, zusammengesetzt aus den Haushalten und den Dienstleistungen.

Schweizer Umweltbundesamt

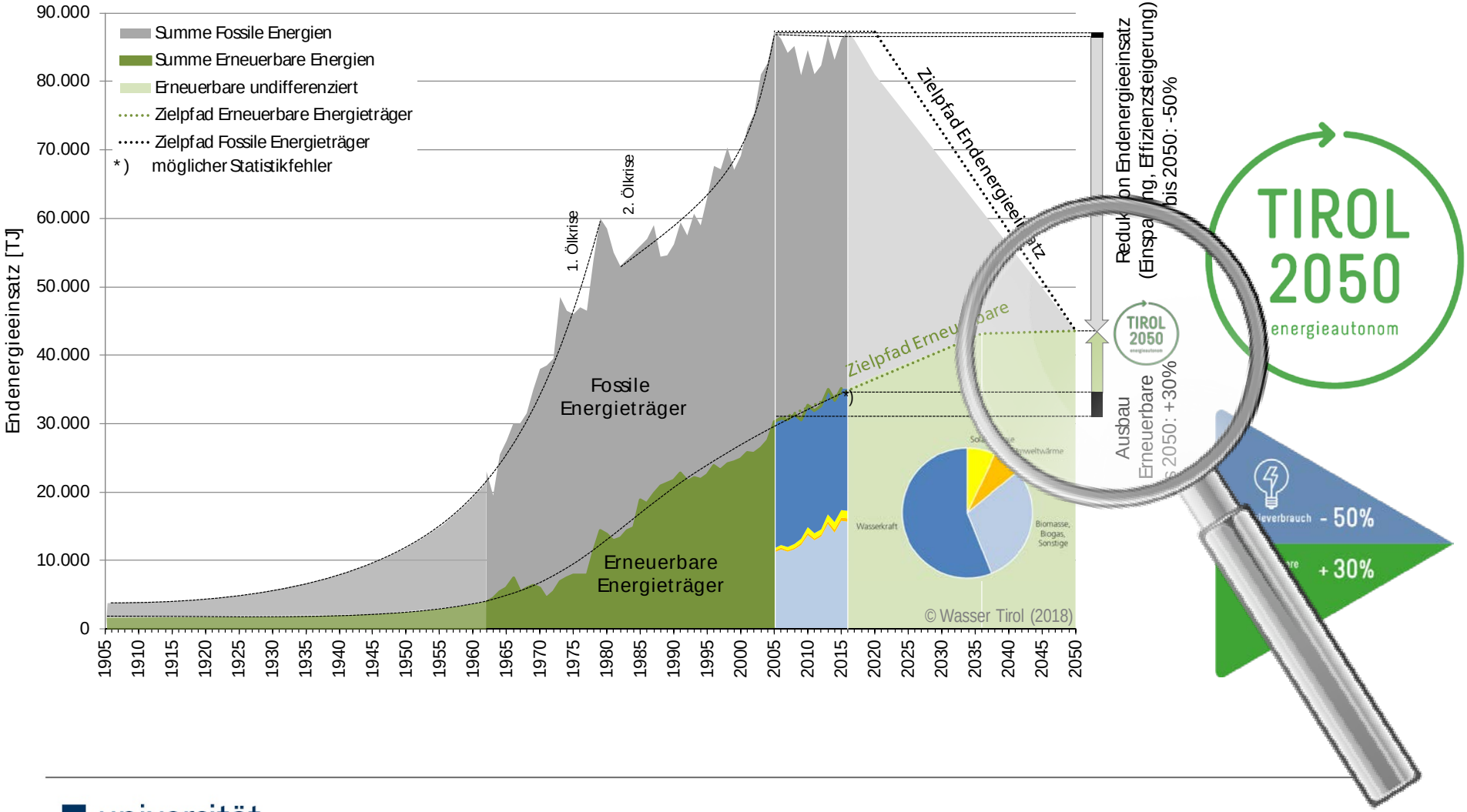


Projekt Tirol

Ressourcen- und Technologie-Einsatzszenarien Tirol 2050

Laufzeit: 07/2017 – 06/2018

https://www.tirol.gv.at/fileadmin/themen/umwelt/wasser_wasserrecht/Downloads/19-03-08_Szenarien-Tirol-2050_Endbericht-Stand-18-10-15.pdf


Endenergieeinsatz [TJ]
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Summe Fossile Energien
Summe Erneuerbare Energien
Erneuerbare undifferenziert
Zielpfad Erneuerbare Energieträger
Zielpfad Fossile Energieträger
*) möglicher Statistikfehler
1. Ölkrise
2. Ölkrise
Fossile Energieträger
Erneuerbare Energieträger
Zielpfad Endenergieeinsatz
Zielpfad Erneuerbare
*)
Reduktion Endenergieeinsatz (Einsparung, Effizienzsteigerung) bis 2050: -50%
Ausbau Erneuerbare bis 2050: +30%
Wasserkraft
Biomasse, Biogas, Sonstige
© Wasser Tirol (2018)
TIROL 2050
energieautonom
- 50%
+ 30%

Projektteam & Advisory Board

Projektteam

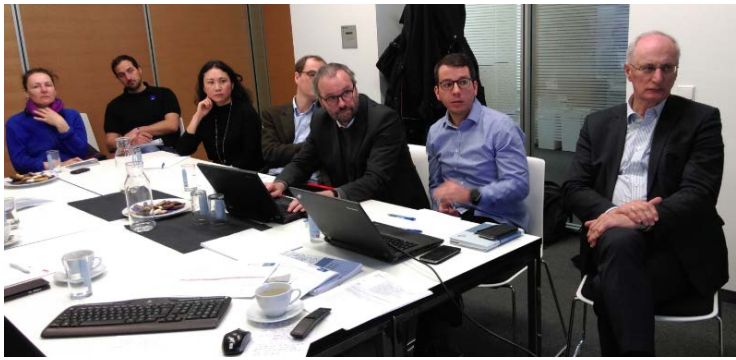
- Wasser Tirol - Wasserdienstleistungs-GmbH (Ressourcen, Koordination)
- Universität Innsbruck, AB Energieeffizientes Bauen (Sonstiges/Gebäude)
- Universität Innsbruck, AB Intelligente Verkehrssysteme (Mobilität)
- Management Center Innsbruck (Produktion)

Advisory Board

Büro LH-Stv. ÖR Geisler
Abt. Wasser-, Energie- Forstrecht
SG Verkehrsplanung
Abt. Landesentwicklung und Zukunftsstrategie
Landesenergiebeauftragter
Nachhaltigkeitsbeauftragte

Einbeziehung Stakeholder

21.09.17	Kick Off
03.11.17	Dargebot: Wald
27.11.17	Advisory Board 01
15.01.18	Gebäude: Stakeholder-WS
17.01.18	Dargebot: Biogas, LW-Kammer
22.01.18	Produktion: Stakeholder-WS
24.01.18	Dargebot: Stakeholder-WS Wasserkraft
26.01.18	Mobilität: Stakeholder-WS
13.02.18	Dargebot: Wasserkraft
22.02.18	Dargebot: Wasserkraft EU-WRRL
09.03.18	Advisory Board 02
27.03.18	Dargebot: Wasserkraft
09.04.18	Produktion: Sandoz
18.04.18	Produktion: GE Jenbacher
04.05.18	Advisory Board 03
07.06.18	Advisory Board 04
13.06.18	Vernetzungstreffen der Tiroler EVU
25.06.18	Stakeholder-Workshop
25.07.18	Dargebot: Wasserkraft im Stromkontext
18.08.18	Advisory Board 05



Tasks

Which **local energy resources** with which extend are needed with what **technological solutions** in order to reach an autonomous energy system by 2050 (Tyrol energieautonom 2050)?

1. Evaluation of the demand development and resources
    - Baseline 2016 (Statistik Austria)
    - Efficiency potentials of all sectors until 2050
    - Quantification of local resources of renewable energy carriers
    - Only todays available technologies are taken into consideration (sector coupling)

2. Demand covering scenarios for the 2050 goals
    - with available resources (only yearly balance
    - No reduction of energy services
    - No economic considerations, no energy storage calculations
    - Not taking “grey energy” into consideration

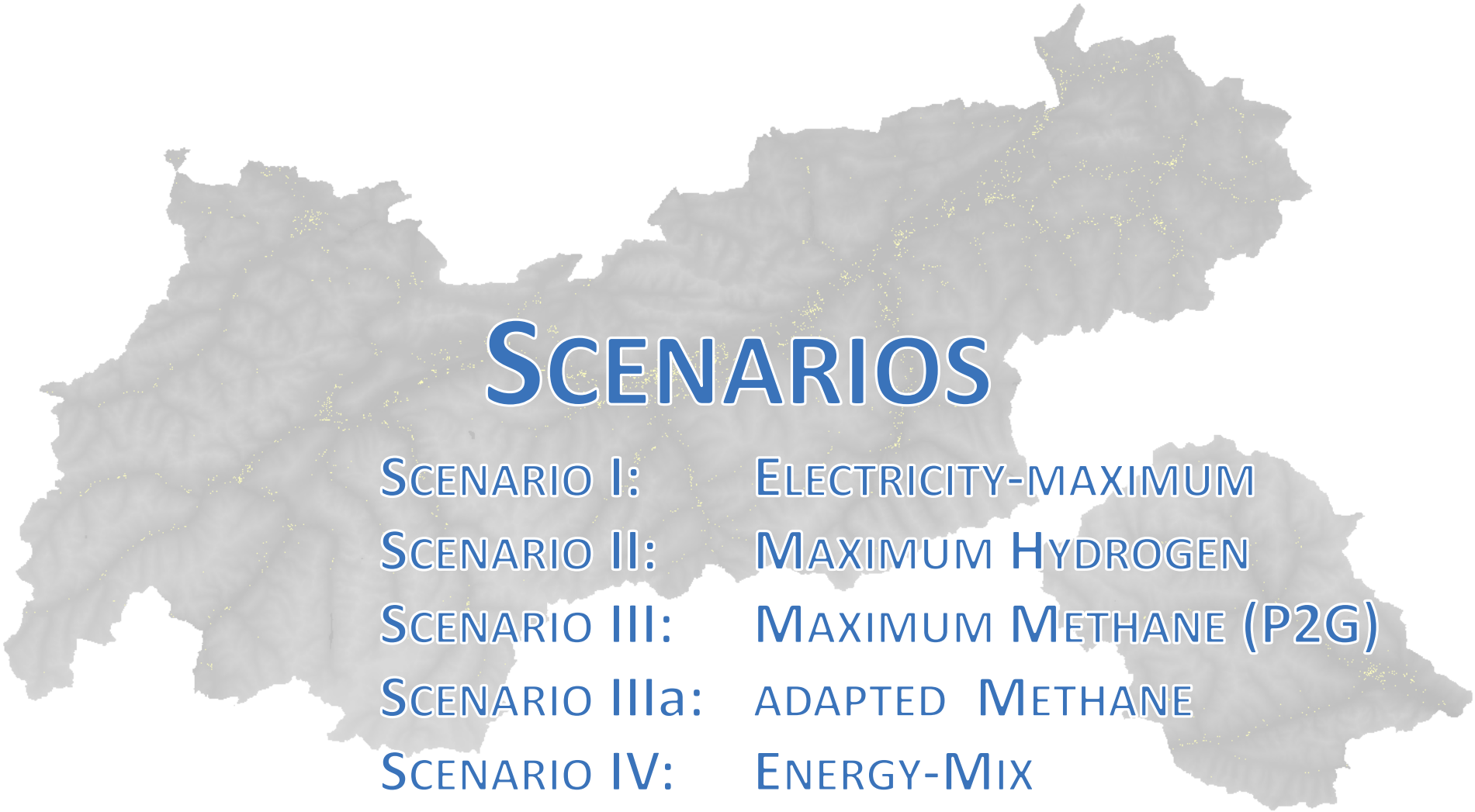
3. Basis for a general pathway to 2050

SECTORS

BUILDINGS/OTHER

PRODUCTION

MOBILITY



Scenarios

Scenario I: Electricity-maximum

Scenario II: Maximum Hydrogen

Scenario III: Maximum Methane (P2G)

Scenario IIIa: adapted Methane

Scenario IV: Energy-Mix

Sector Buildings/Other

- Szenario I: maximum Electricity → Timeline available
  - New Buildings or change of heating system: Heat pumps (92 %), Rest Biomass, electricity, district heat (renewable)
- Szenario II: Hydrogen → Only start and end values
  - For buildings ident to Scenario I (Hydrogen in decentralized networks does not look feasible)
- Szenario III und IIIa: P2G-Methane → Only start and end values
  - All buildings, that are using gas heating in 2016 will also use gas (methane) in 2050 with P2G
- Szenario IV: Energy-Mix → Only start and end values
  - P2G: 5 % of buildings that used gas in 2016 mit (=2,65 % of all builindgs)
  - Rest mainly heat pumps

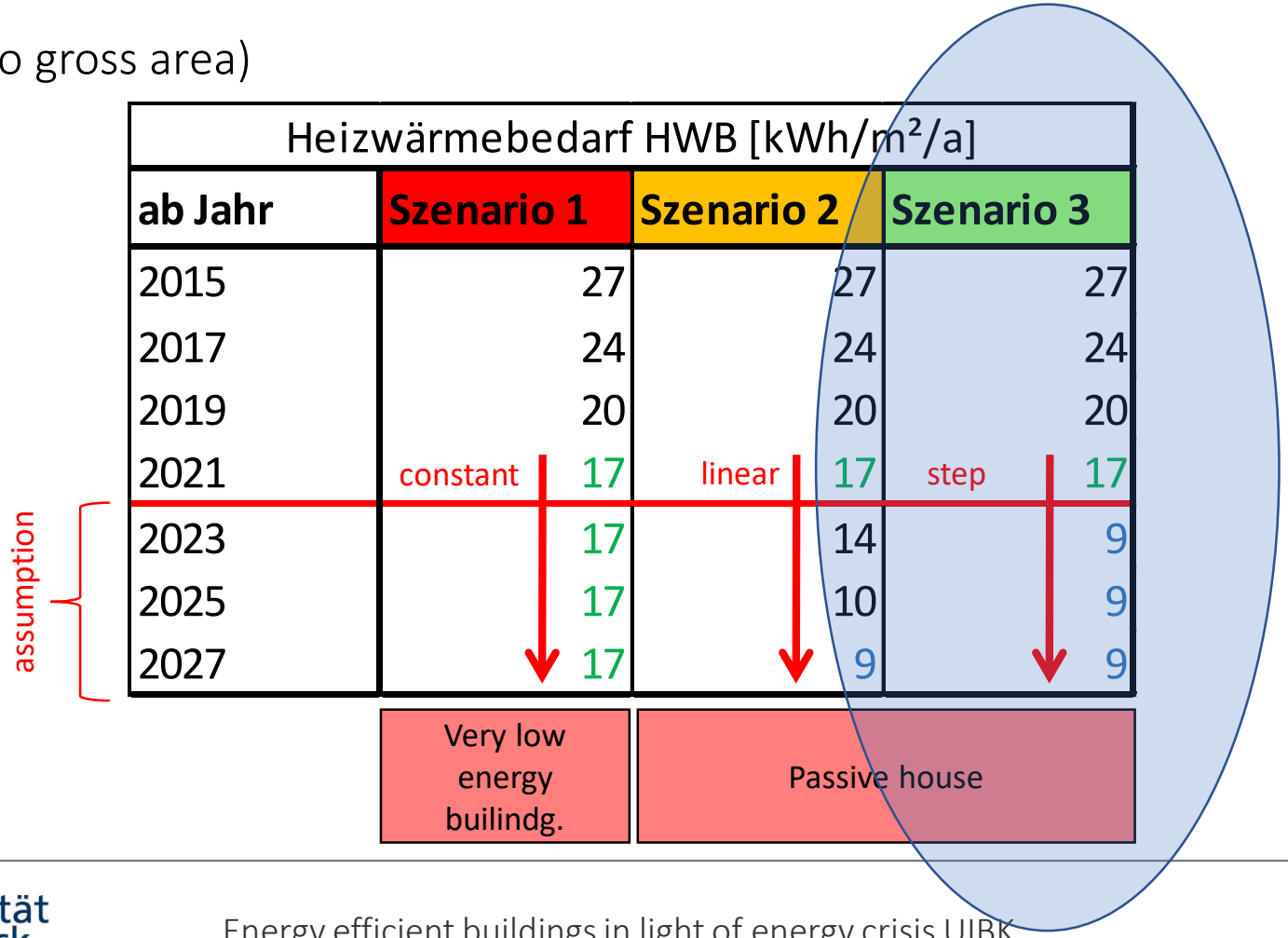
Sektor Gebäude/Sonstiges

- **Assumptions to reach the goals:**
  - Baseline is NEA 2016 Tyrol: Al values for HWB und WWWB and energy carrier distruibution is adapted.
  - Starting with 2023: Passive House standard for new buildings, high thermal level renovation, Renovation rate 1,3 %/a, New builoidng rate according to population growth
  - Starting with 2023 no fossil fuels for new buildings and when the heating device is changed (exchange rate 3%/a)
  - Efficiency increase for heating devices (e.g. Heat Pump COP from 3,5 => 4)
  - Efficiency increase 1%/a electrivcity

Thermal quality of new buildings – Exaple MFH-M

HWB (Useful Energy demand space heating) inclgains from air heat recovery unit

(related to gross area)



Renovation Quality – Example MFH-M

HWB (Useful Energy demand space heating) incl. gains from air heat recovery unit

(related to gross area)

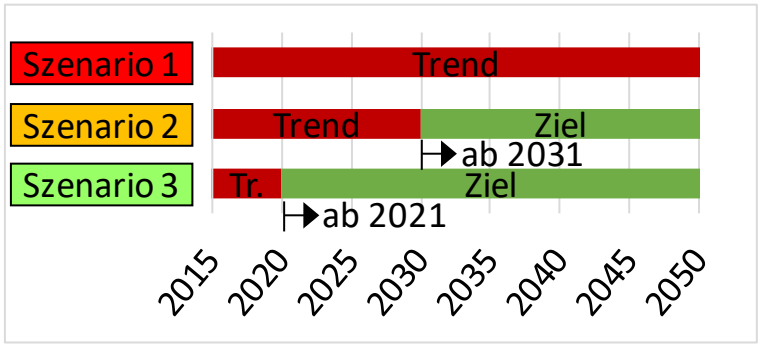
Heizwärmebedarf HWB [kWh/m²/a]			
ab Jahr	**Szenario 1**	**Szenario 2**	**Szenario 3**
2015	47	47	47
2017	43	43	43
2019	39	39	39
2021	konstant 35	linear 35	Sprung 35
2023	35	31	23
2025	35	27	23
2027	35	23	23

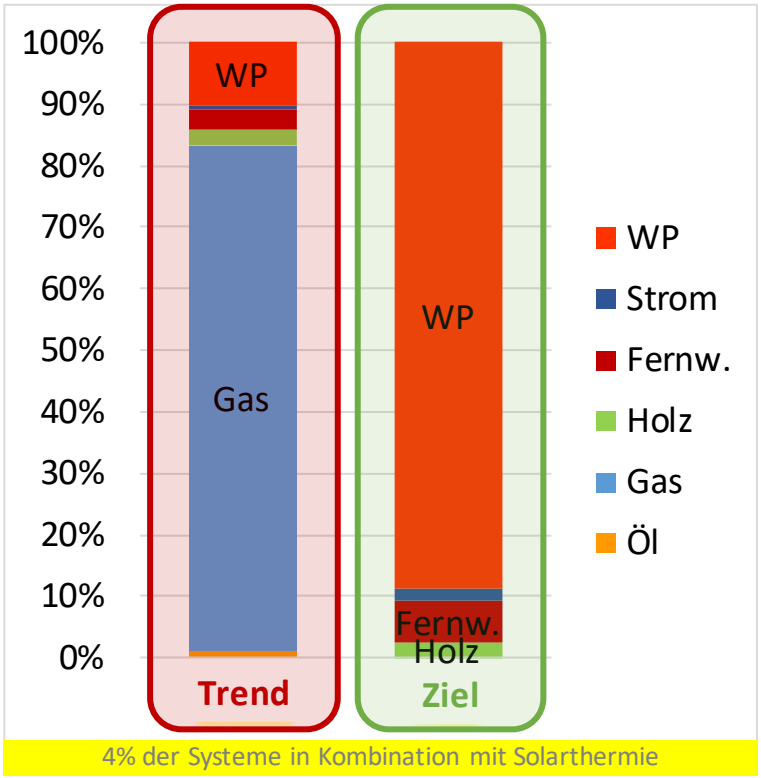
Annahme

Niedrigstenergiegebäude

Distribution Energy Carriers – Esample MFH-M
Space Heating

New Buildings



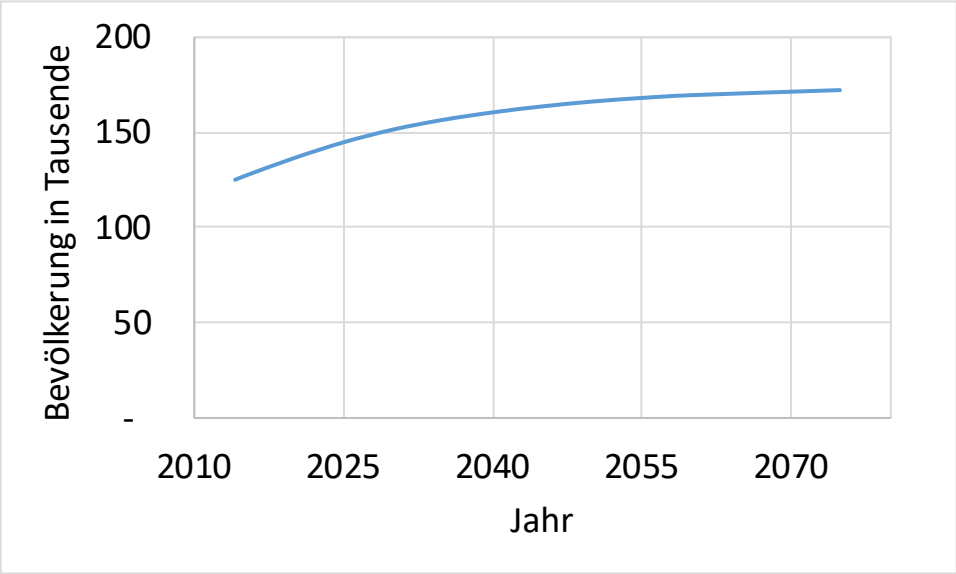


Popoulation Increase (Innsbruck)

2 Komponenten: – Bevölkerungsentwicklung

– Flächenentwicklung pro Person

ÖROK[4]: Bevölkerungsprognose für IBK



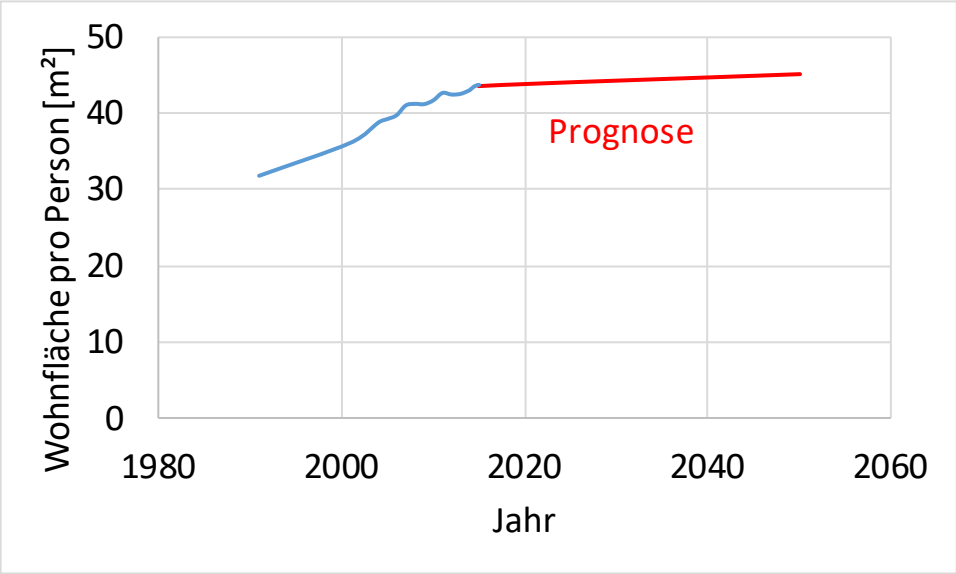
[4] ÖROK. (2015). ÖROK-Regionalprognosen 2014 - Bevölkerung: Ausführliche Tabellen zur kleinräumigen ÖROK-Prognose 2014.

Increase of Living Space per person

2 Komponenten: – Bevölkerungsentwicklung

– **Flächenentwicklung pro Person**

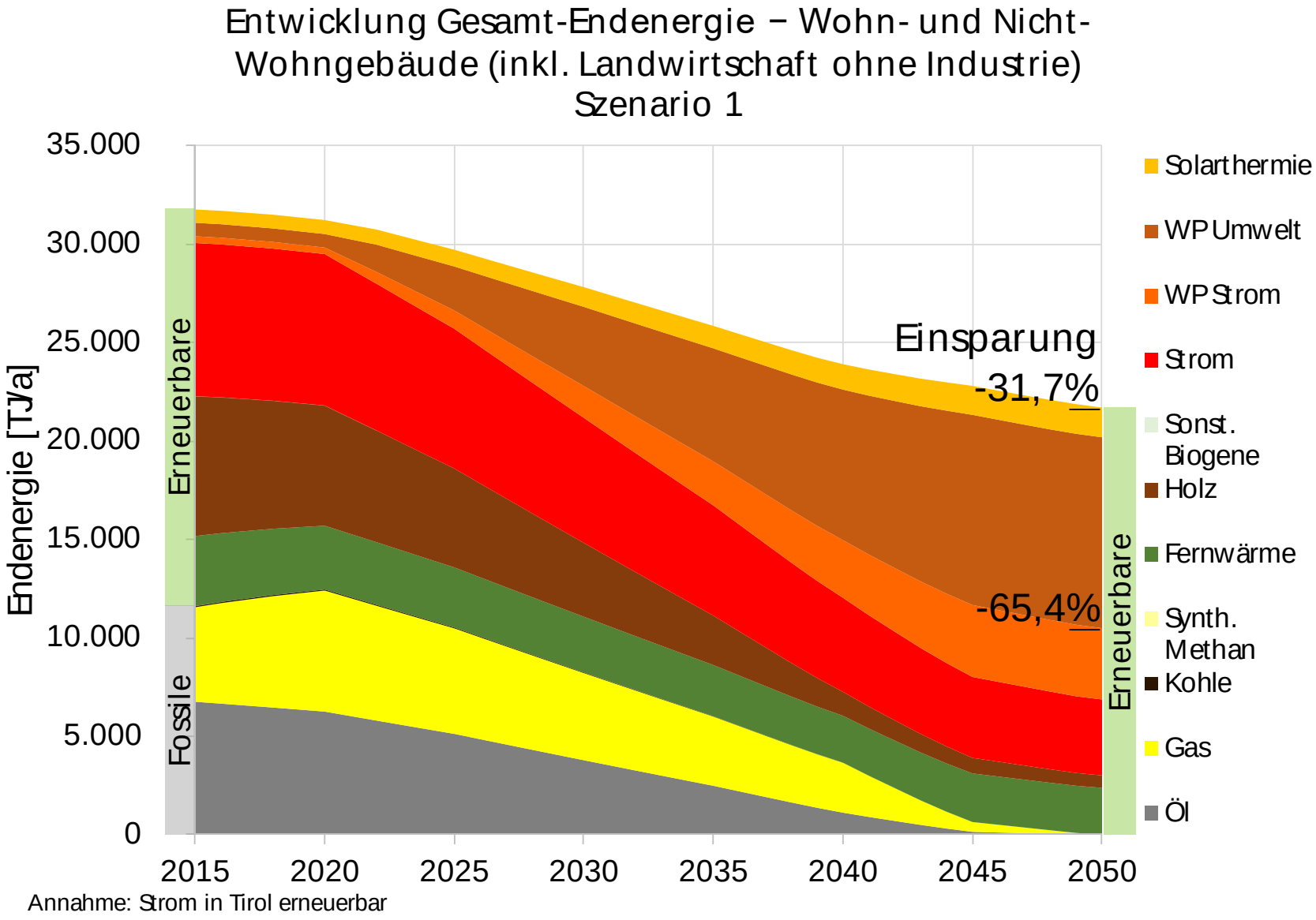
Wohnfläche pro Person in Tirol[5],[6] → Annahme: bis 2050 45m²



[5] Würlinger, J., & Kaiser, M. (2004). Gebäude und Wohnungen in Tirol: Ergebnisse der Gebäude - und Wohnungszählung 2001.

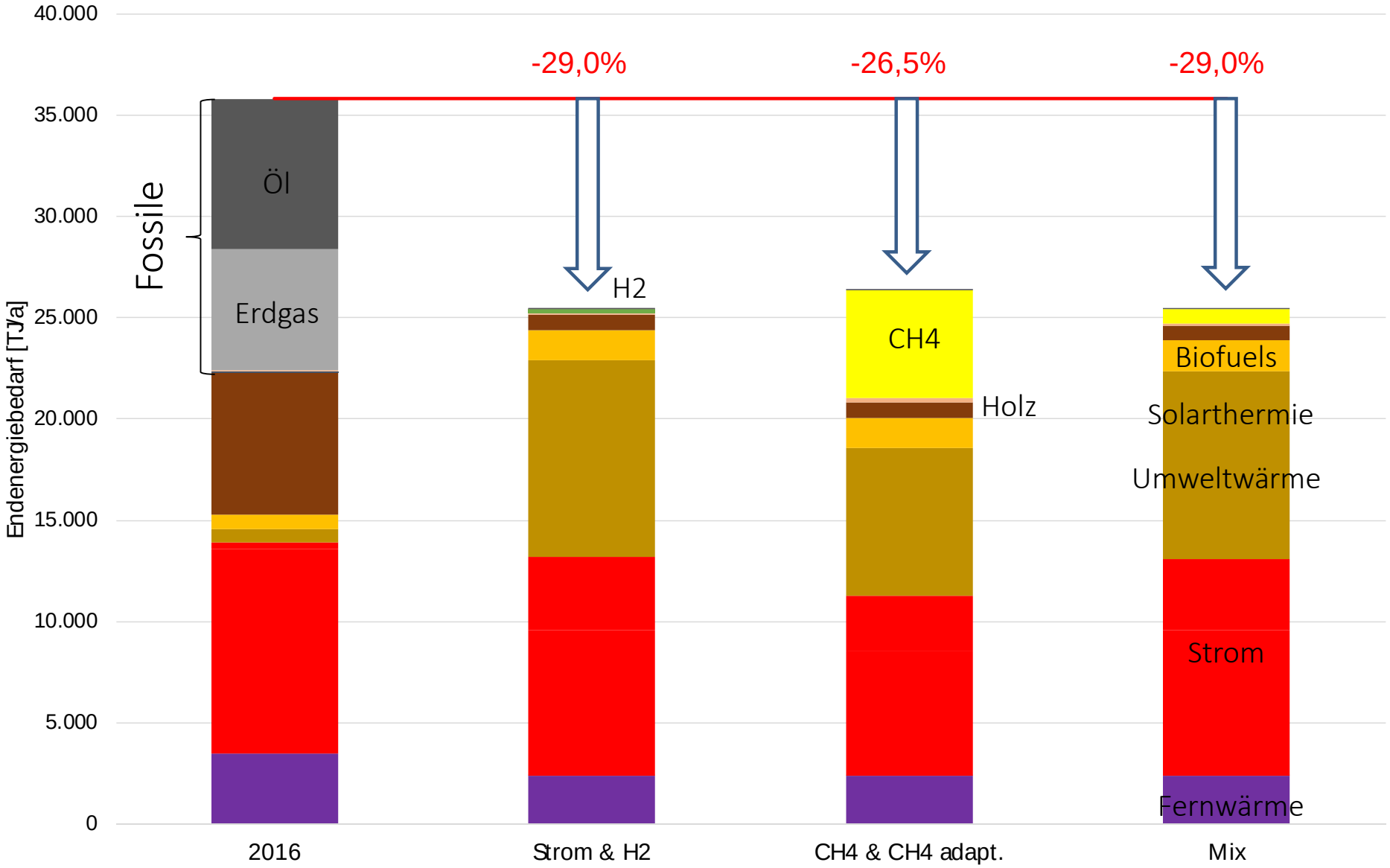
[6] Statistik Austria. (2016). Wohnungsgröße von Hauptwohnsitzwohnungen nach Bundesland (Zeitreihe).

Final Energy Demand Sector Other / Buildings

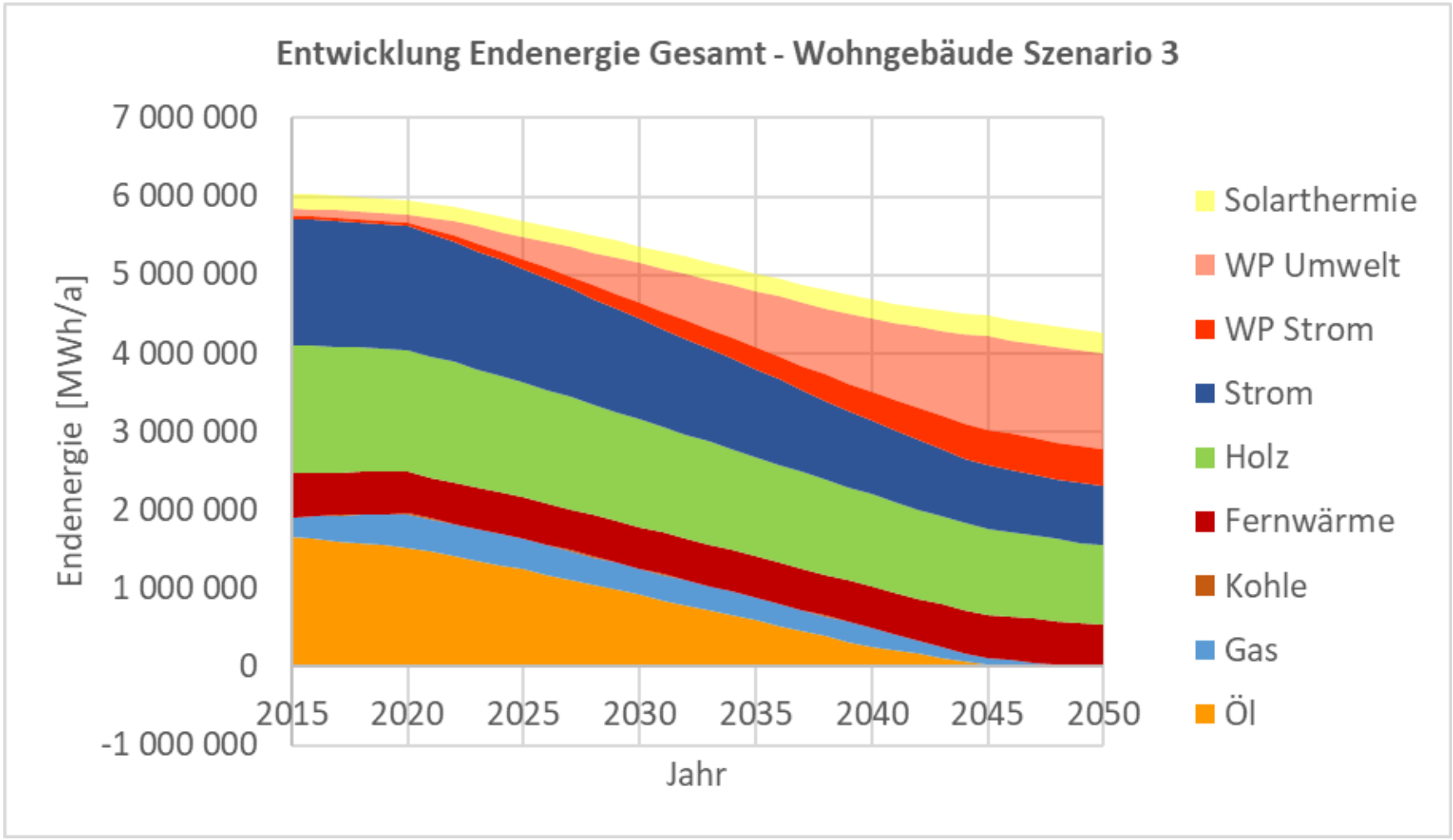


Annahme: Strom in Tirol erneuerbar

Final Energy Demand Sector Other / Buildings



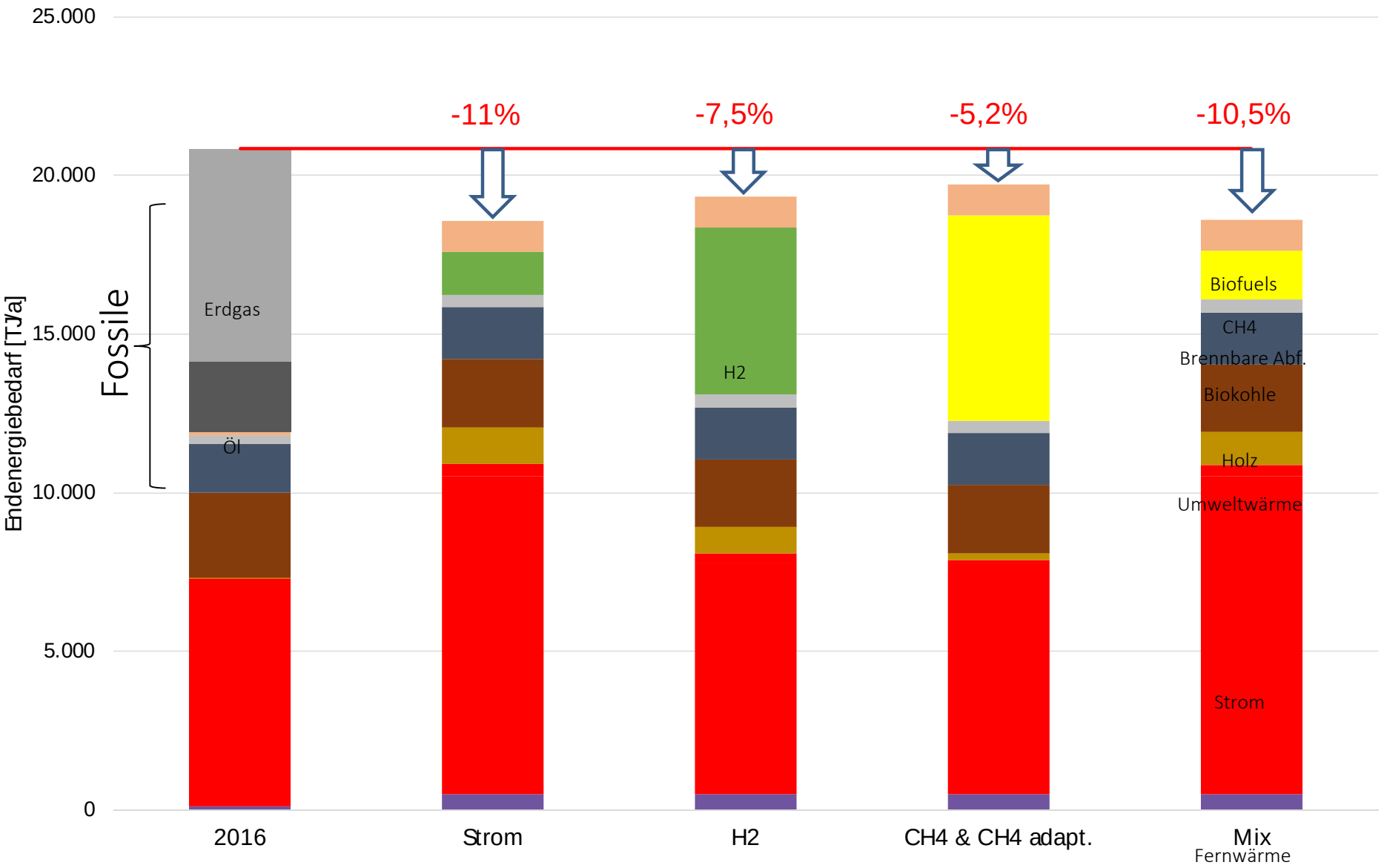
Scenario with more Biomass, whole Austria



Sektor Production

- Scenario I: Maximum Electrcity
  - All Comsumers are – if techically feasable – changed to electricity based technologies
  - Industrial stoves with the „Need of Flame“ will be driven by Hydrogen
- Szenario II: Hydrogen
  - Moderate Use of Elelectricity
  - Most of fossil Fuels are replaced by hydrogen
- Szenario III und IIIa: P2G-Methane
  - Like Scenario II, but fossil energy carriers are replaced by P2G-Methane
- Szenario IV: Energy-Mix
  - Maximierung of electricity - technologies
  - Little fossile fuels will be replaced by P2G-Methane

Final Energy Demand Sector Production



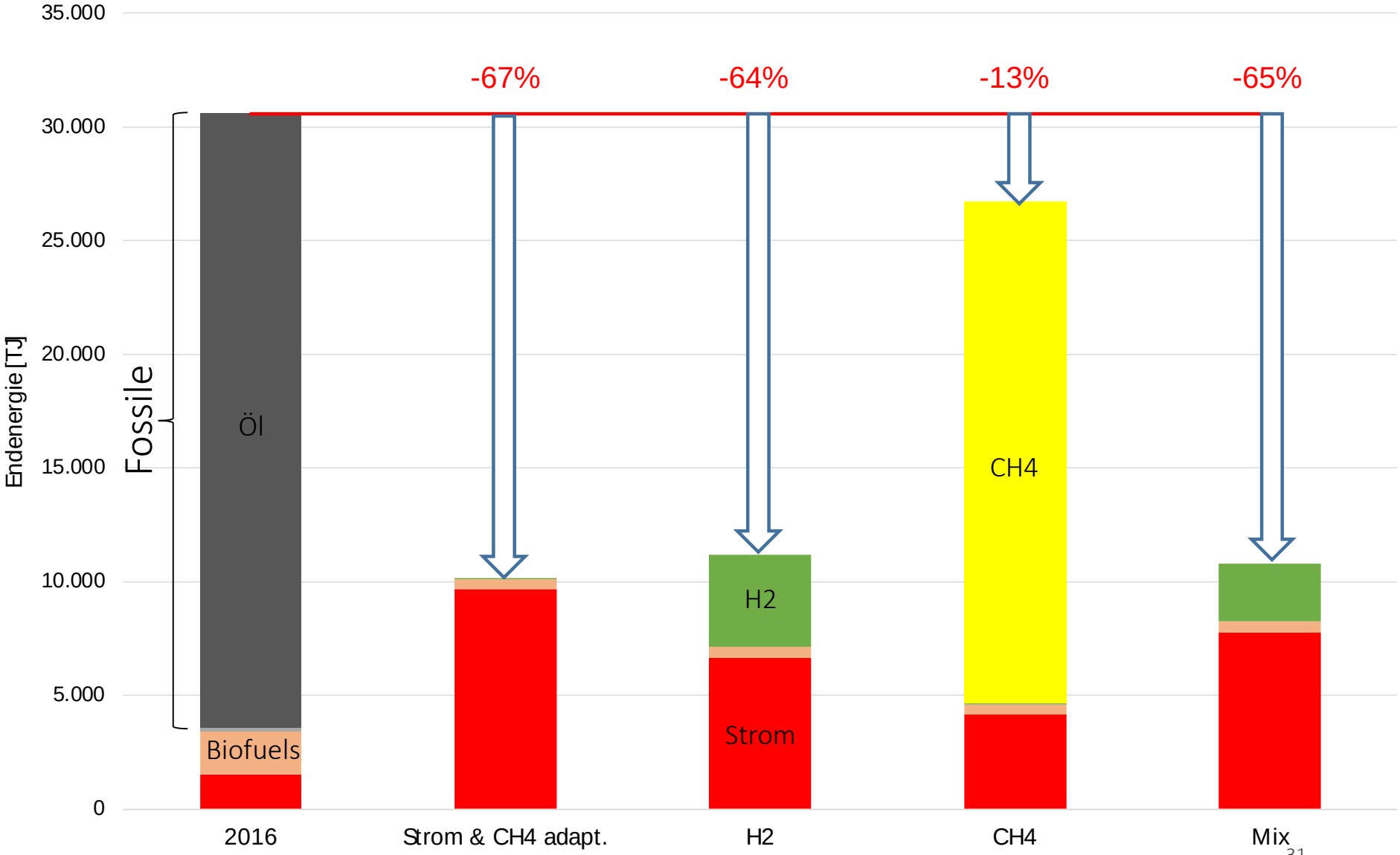
Sektor Mobility

In allen Szenarien:

Schiene elektrisch außer Zillertalbahn H_2; Flugverkehr Biofuel (Import)

- Scenario I: Maximum Electrcity
  - All road traffic will be electrified
- Szenario II: Hydrogen
  - Road traffic: Cars & Vans Electric, Trucks H_2
- Szenario III: P2G-Methane
  - Road traffic : je 50% Cars & Vans CH_4 / electric, Trucks CH_4
- Szenario IIIa: in Mobility like Scenario I
- Szenario IV: Energy-Mix
  - Road traffic: Cars & Vans, Buses and 30% Trucks electric, 70% trucks H_2

Final Energy Demand Sector Mobility



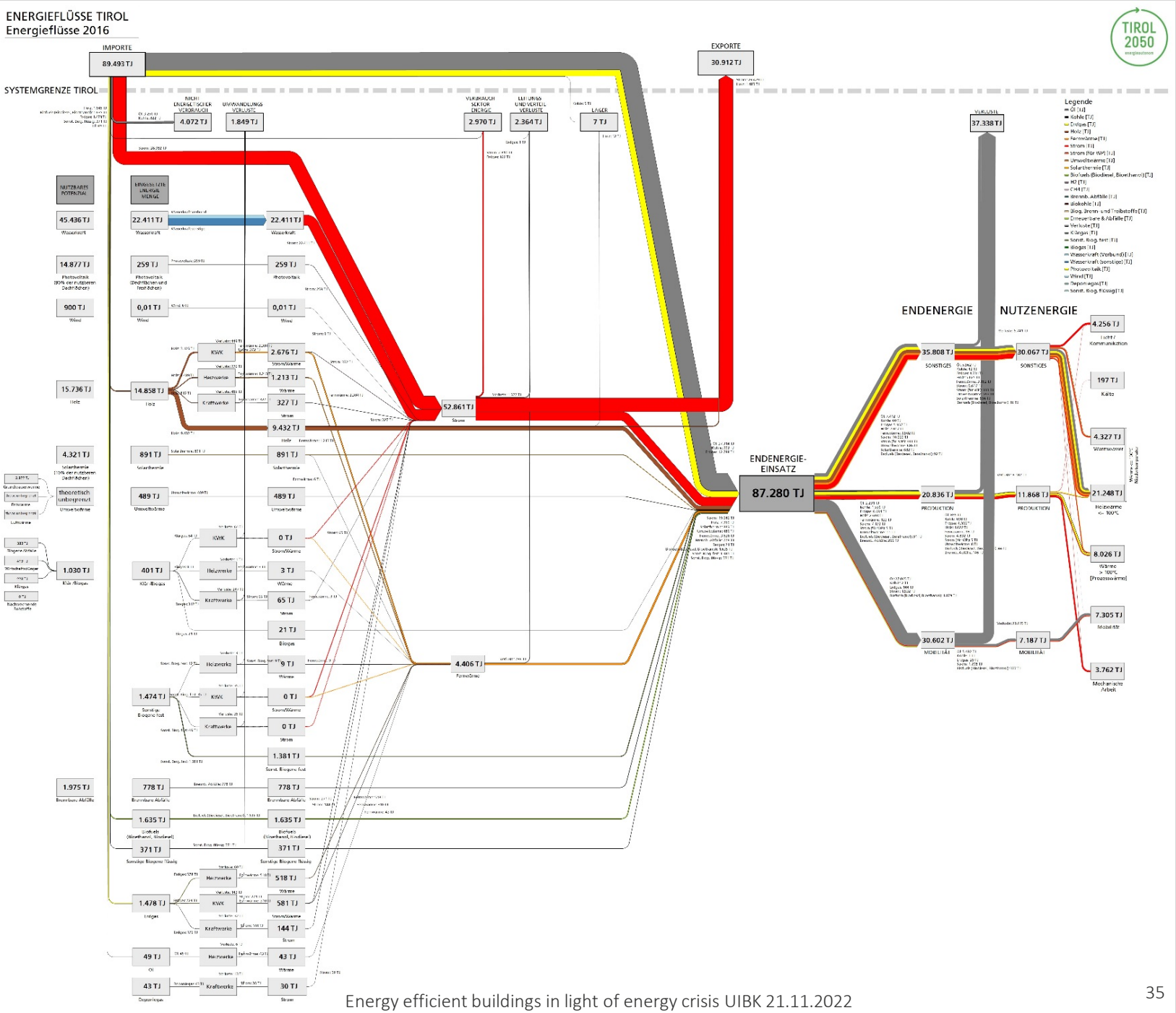
Renewable Energy Ressources

Useful Renewable Energy Ressources of Tyrol

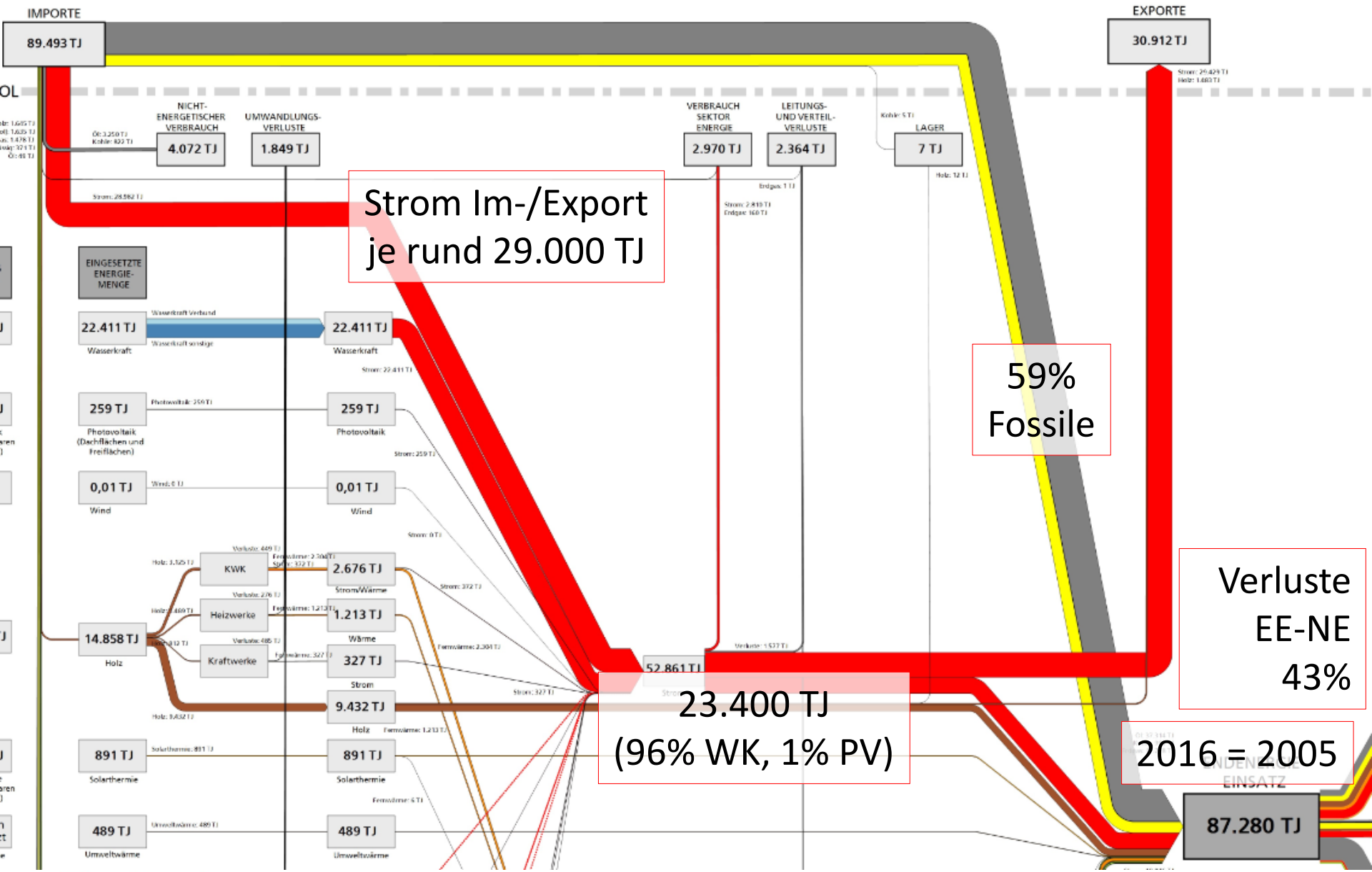
Energieressource	Nutzbares Potential [TJ]
Wasserkraft	30.600
Sonne	
Photovoltaik (95% der nutzbaren Dachflächen)	15.704
Solarthermie (5% der nutzbaren Dachflächen)	2.161
Photovoltaik Freiflächen	**nicht beziffert**
Holz	15.736
Abfälle	2.262
Wind	900
Biogas	
aus Bioabfall und Grünpflanzen	401
aus Wirtschaftsdünger	549
aus Klärgas	266
aus nachwachsenden Rohstoffen	0
Umweltwärme	
aus dem Grundwasser	2.877
aus der Erde	nicht beziffert
aus der Luft	nicht beziffert
Tiefengeothermie	nicht beziffert

SCENARIOS

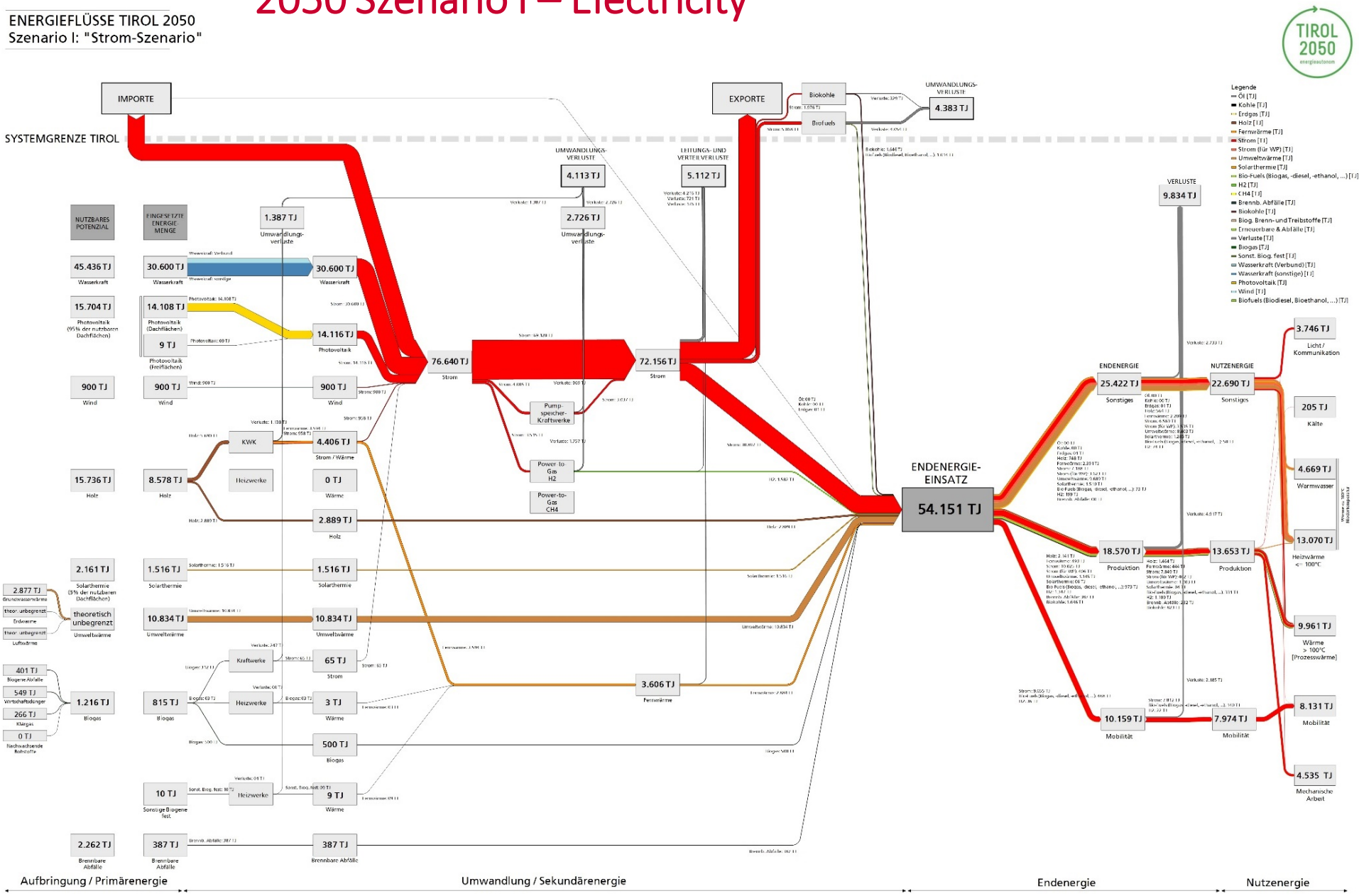
RESULTS


ENERGIEFLÜSSE TIROL
Energieflüsse 2016
IMPORTE
89.493 TJ
SYSTEMGRENZE TIROL
EXPORTE
30.912 TJ
NICHT ENERGETISCHER VERBRAUCH
4.072 TJ
UMWANDLUNGS VERLUSTE
1.849 TJ
VERBRAUCH SEKTOR ENERGIE
2.970 TJ
LEITUNGS UND VERTEIL VERLUSTE
2.364 TJ
LAGER
7 TJ
VERLUSTE
37.338 TJ
NUTZBARES POTENZIAL
INVASSIVE NUTZBARE MENGE
45.436 TJ
22.411 TJ
22.411 TJ
14.877 TJ
259 TJ
259 TJ
900 TJ
0,01 TJ
0,01 TJ
15.736 TJ
14.858 TJ
2.676 TJ
1.213 TJ
327 TJ
9.432 TJ
52.861 TJ
4.321 TJ
891 TJ
891 TJ
489 TJ
489 TJ
1.030 TJ
401 TJ
0 TJ
3 TJ
65 TJ
21 TJ
9 TJ
4.406 TJ
1.474 TJ
0 TJ
0 TJ
1.381 TJ
1.975 TJ
778 TJ
778 TJ
1.635 TJ
1.635 TJ
371 TJ
371 TJ
1.478 TJ
518 TJ
581 TJ
144 TJ
49 TJ
43 TJ
43 TJ
30 TJ
KWK
Heizwerke
Kraftwerke
ENDENERGIE-EINSATZ
87.280 TJ
ENDENERGIE
NUTZENERGIE
35.808 TJ
SONSTIGES
20.836 TJ
PRODUKTION
30.602 TJ
MOBILITÄT
30.067 TJ
11.868 TJ
7.187 TJ
4.256 TJ
197 TJ
4.327 TJ
21.248 TJ
8.026 TJ
7.305 TJ
3.762 TJ
Legende

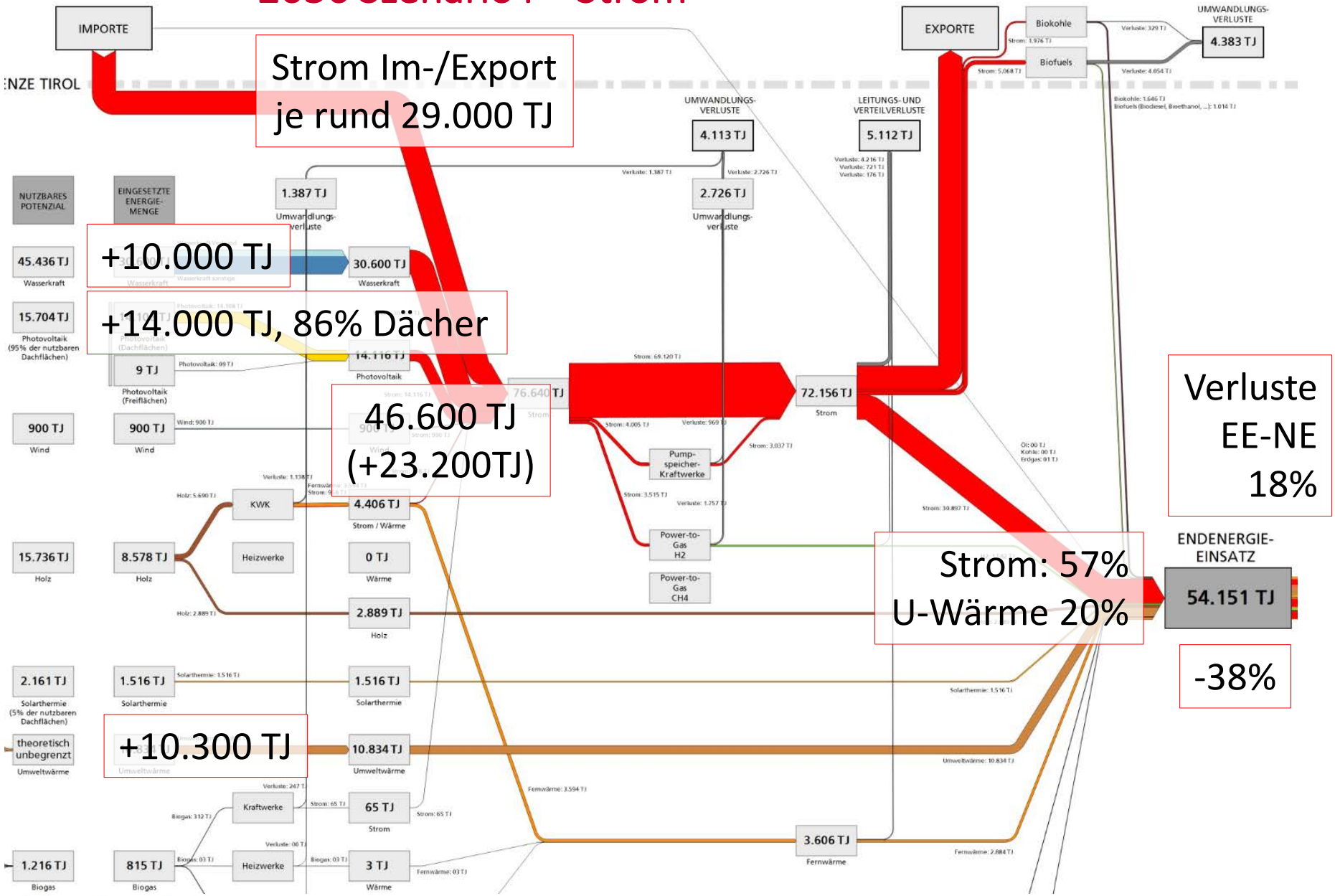
State 2016


IMPORTE
89.493 TJ
EXPORTE
30.912 TJ
NICHT-ENERGETISCHER VERBRAUCH
4.072 TJ
UMWANDLUNGS-VERLUSTE
1.849 TJ
VERBRAUCH SEKTOR ENERGIE
2.970 TJ
LEITUNGS- UND VERTEIL-VERLUSTE
2.364 TJ
LAGER
7 TJ
Strom Im-/Export
je rund 29.000 TJ
EINGESETZTE ENERGIE-MENGE
22.411 TJ
Wasserkraft
22.411 TJ
Wasserkraft
259 TJ
Photovoltaik (Dachflächen und Freiflächen)
259 TJ
Photovoltaik
0,01 TJ
Wind
0,01 TJ
Wind
KWK
2.676 TJ
Strom/Wärme
Heizwerke
1.213 TJ
Wärme
14.858 TJ
Holz
Kraftwerke
327 TJ
Strom
9.432 TJ
Holz
891 TJ
Solarthermie
891 TJ
Solarthermie
489 TJ
Umweltwärme
489 TJ
Umweltwärme
52.861 TJ
59%
Fossile
Verluste
EE-NE
43%
23.400 TJ
(96% WK, 1% PV)
2016 = 2005
87.280 TJ

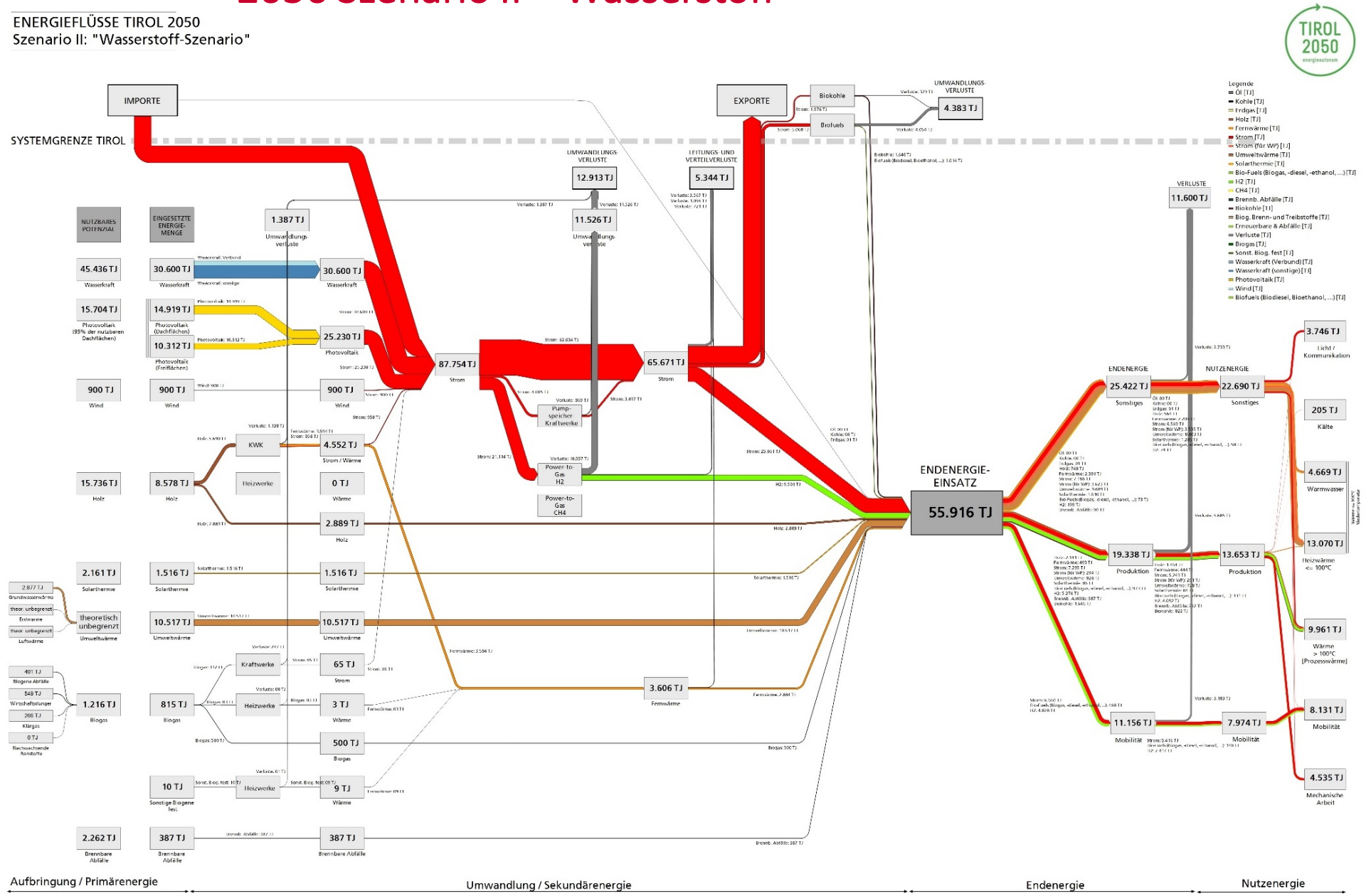
2050 Szenario I – Electricity



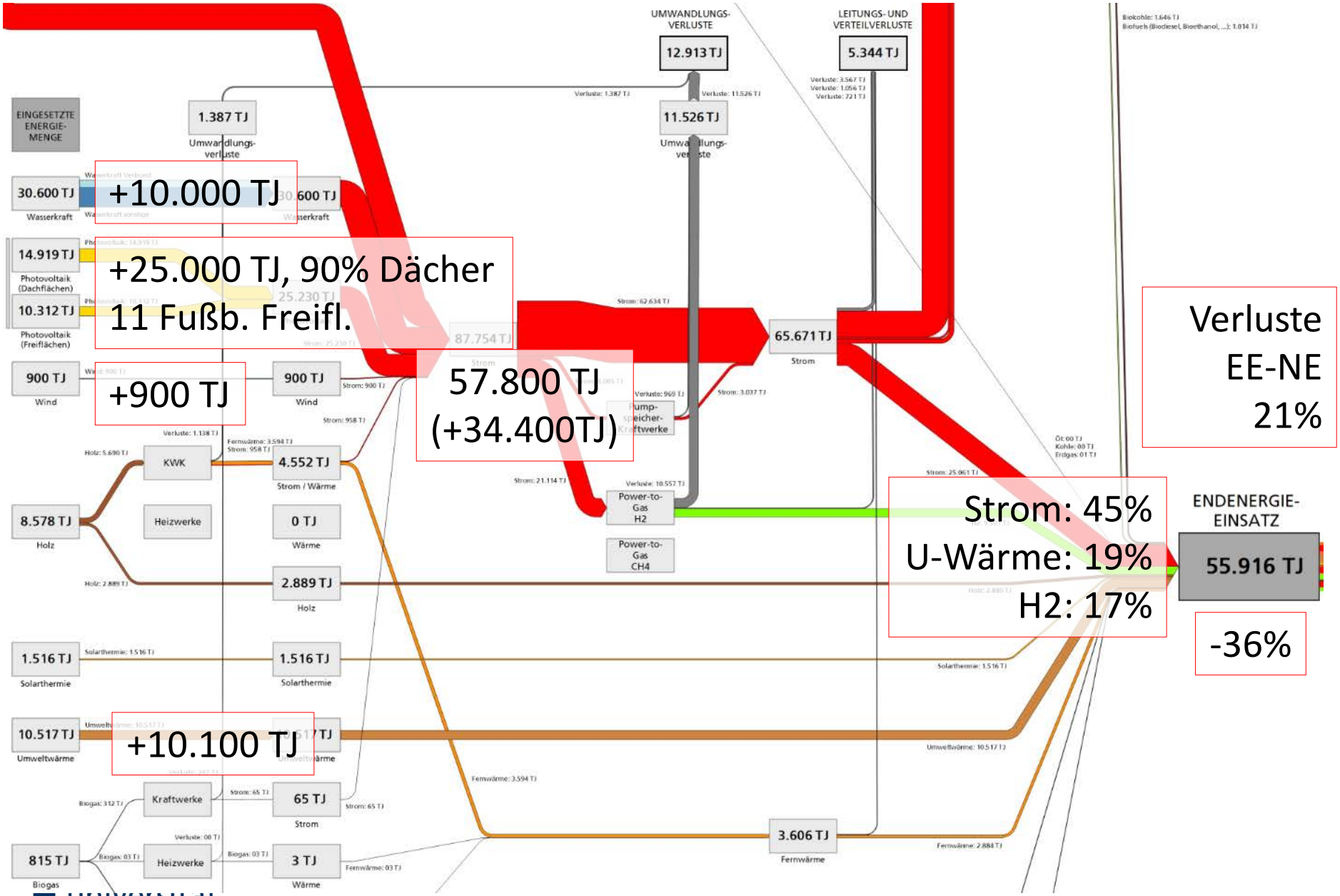
2050 Szenario I – Strom



2050 Szenario II – Wasserstoff

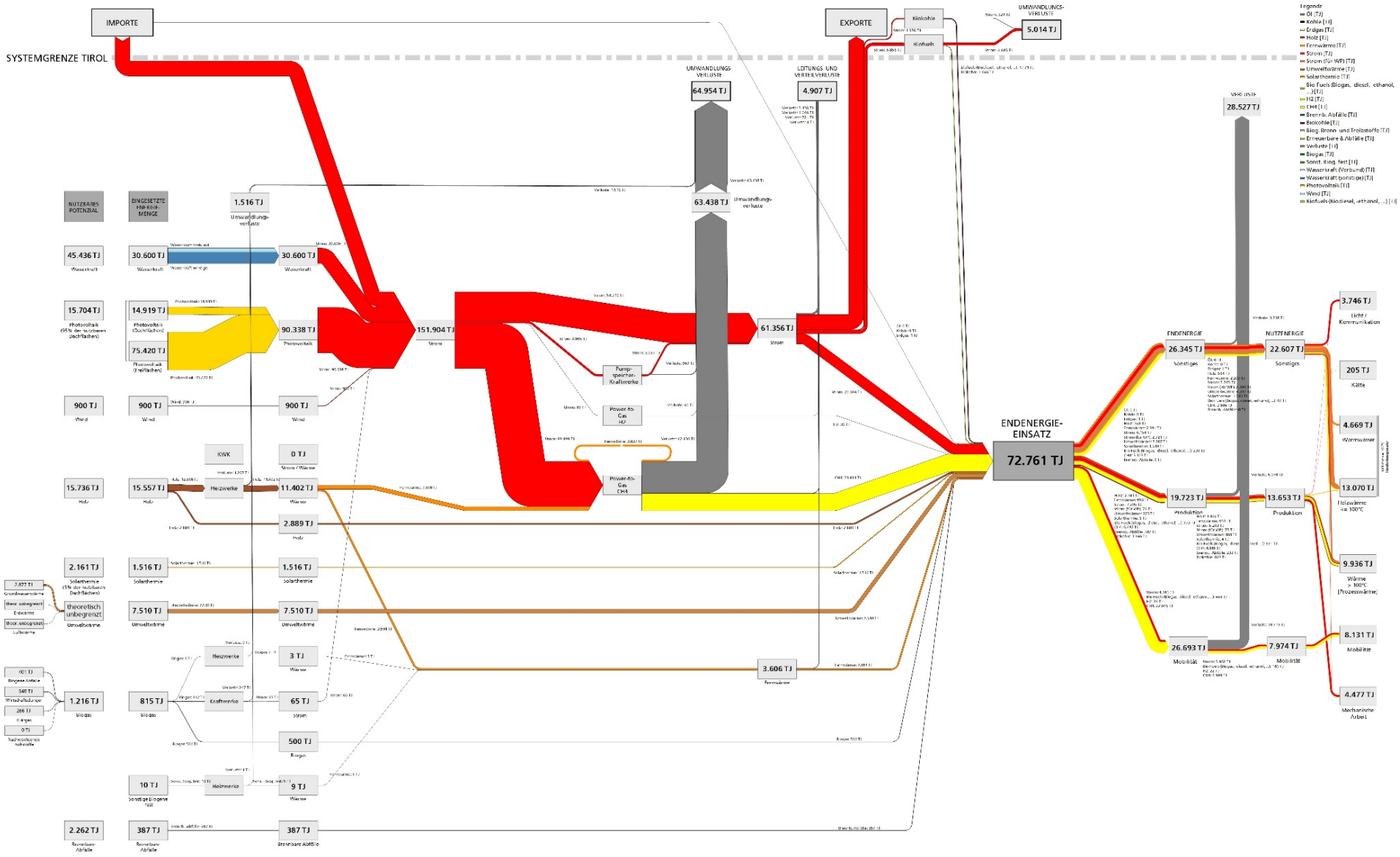


2050 Szenario II – Wasserstoff



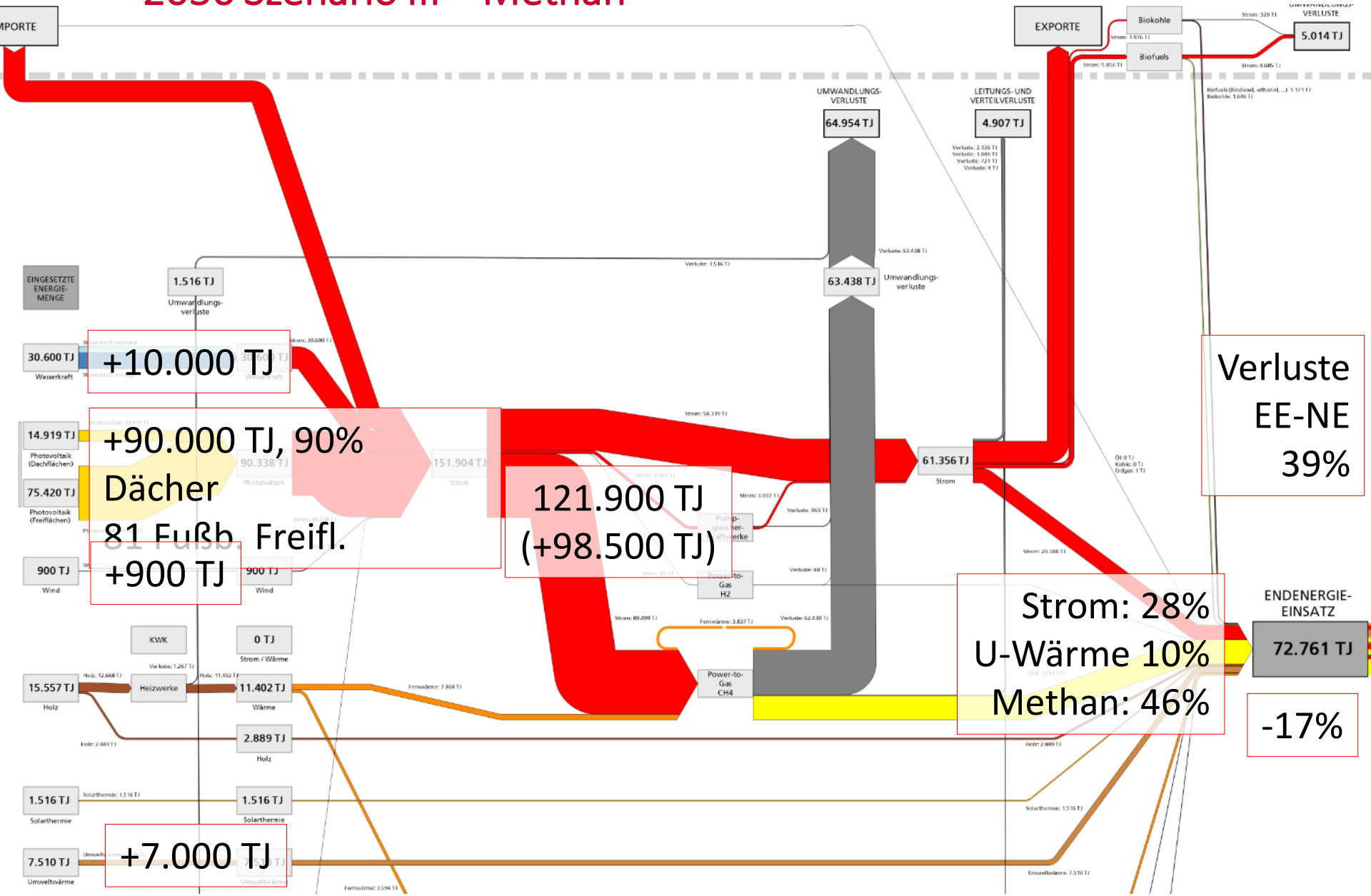
2050 Szenario III – Methan

ENERGIEFLÜSSE TIROL 2050
Szenario III: "Methan-Szenario"



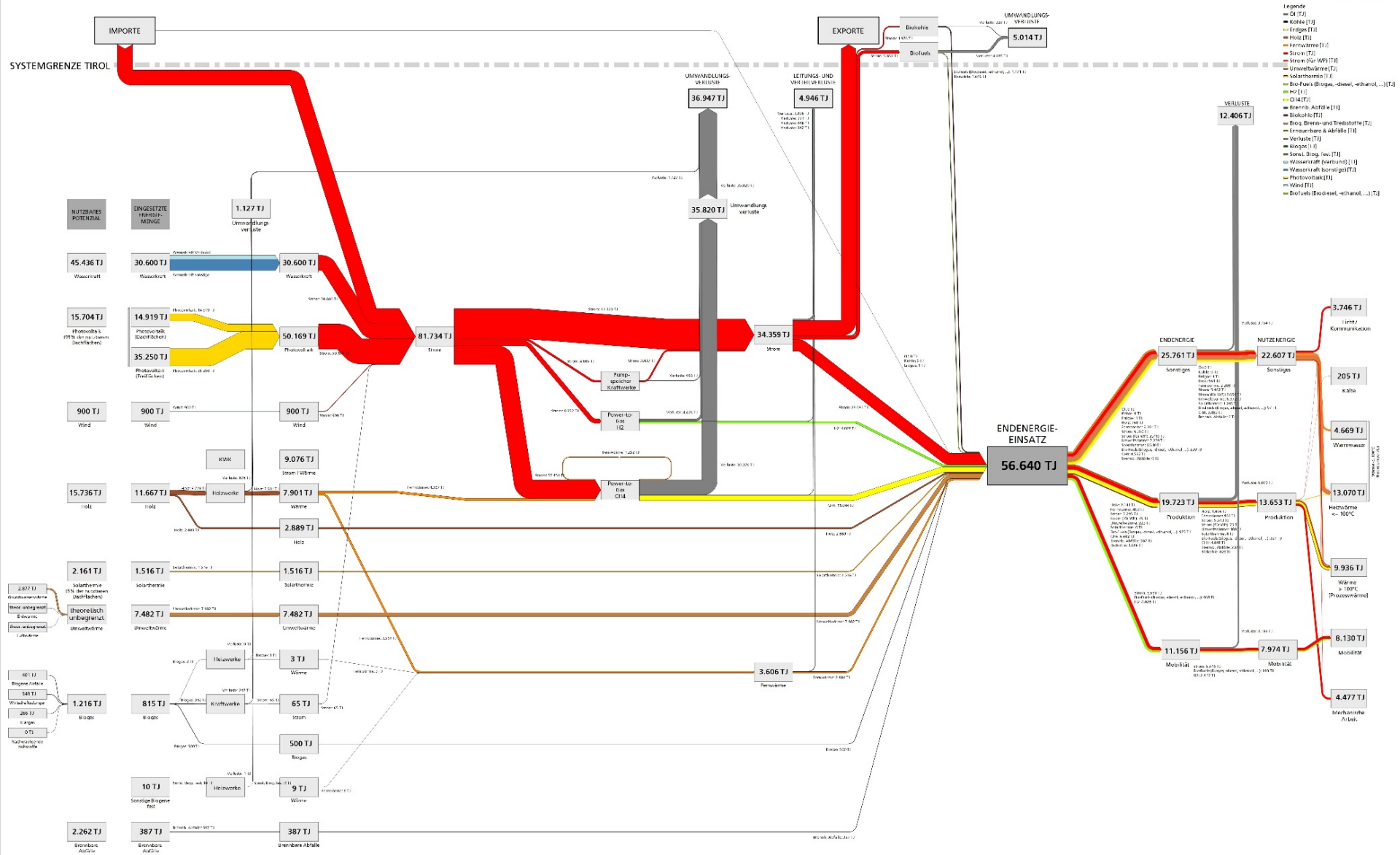
Aufbringung / Primärenergie · Umwandlung / Sekundärenergie · Endenergie · Nutzenergie

2050 Szenario III – Methan

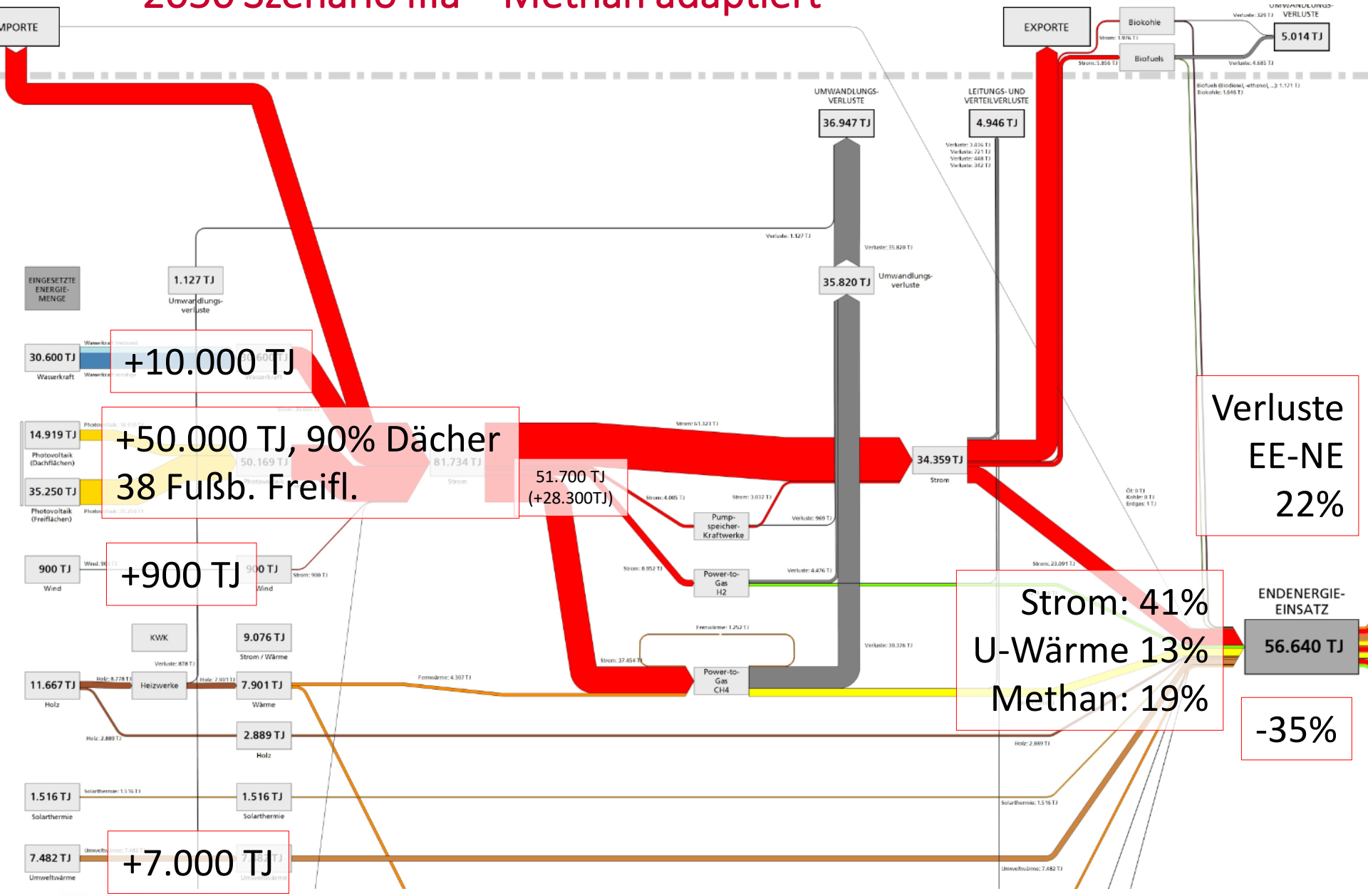


ENERGIEFLÜSSE TIROL 2050
Szenario IIIa: "adaptiertes Methan-Szenario"

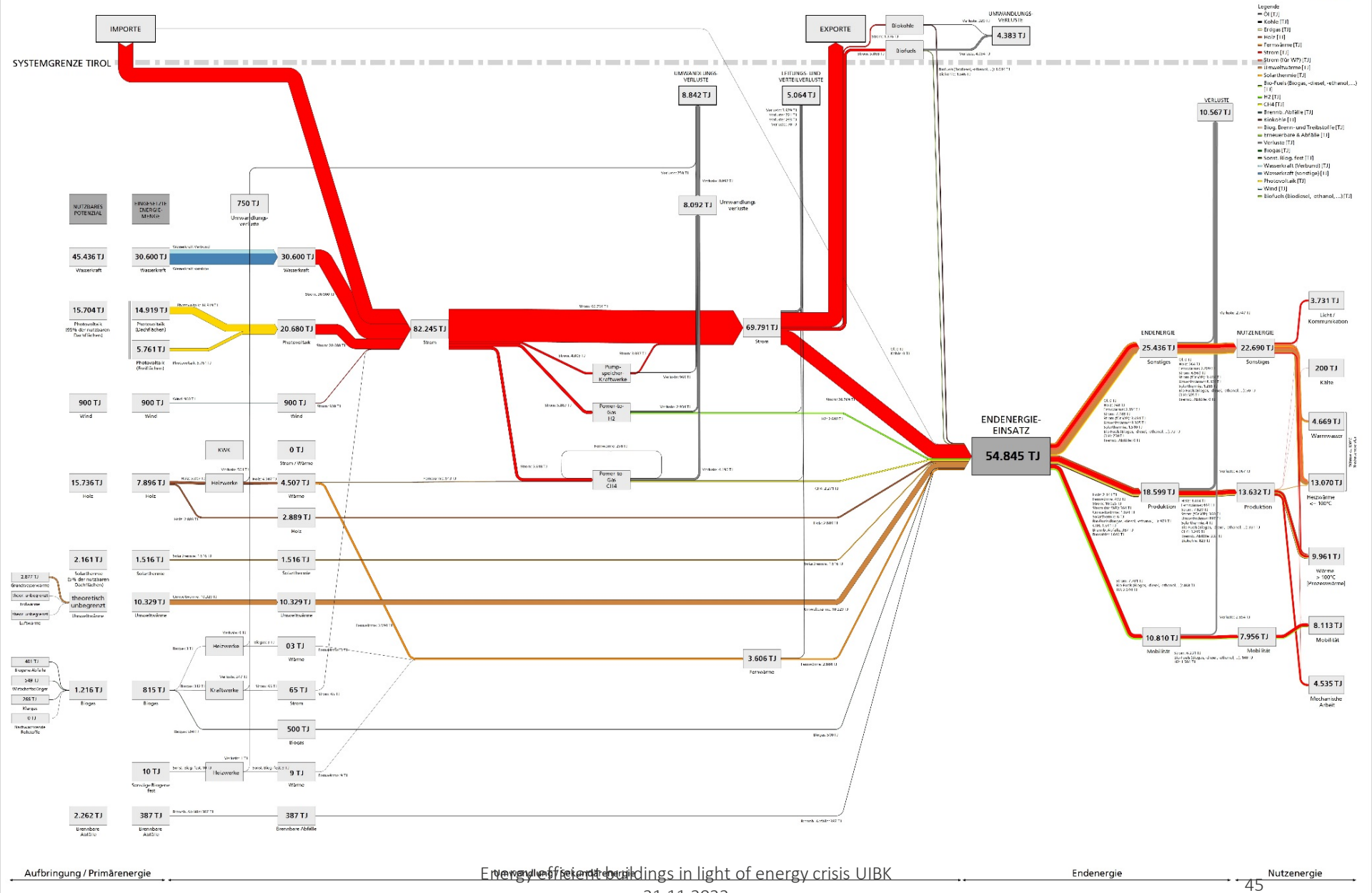
2050 Szenario IIIa – Methan adaptiert



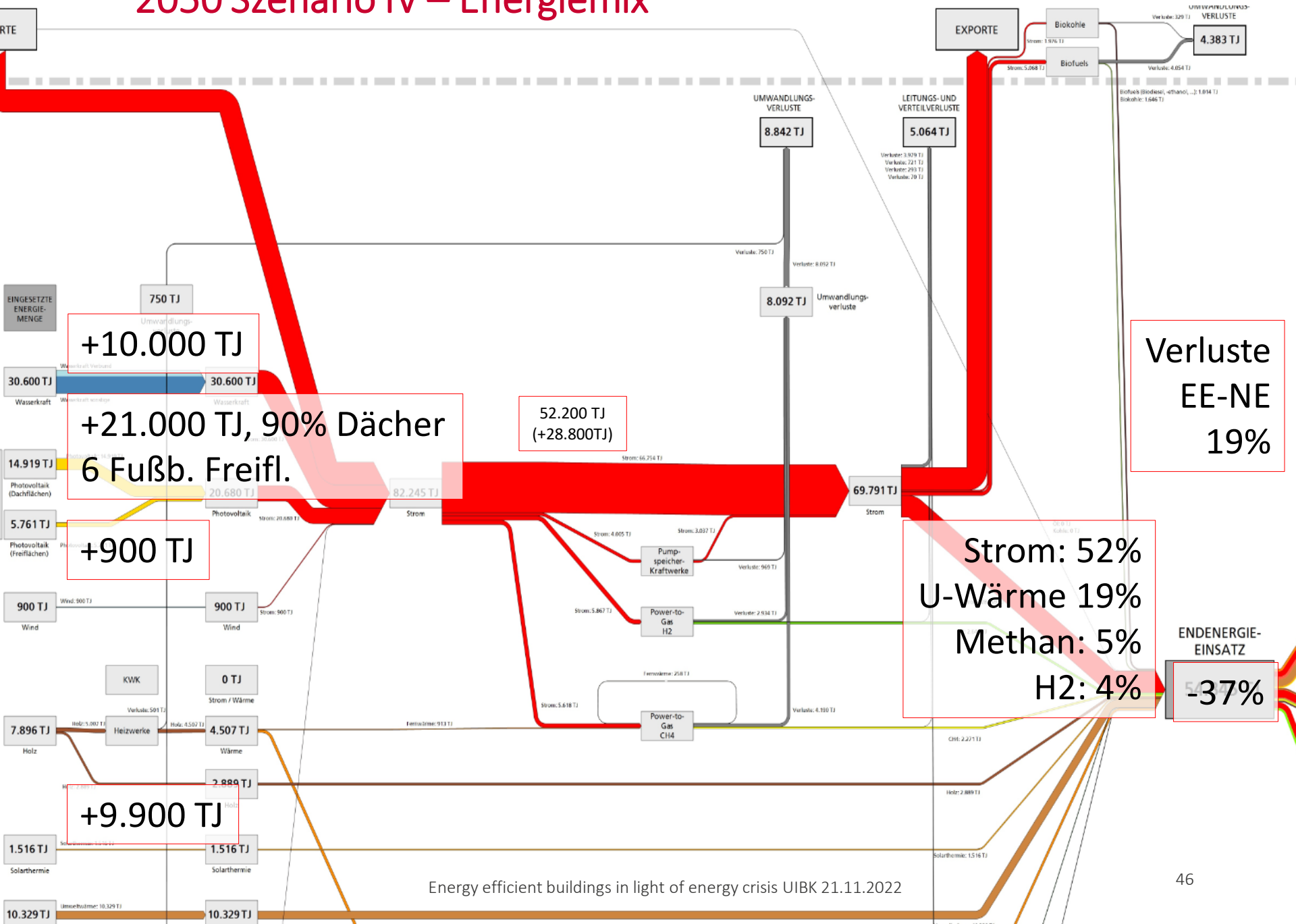
2050 Szenario IIIa – Methan adaptiert



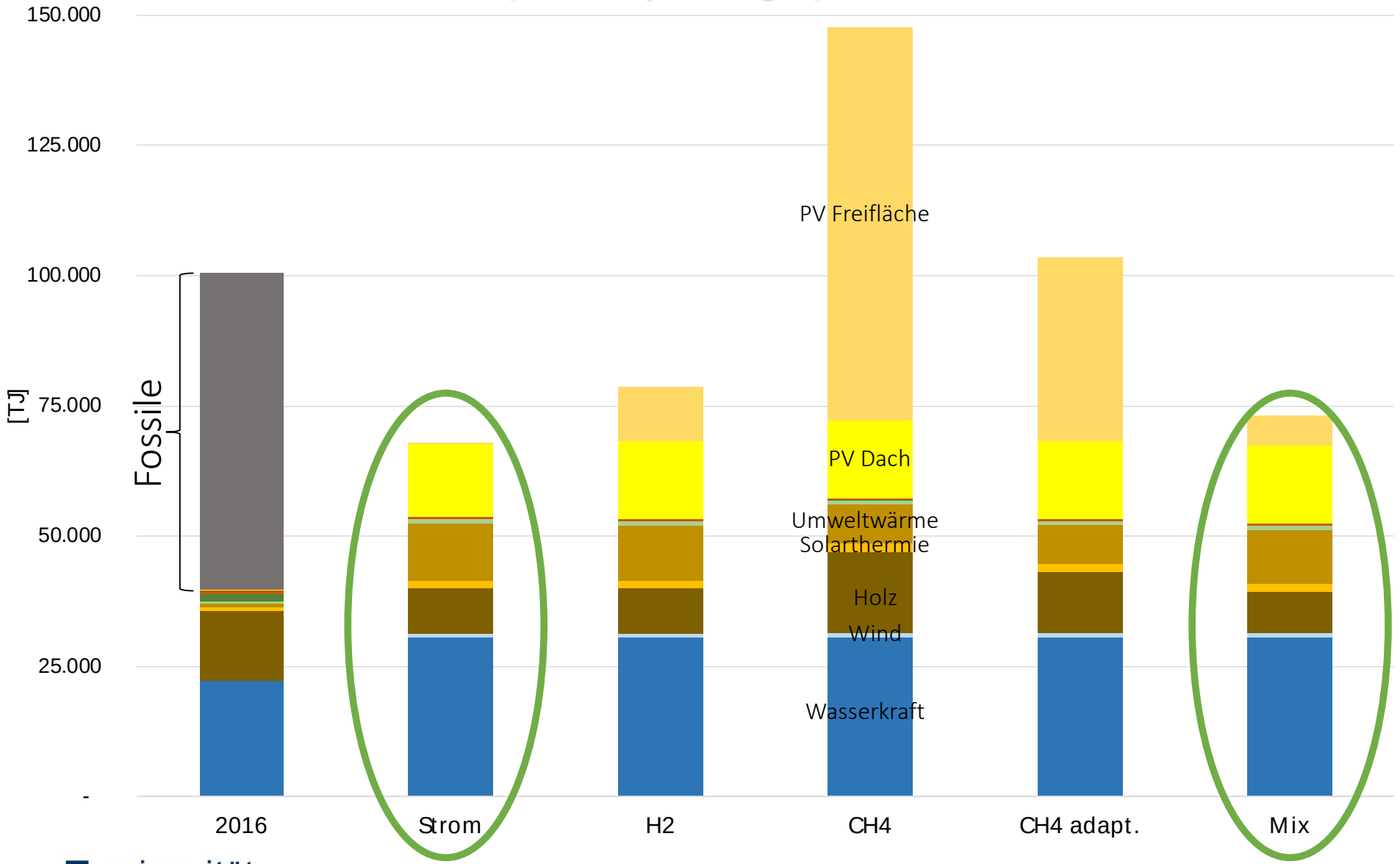
2050 Szenario IV – Energiemix



2050 Szenario IV – Energiemix



Results
Ressource Use (Primary Energie)



Zusammenfassung Szenarien Tirol

- All 5 Scenarios can be reached with today´s technologies.
- The Scenarios have realistic user behavior (no reduction of energy serviced underlayed.
- To reach the goals in Tirol 2050 huge efforts are needed in all sectors.
- The measures in allsectors have to start NOW.
- The most efficient scenario is the electriciy scenario
- Seasonal storage is not yet included in the calculations.

Who will be winner and who losers ?

Winners

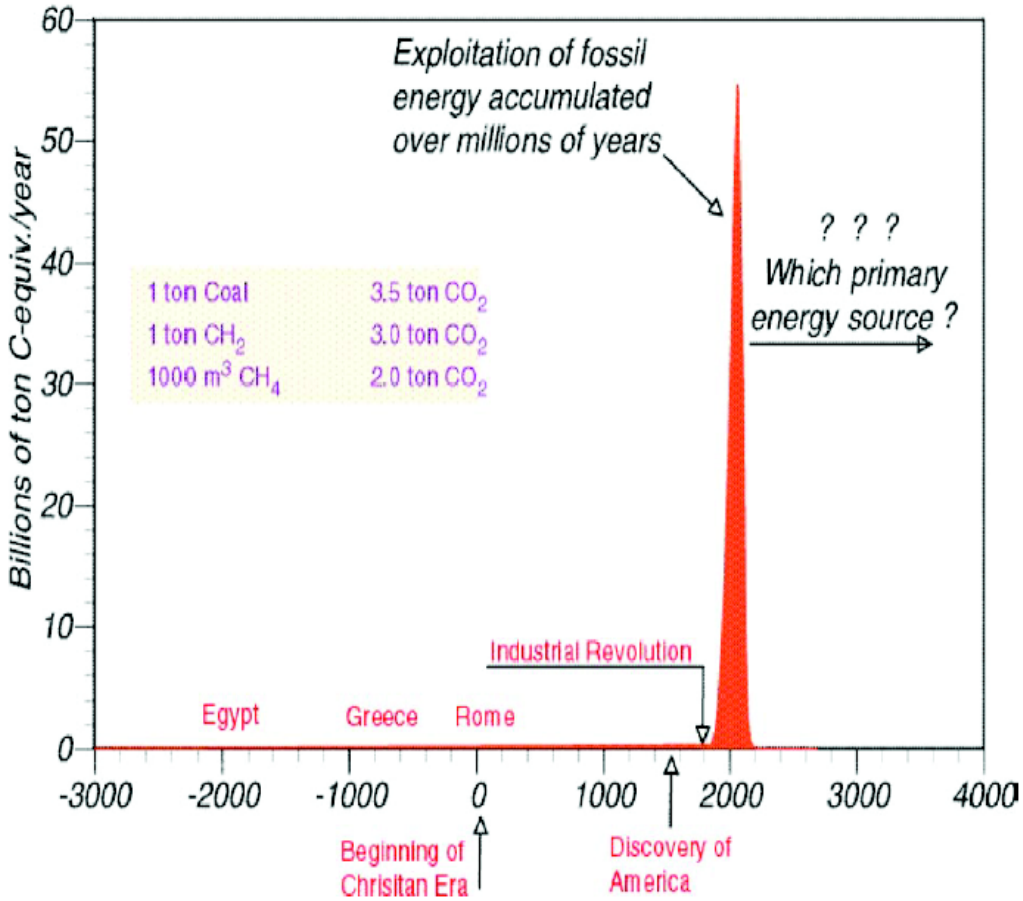
- Countries with a lot of Sun (this is you!!!), Water, Wind
- PV, Wind, Hydro
- Electric Networks
- Batteries, power-to-x
- Industrial processes (a lot has to be redesigns or newly built)
- Heat pumps
- Building industry (renovation

Losers

- Fossil fuel producers, owners of oil/gas/coal fields (oil, gas, coal companies)
- Internal combustion engine producers, oil/gas burner producers (partly)
- classical steam plant producers

A transition give always chances

The (short) era of fossil fuels



Thank you for your attention

THANKS FOR YOUR KIND ATTENTION

https://www.tirol.gv.at/fileadmin/themen/umwelt/wasser_wasserrecht/Downloads/19-03-08_Szenarien-Tirol-2050_Endbericht-Stand-18-10-15.pdf