Perspectives for the transformation towards a low-carbon building stock - the example of Tyrol/Austria?

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Content

Method Baseline (current state)

Results number and type of buildings

Scenario Assumptions

Results

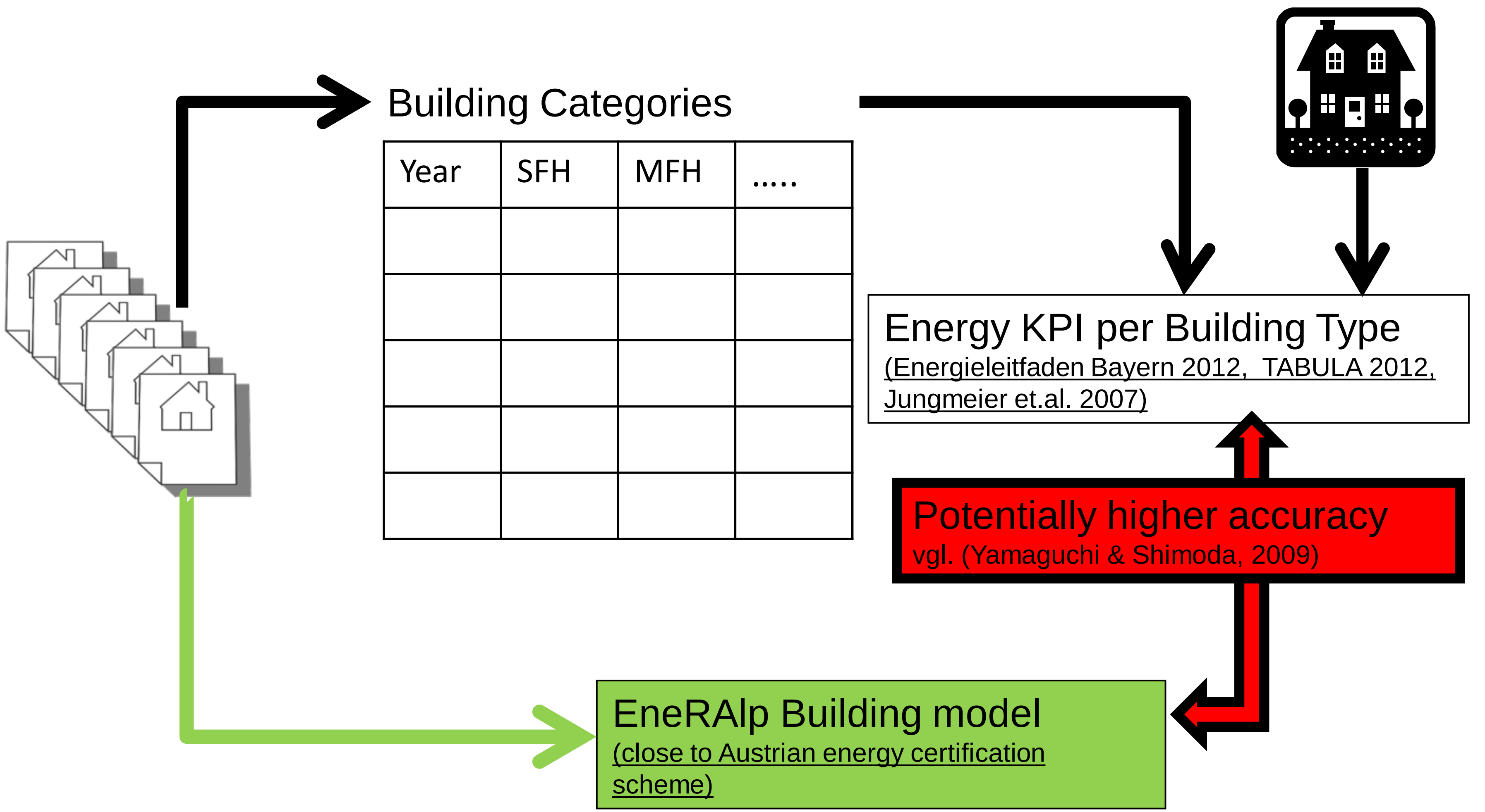
Summary / critical reflection

Starting with Innsbruck: Main datasets SINFONIA district

Main Datasets	**Source**
AGWR* Administrative Report buildings	Municipality Innsbruck
AGWR Administrative Report building units	Municipality Innsbruck
AGWR Administrative Report construction projects of buildings	Municipality Innsbruck
AGWR Administrative Report construction projects building units	Municipality Innsbruck
Digital Building polygons and address	Municipality Innsbruck
Surface and Terrain Model	Municipality Innsbruck
Electricity Consumption Data (Raster)	IKB
Gas Consumption Data (Raster)	TIGAS

*Austrian Federal Building and Dwelling Database; table source [5]

Model-setting: Bottom up



Year	SFH	MFH	.....

Building categories

Building category	Useage
Single family house (EFH, SFH)	1 appartment (single house)
Row house (RH)	1 appartment (attached walls)
Multi family house „small“ (MFH-K)	2-4 appartments
Multi family house „middle“(MFH-M)	5-10 appartments
Multi family house „large“ (MFH-G)	> 10 appartments
Mixed use* (MN)	Appartment, office, large and small shops, hotel and other units for temporary renting, transportation and telecom, industry, storages, culture, leasure, education, health, public buildings, other
Trade (GW)	Office, large and small shops, hotel and other units for temporary renting
Industry (IND)	Industry, storages
Miscellaneous	culture, leasure, education, health, agriculture, transportation and telecom, churches, other religious, residential areas for communities
Other	Private garage, non permanent builindgs (tents, caravans) other

* min. two different units in one building

Model calibration factor / Servicefactor (fs)

$$fm_{\text{(building category, building age)}} = \frac{\text{measured energy consumption}}{\text{calculated energy demand}}$$

Base values:

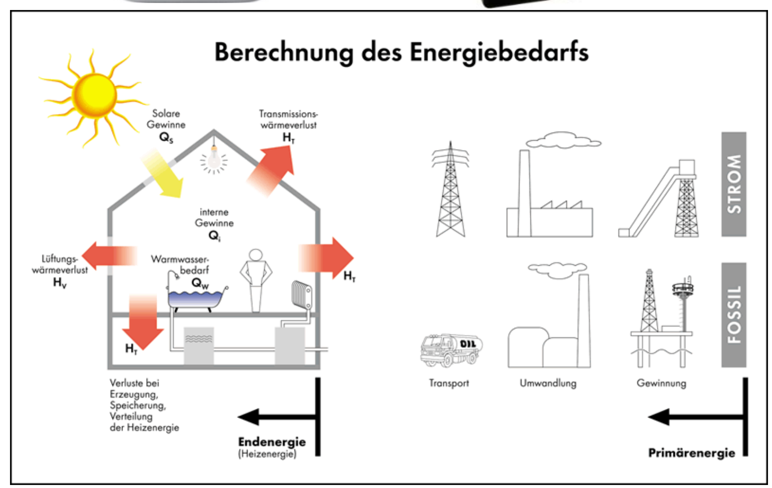
- Measured gas demand
- Measured electricity demand
- KPIs from calculation schemes

Influences included:

- Climate dependecy of demand

Factor includes wihout separation:

- User behaviour
- Renovation measured
- Data accuracy
- Partly heating
- Partly not habited houses
- …



Bildquellen: www.duden.de / de.wikipedia.org / www.energiemanagement.stadt-frankfurt.de 20.01.2015

Calibration factors heat (average value)

Bauperiode	EFH	RH	MFH-K	MFH-M	MFH-G	MN
vor 1919	0,38	0,32	0,35	0,37	0,27	0,43
1919 bis 1944	0,33	0,28	0,32	0,29	0,27	0,34
1945 bis 1960	0,24	0,22	0,30	0,25	0,29	0,53
1961 bis 1970	0,30	0,36	0,35	0,28	0,66	0,71
1971 bis 1980	**0,41**[19]	**0,61**	0,47	**0,12**	1,06	0,79
1981 bis 1990	0,62	0,58	**0,66**	1,01	1,25	1,10
1991 bis 2000	0,54	1,11	0,61	1,08	1,27	**0,91**
2001 bis 2013	0,66	1,04	0,83	1,12	1,16	1,01

Quelle: Dissertation, Pfeifer D.

Calibration factor heat distribution example SFH + RH, all ages

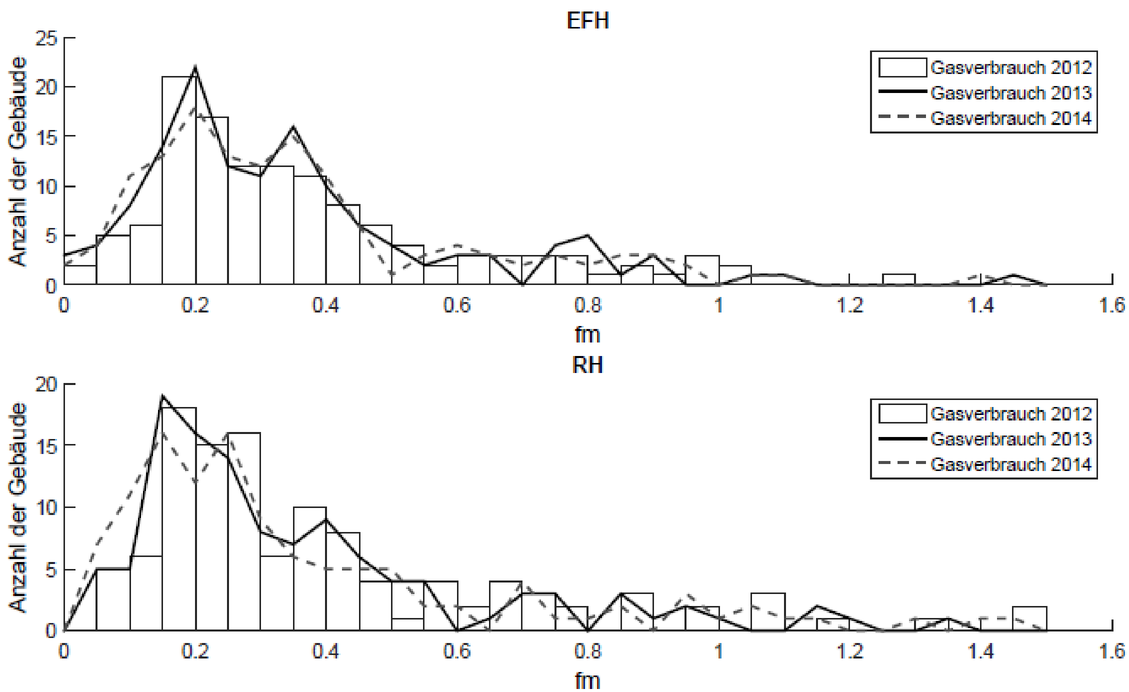


Abbildung 4.7.: Modellkalibrierfaktoren Wärme Kategorie EFH und RH - Quelle: EneRAlp Berechnungsmodell, TIGAS, Auswertungen in Zusammenarbeit TIGAS

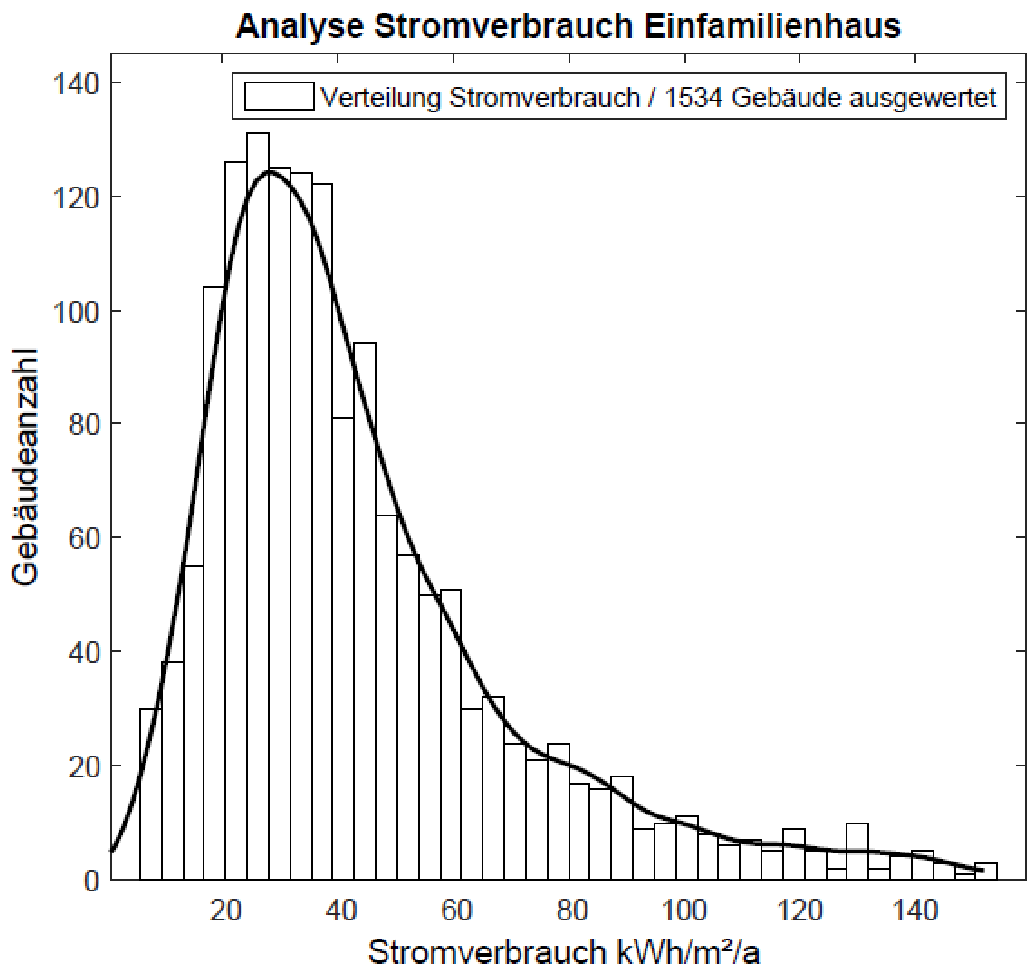
Quelle: Dissertation, Pfeifer D.

Calibration factors electricity (average value)

Bauperiode	EFH	RH	MFH-K	MFH-M	MFH-G	MN	GW
vor 1919	2,17	2,09	2,34	2,45	2,32	1,47	1,33
1919 bis 1944	1,97	2,16	2,21	2,47	2,56	1,66	1,94
1945 bis 1960	1,96	2,01	2,10	2,62	2,57	1,51	1,87
1961 bis 1970	1,89	1,71	2,04	2,06	2,30	1,42	1,64
1971 bis 1980	1,90	1,68	1,84	1,75	1,89	1,11	1,93
1981 bis 1990	2,24	2,16	2,18	2,40	2,39	1,42	1,51
1991 bis 2000	2,11	1,89	2,19	2,49	2,61	1,63	2,87
2001 bis 2014	2,00	1,87	1,73	1,95	2,10	1,52	3,24

Quelle: Dissertation, Pfeifer D.

Specific electricity demand SFH



Quelle: Dissertation, Pfeifer D.

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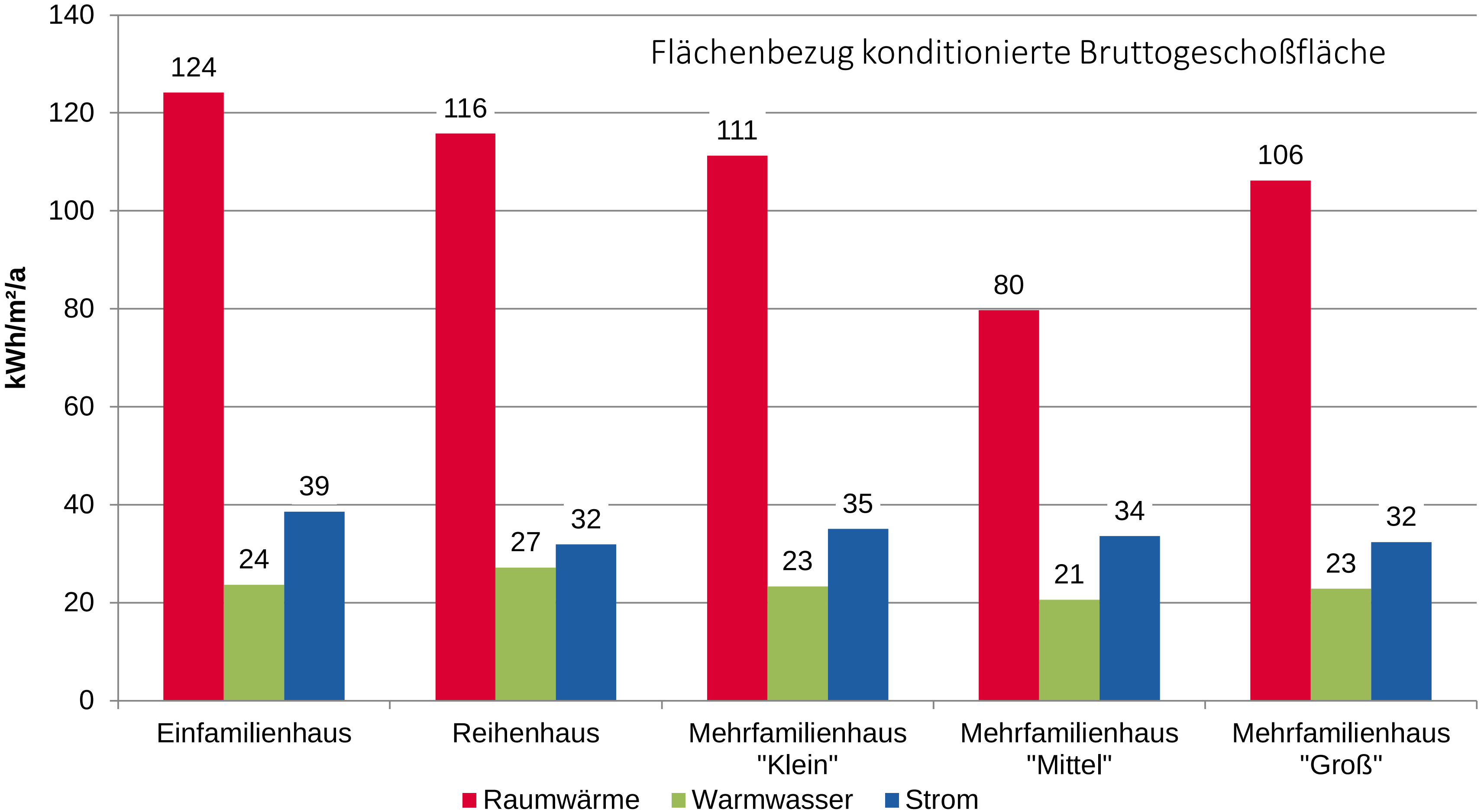
Specific space heating, domestic hot water and electricity demand – residential buildings (calculated and calibrated (fm) energy demand)



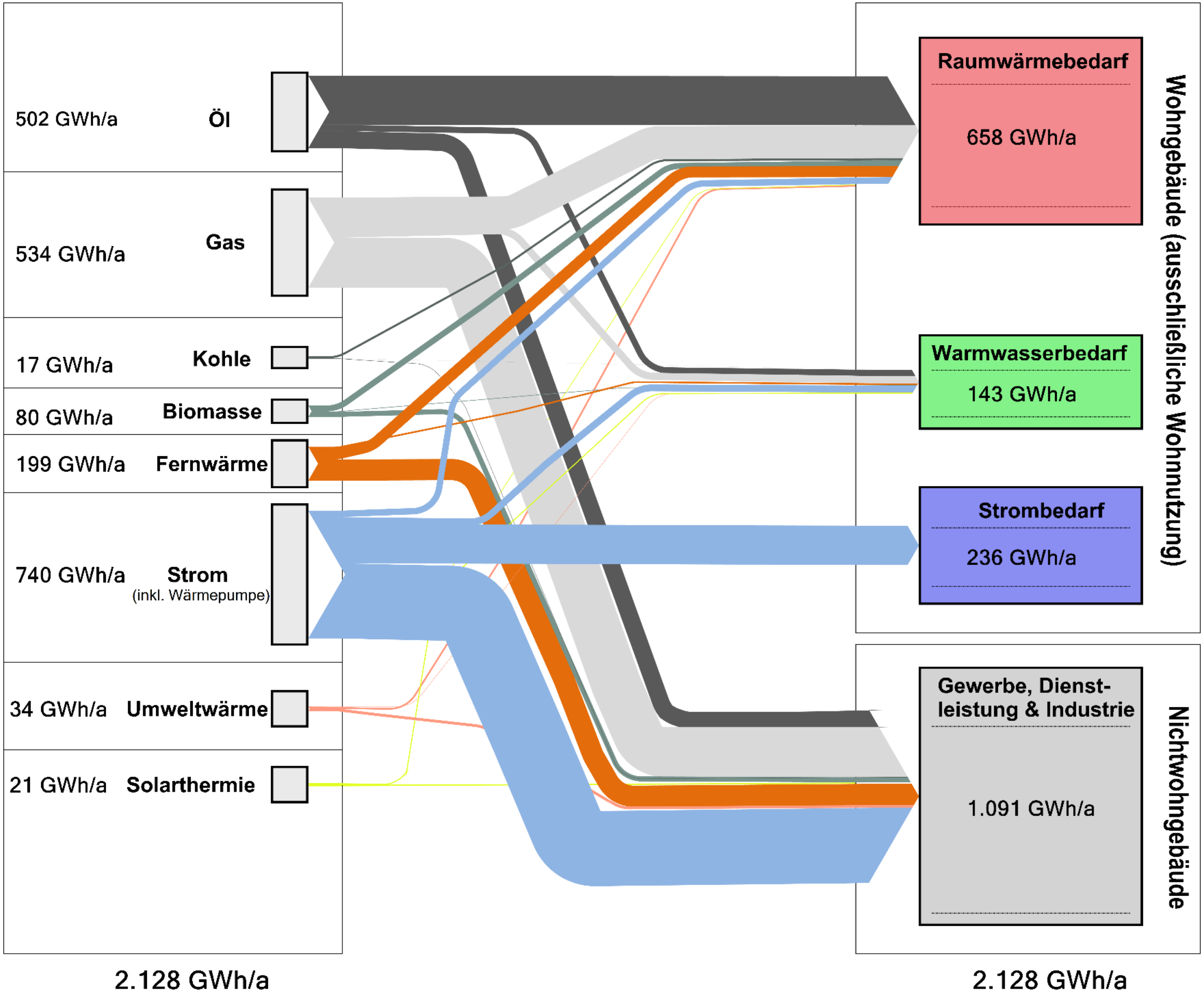
Quelle: Dissertation, Pfeifer D.

Distribution of energy carriers baseline – residential heating

Energieträger	Endenergie [GWh/a]	Anteil [%]
Öl	247	31%
Gas	257	32%
Kohle	17	2,2%
Scheitholz	40	5,0%
Pellets	2	0,3%
Hackschnitzel	0,4	0,05%
Fernwärme	61	7,6%
Strom	67	8,4%
Wärmepumpe (Strom)	2	0,3%
Wärmepumpe (Umweltwärme)	6	0,8%
Solarthermie	3	0,4%
unbekannt	100	12%
Summe	**802**	**100%**

Quelle: Dissertation, Pfeifer D.

Energy flow scheme Innsbruck (2015)



Quelle: Dissertation, Pfeifer D. / Dobler C.

Projekt Tirol

Ressourcen- und Technologie-
Einsatzszenarien Tirol 2050

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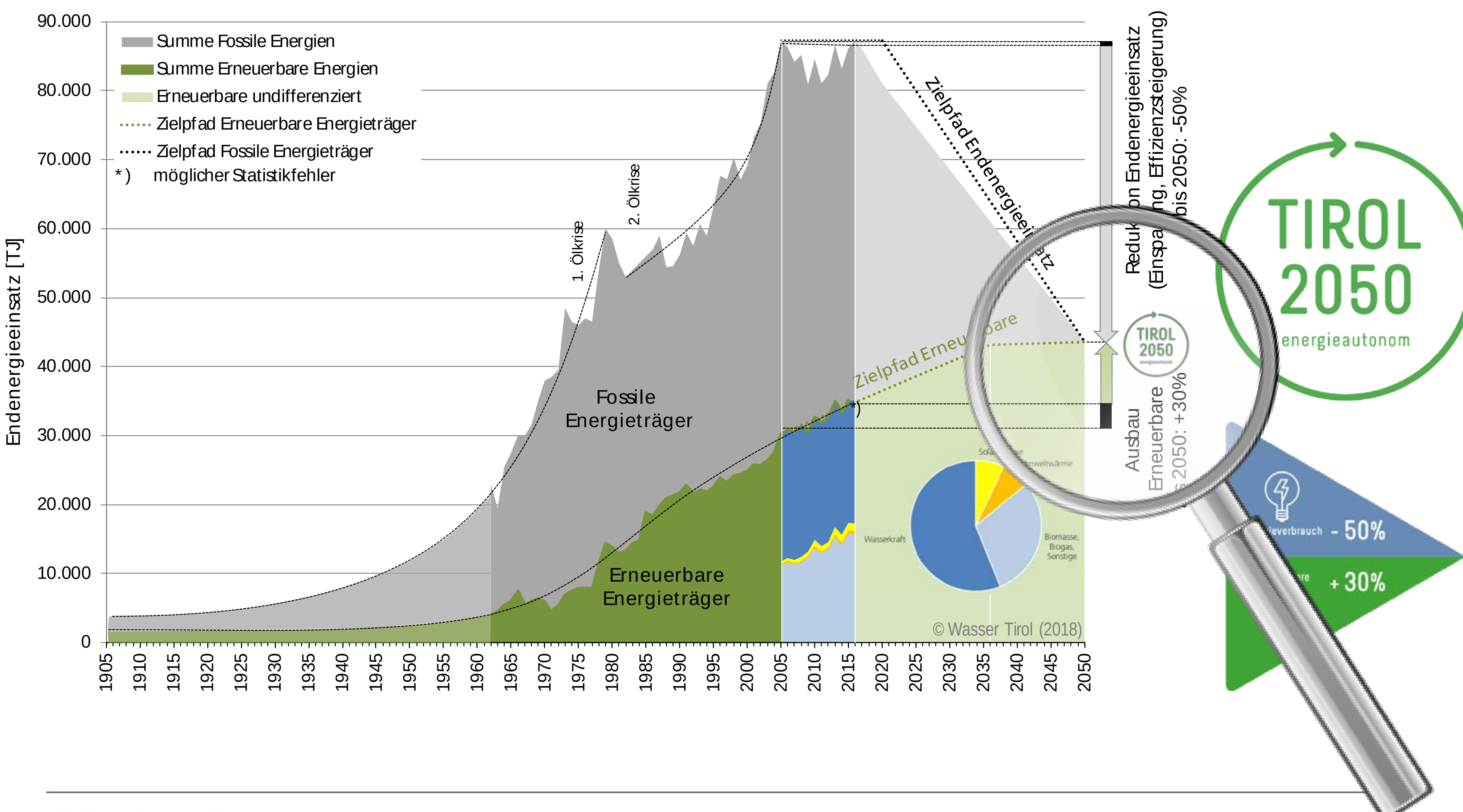
MCI

wasser tirol

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


Summe Fossile Energien
Summe Erneuerbare Energien
Erneuerbare undifferenziert
Zielpfad Erneuerbare Energieträger
Zielpfad Fossile Energieträger
*) möglicher Statistikfehler
Endenergieeinsatz [TJ]
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
1. Ölkrise
2. Ölkrise
Fossile Energieträger
Erneuerbare Energieträger
Zielpfad Endenergieeinsatz
Zielpfad Erneuerbare
Wasserkraft
Biomasse, Biogas, Sonstige
Umweltwärme
© Wasser Tirol (2018)
Ausbau Erneuerbare
2050: +30%
(Einsparung, Effizienzsteigerung)
bis 2050: -50%
TIROL 2050
energieautonom
- 50%
+ 30%
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

Aufgabenstellung

Welche **heimischen Energieressourcen** werden in welcher Größenordnung mit welchen **technologischen Lösungen** zur Erreichung der bilanziellen Energieautonomie im Jahre 2050 (Ziel Tirol energieautonom 2050) benötigt?

1. Ermittlung der Bedarfsentwicklung und Ressourcen

- Bedarfsberechnung auf Basis aktueller Bedarfswerte und -muster, Ermittlung von Einspar- und Effizienzsteigerungspotenzialen
- Quantifizierung heimischer Ressourcendargebote
- Berücksichtigung heute absehbarer Technologien, Synergien (Sektorkopplung)

2. Bedarfsdeckungsszenarien für das Ziel 2050
mit den gegebenen heimischen nutzbaren Ressourcen im Jahressaldo

- keine energiewirtschaftlichen Betrachtungen, monatliche oder wöchentliche Betrachtung / Speicherbetrachtung
- keine Betrachtung der „grauen Energie“

3. Grundlagen für eine grobe Marschrichtung bis 2050

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

tirol Unser Land

ENERGIE TIROL

AK Tirol

WKO WIRTSCHAFTSKAMMER TIROL

INNS' BRUCK

Einbeziehung Stakeholder

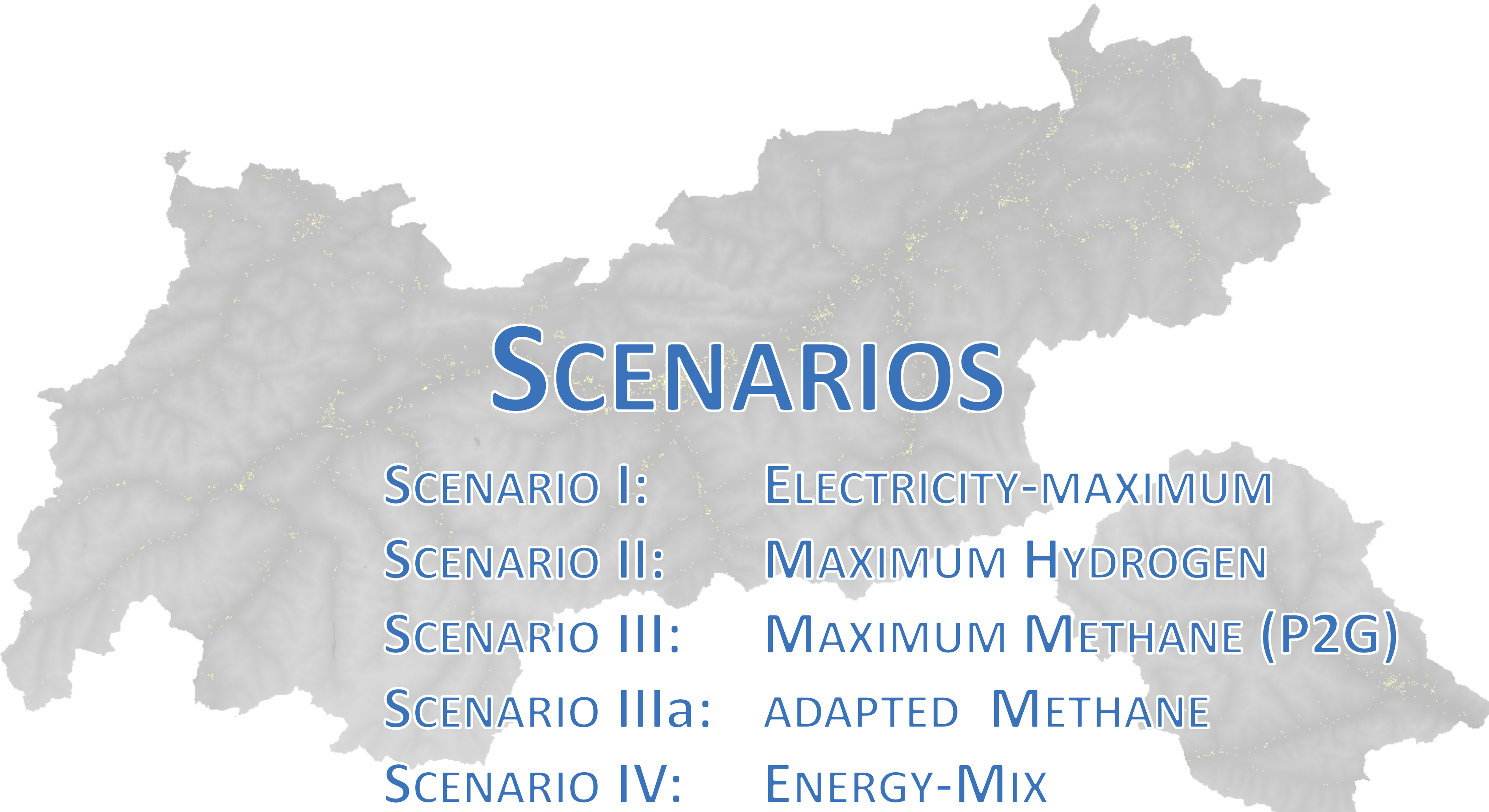
21.09.17	Kick Off
03.11.17	Dargebot: Wald
27.11.17	Advisory Board 01
15.01.18	Gebäude: Stakeholder-WS
17.01.18	Dargebot: Biogas, LW-Kammer
22.01.18	Produktion: Stakeholder-WS
24.01.18	Dargebot: Stakeholder-WS Wasserkraft
26.01.18	Mobilität: Stakeholder-WS
13.02.18	Dargebot: Wasserkraft
22.02.18	Dargebot: 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

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)

Heizwärmebedarf HWB [kWh/m²/a]			
ab Jahr	**Szenario 1**	**Szenario 2**	**Szenario 3**
2015	27	27	27
2017	24	24	24
2019	20	20	20
2021	constant 17	linear 17	step 17
2023	17	14	9
2025	17	10	9
2027	17	9	9
	Very low energy builindg.	Passive house	

assumption (2023–2027)

Renovation Quality – Example MFH-M

HWB (Useful Energy demand space heating) **<u>incl.</u>** **gains from air heat recovery unit**

(related to gross area)

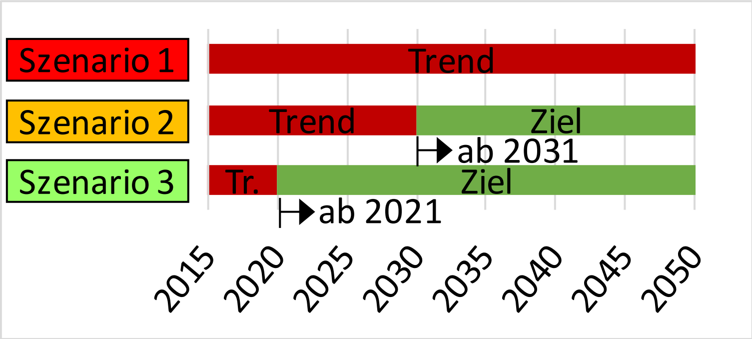
Heizwärmebedarf HWB [kWh/m²/a]			
ab Jahr	**Szenario 1**	**Szenario 2**	**Szenario 3**
2015	47	47	47
2017	43	43	43
2019	39	39	39
2021	konstant 35	linear 35	Sprung 35
2023	35	31	23
2025	35	27	23
2027	35	23	23

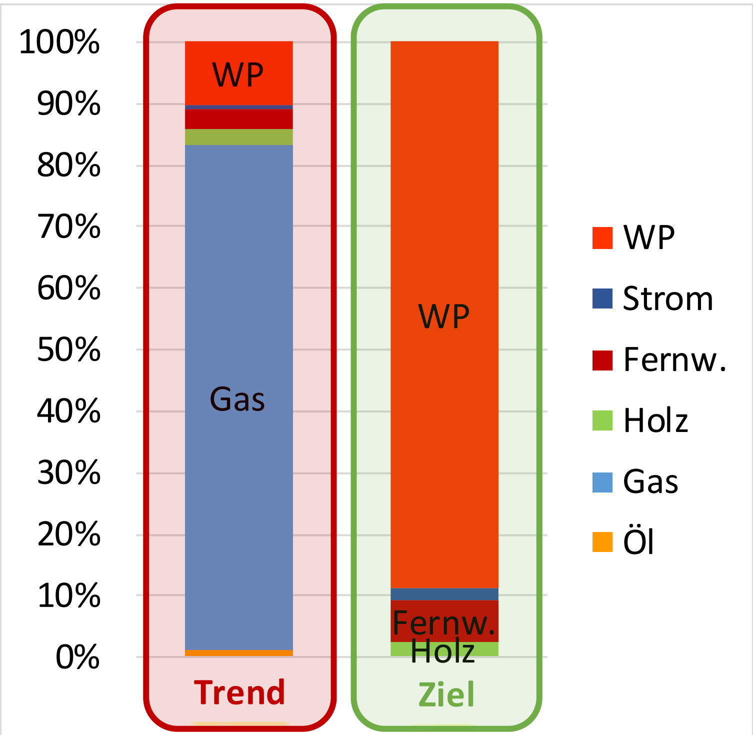
Annahme (2023–2027)

Niedrigstenergiegebäude

Distribution Energy Carriers – Esample MFH-M
Space Heating

New Buildings





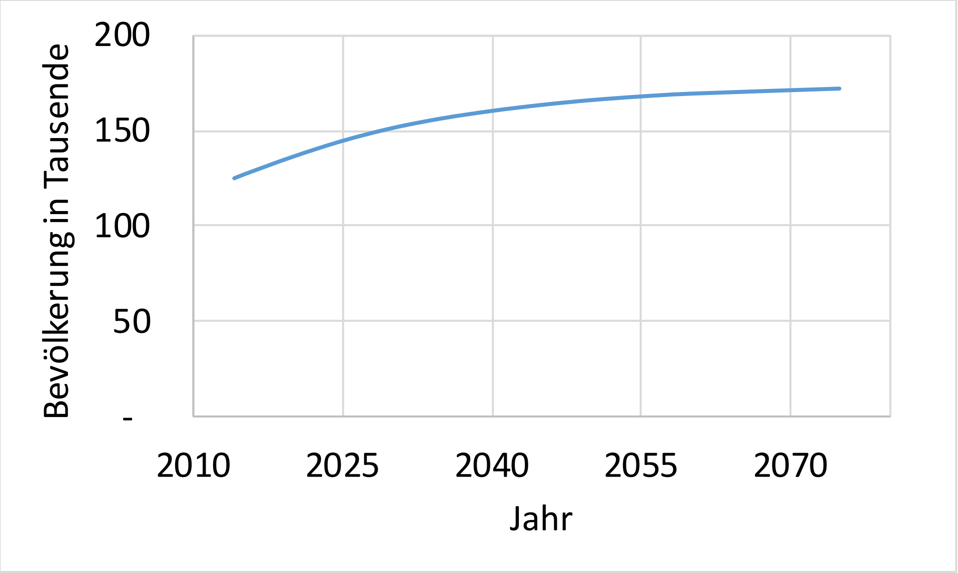
4% der Systeme in Kombination mit Solarthermie

Popoulation Increase (Innsbruck)

2 Komponenten: – <u>Bevölkerungsentwicklung</u>

– Flächenentwicklung pro Person

ÖROK[4]: Bevölkerungsprognose für IBK



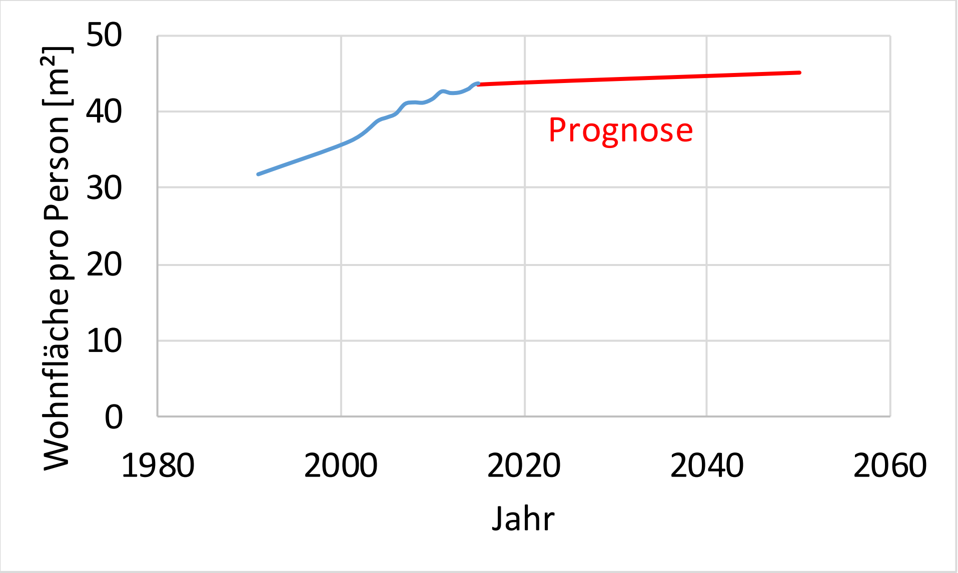
[4] ÖROK. (2015). ÖROK-Regionalprognosen 2014 - Bevölkerung: Ausführliche Tabellen zur kleinräumigen ÖROK-Prognose 2014.

Increase of Living Space per person

2 Komponenten: – Bevölkerungsentwicklung

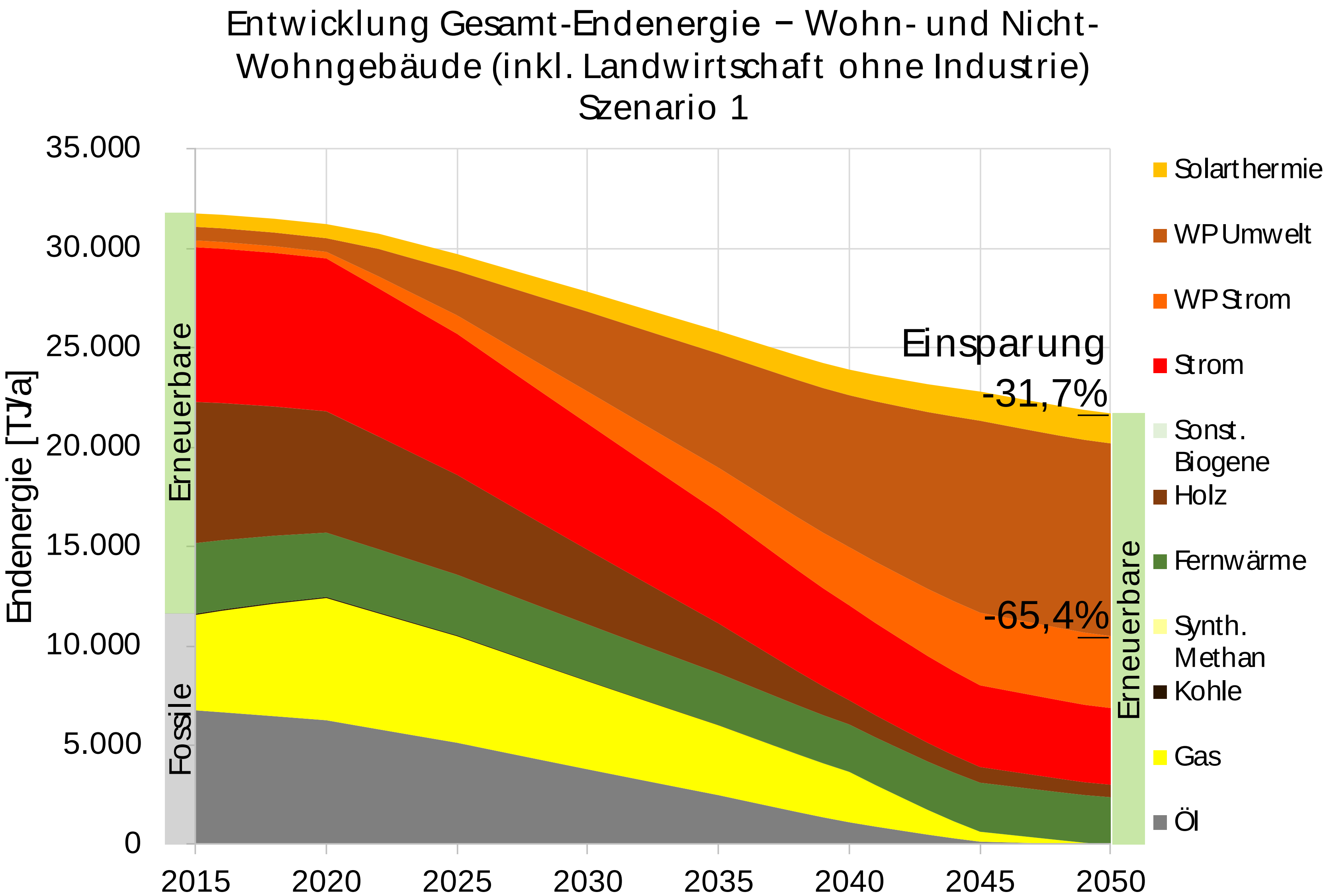
– **Flächenentwicklung pro Person**

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



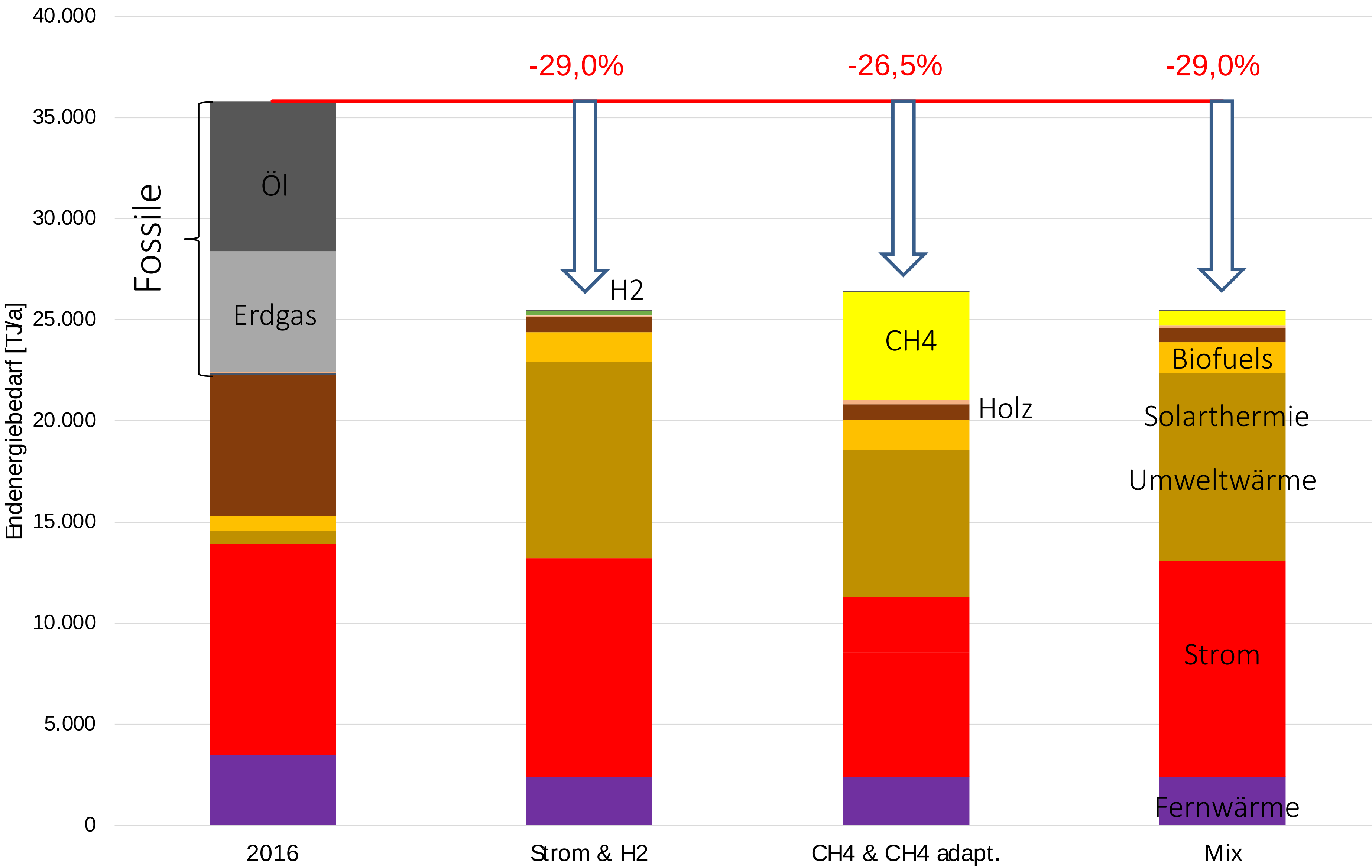
[5] Würlinger, J., & Kaiser, M. (2004). Gebäude und Wohnungen in Tirol: Ergebnisse der Gebäude - und Wohnungszählung 2001.
[6] Statistik Austria. (2016). Wohnungsgröße von Hauptwohnsitzwohnungen nach Bundesland (Zeitreihe).

Final Energy Demand Sector Other / Buildings



Annahme: Strom in Tirol erneuerbar

Final Energy Demand Sector Other / Buildings



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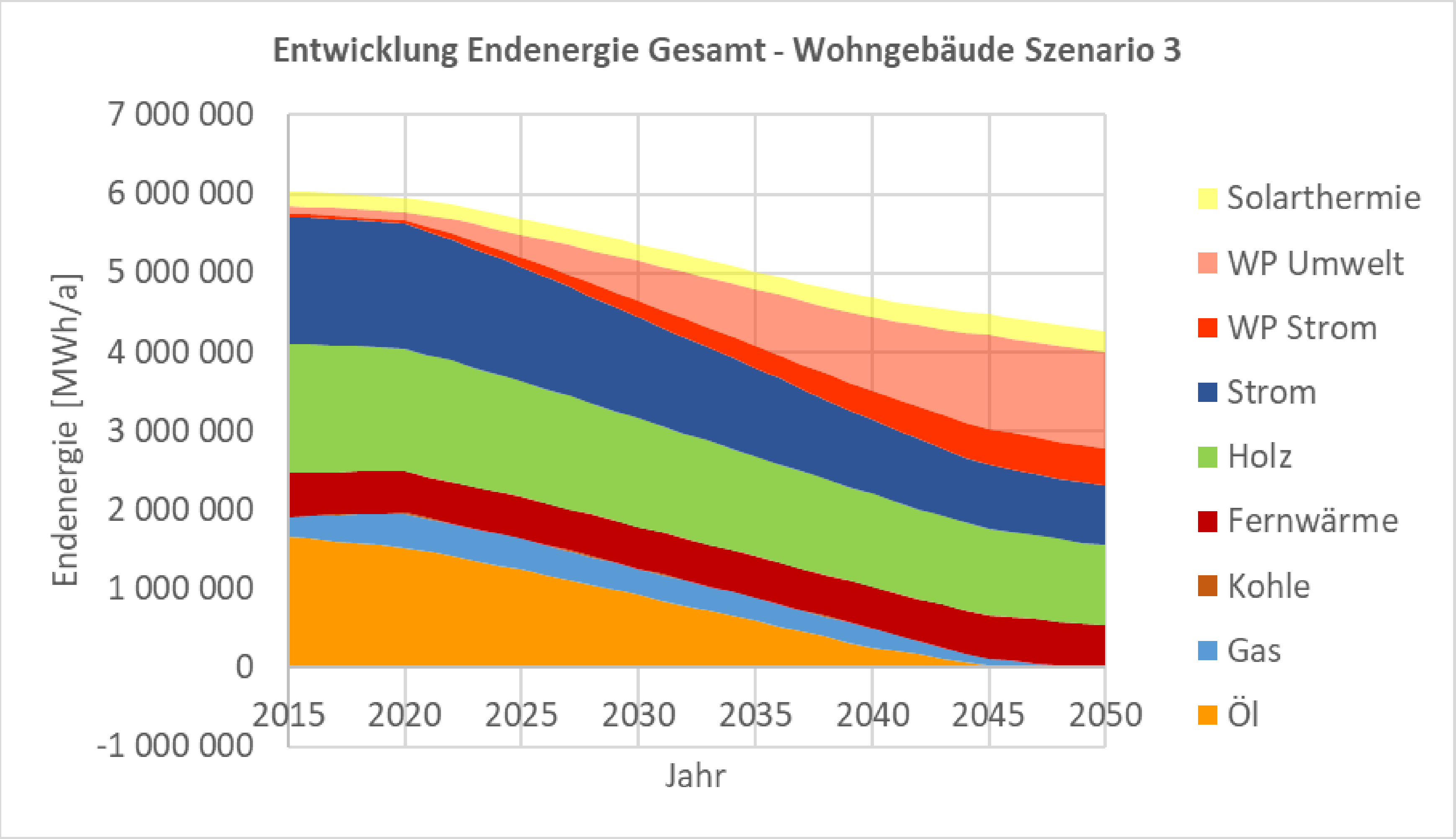
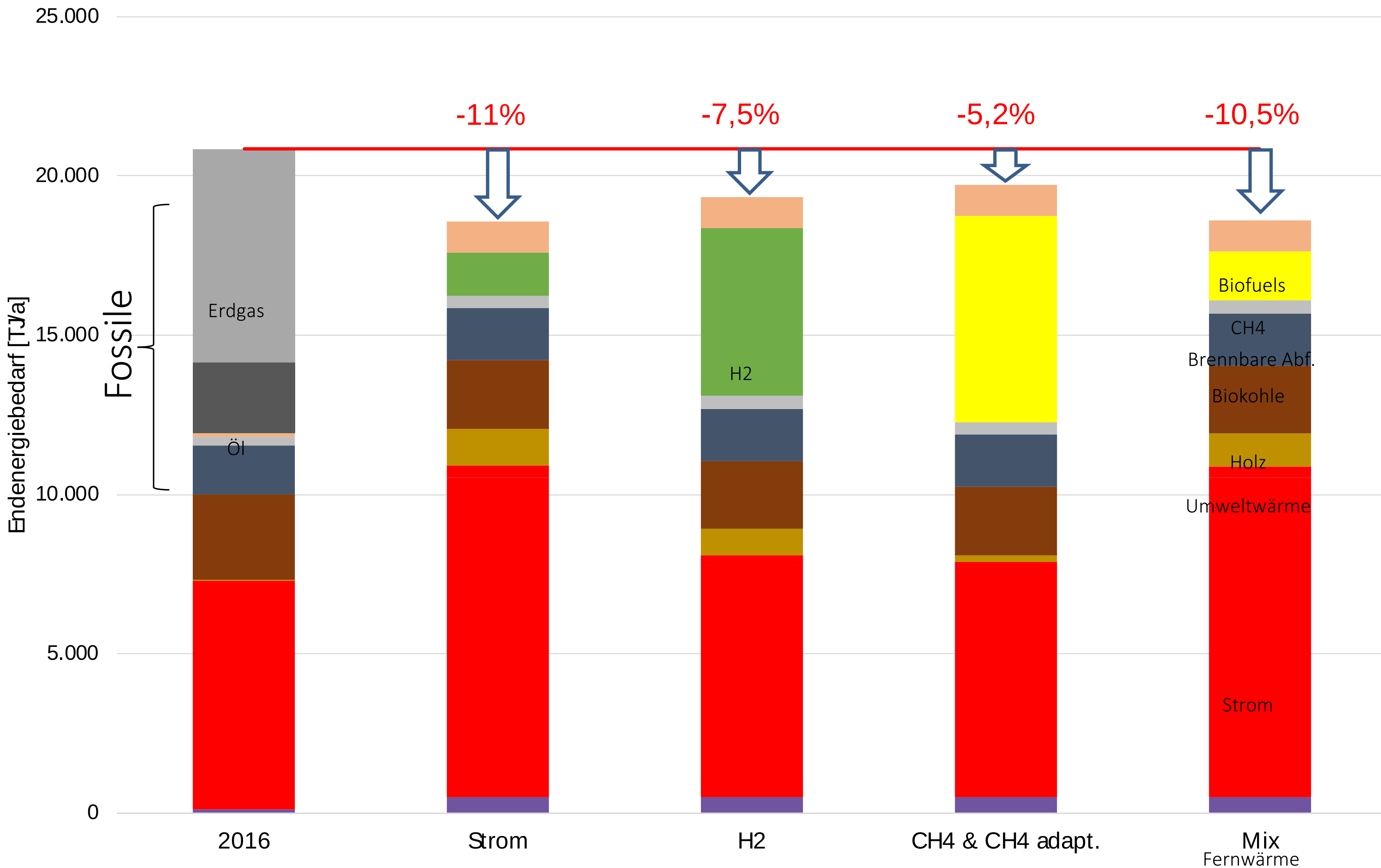
Scenario with more Biomass, whole Austria



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



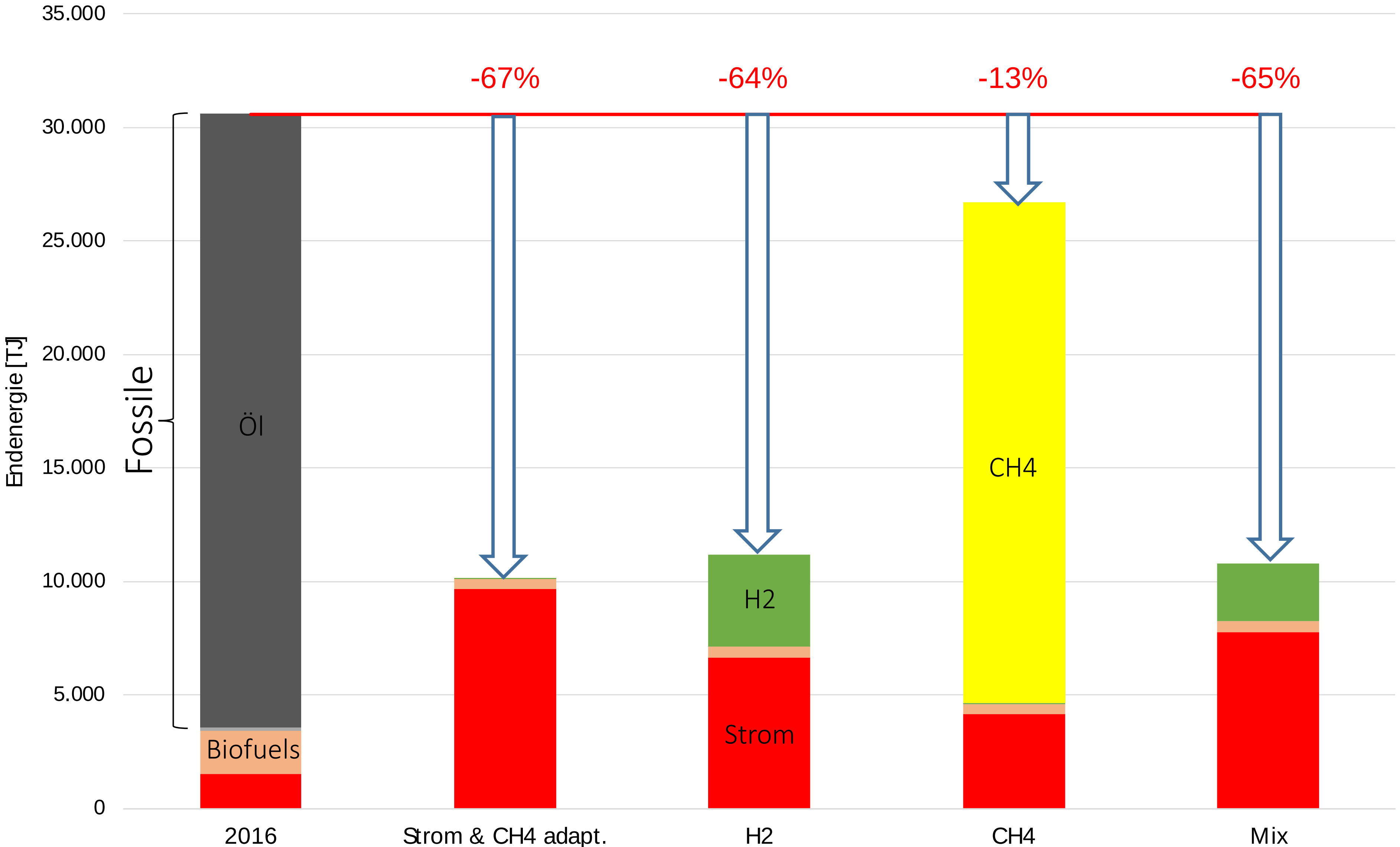
Sektor Mobility

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



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Renewable Energy Ressources

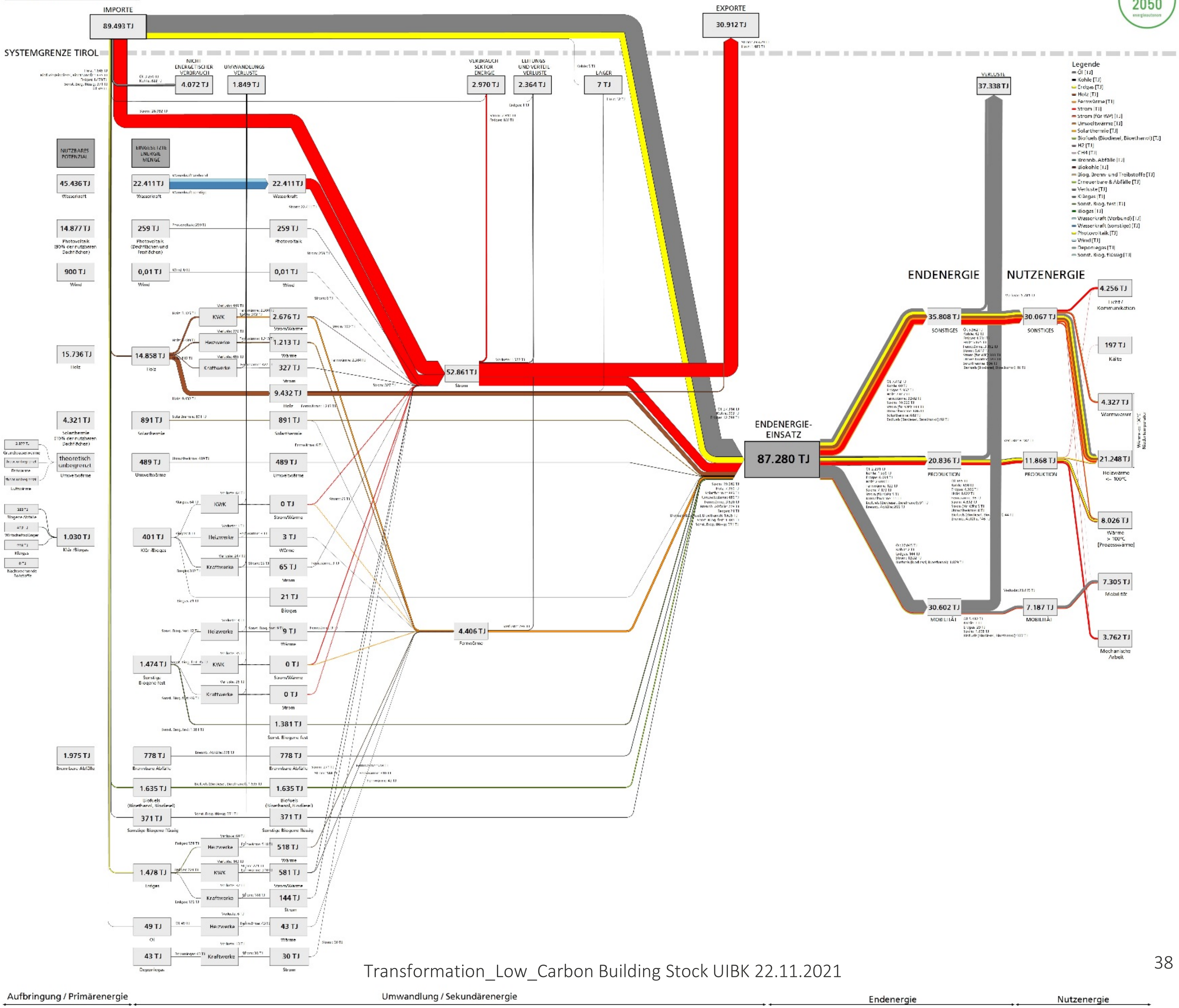
Useful Renewable Energy Ressources of Tyrol

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

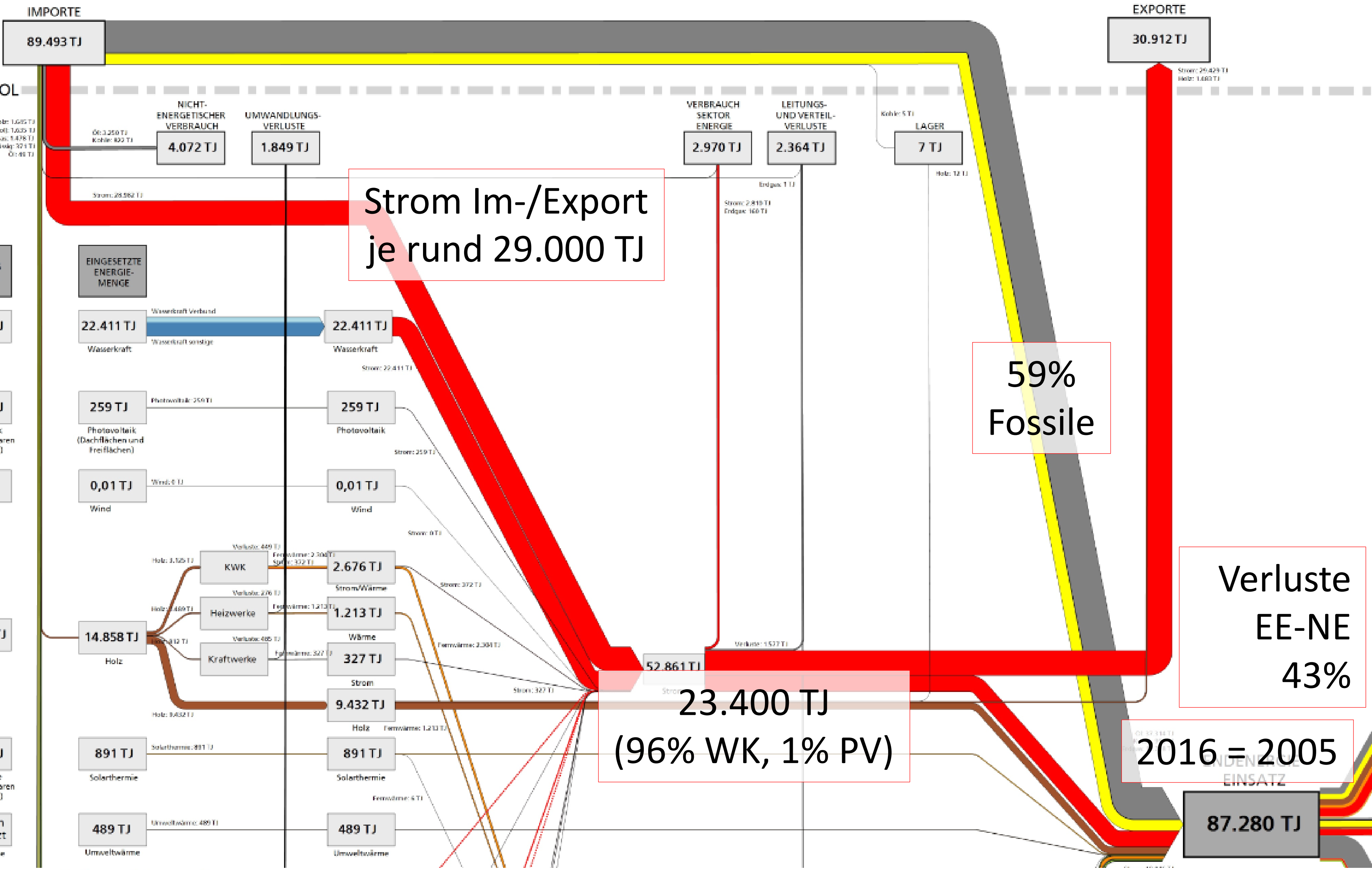
SCENARIOS

RESULTS

ENERGIEFLÜSSE TIROL
Energieflüsse 2016

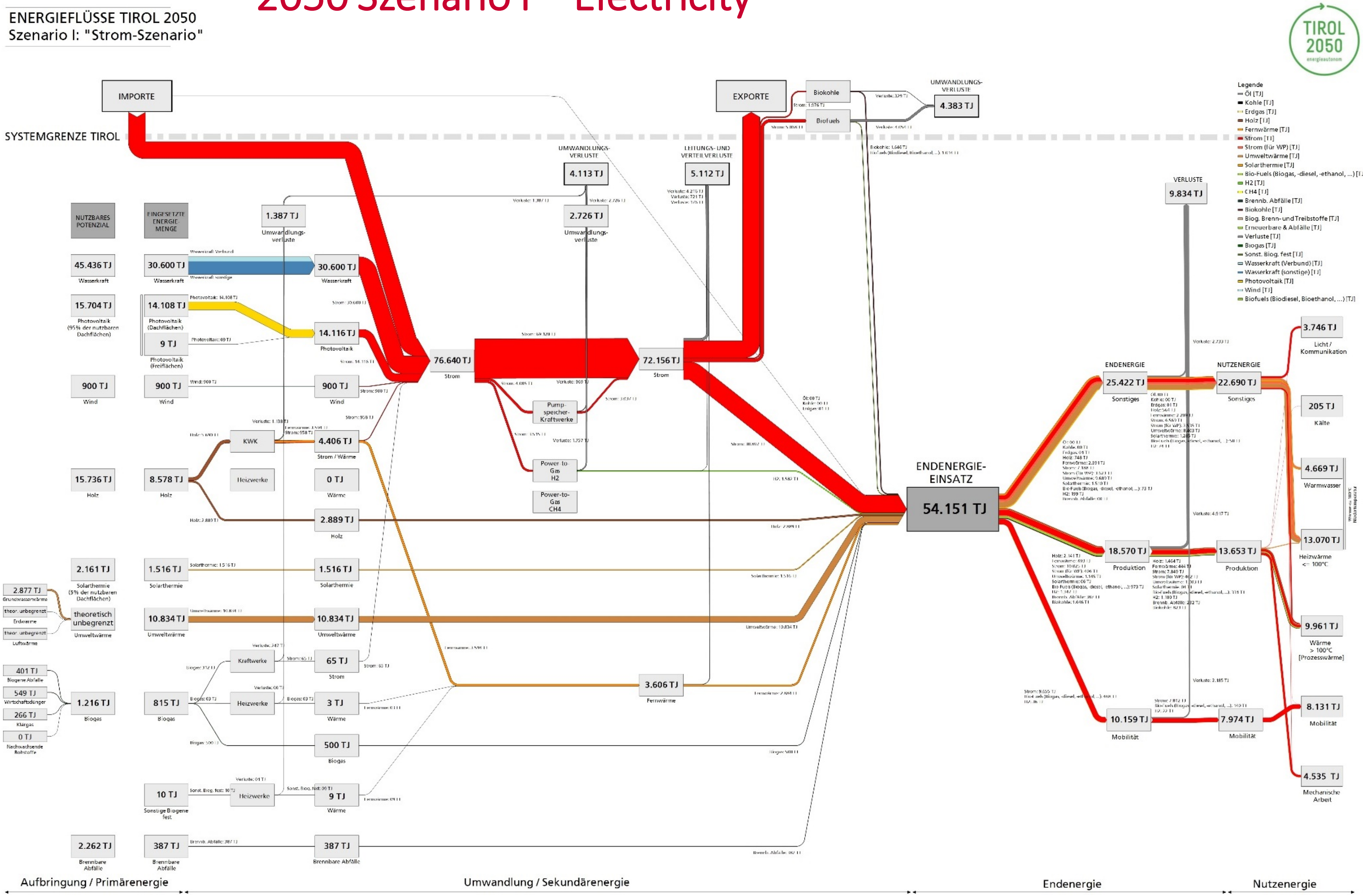


State 2016

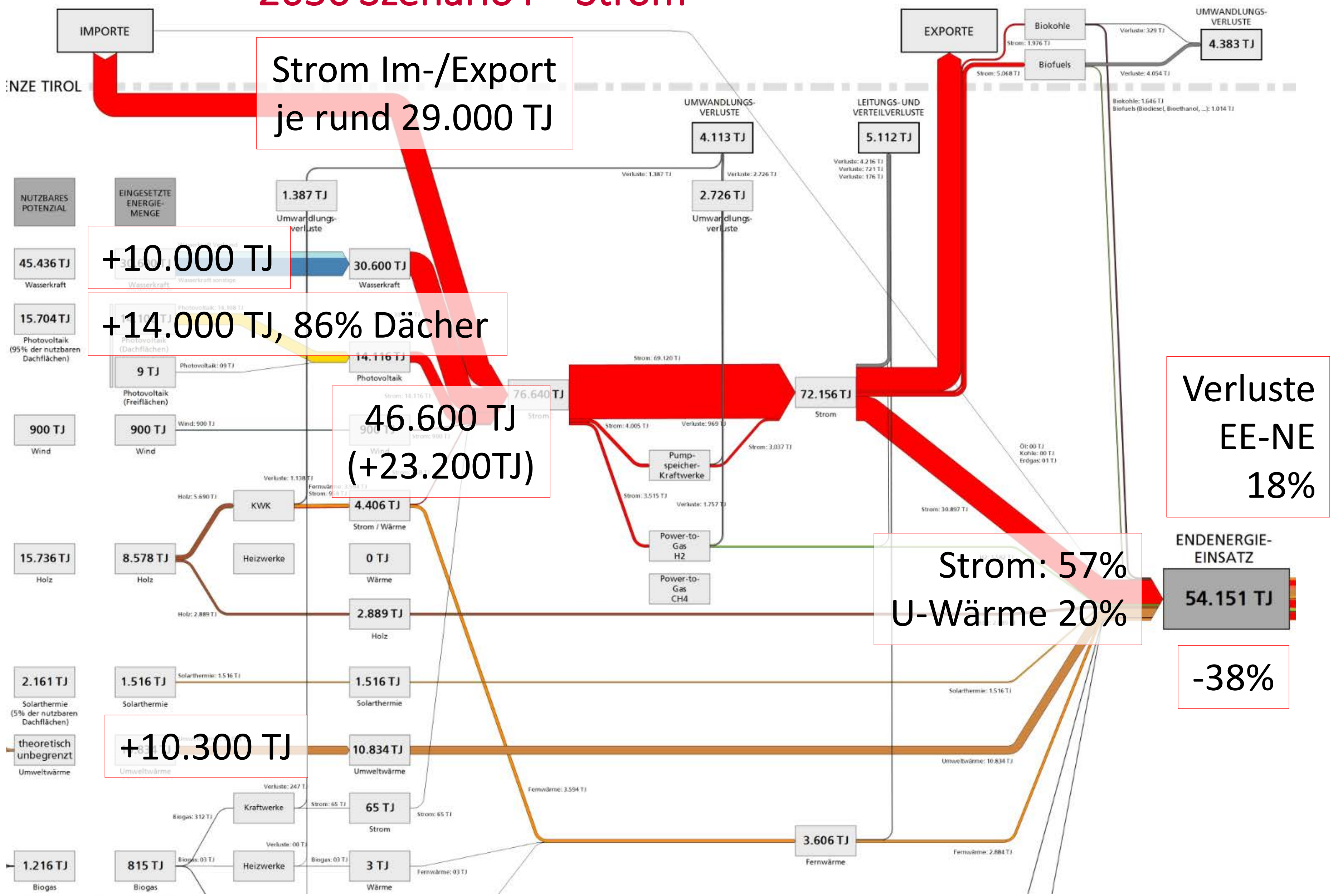


IMPORTE
89.493 TJ
EXPORTE
30.912 TJ
NICHT-ENERGETISCHER VERBRAUCH
4.072 TJ
UMWANDLUNGS-VERLUSTE
1.849 TJ
VERBRAUCH SEKTOR ENERGIE
2.970 TJ
LEITUNGS- UND VERTEIL-VERLUSTE
2.364 TJ
LAGER
7 TJ
Strom Im-/Export
je rund 29.000 TJ
EINGESETZTE ENERGIE-MENGE
22.411 TJ
Wasserkraft
22.411 TJ
Wasserkraft
259 TJ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

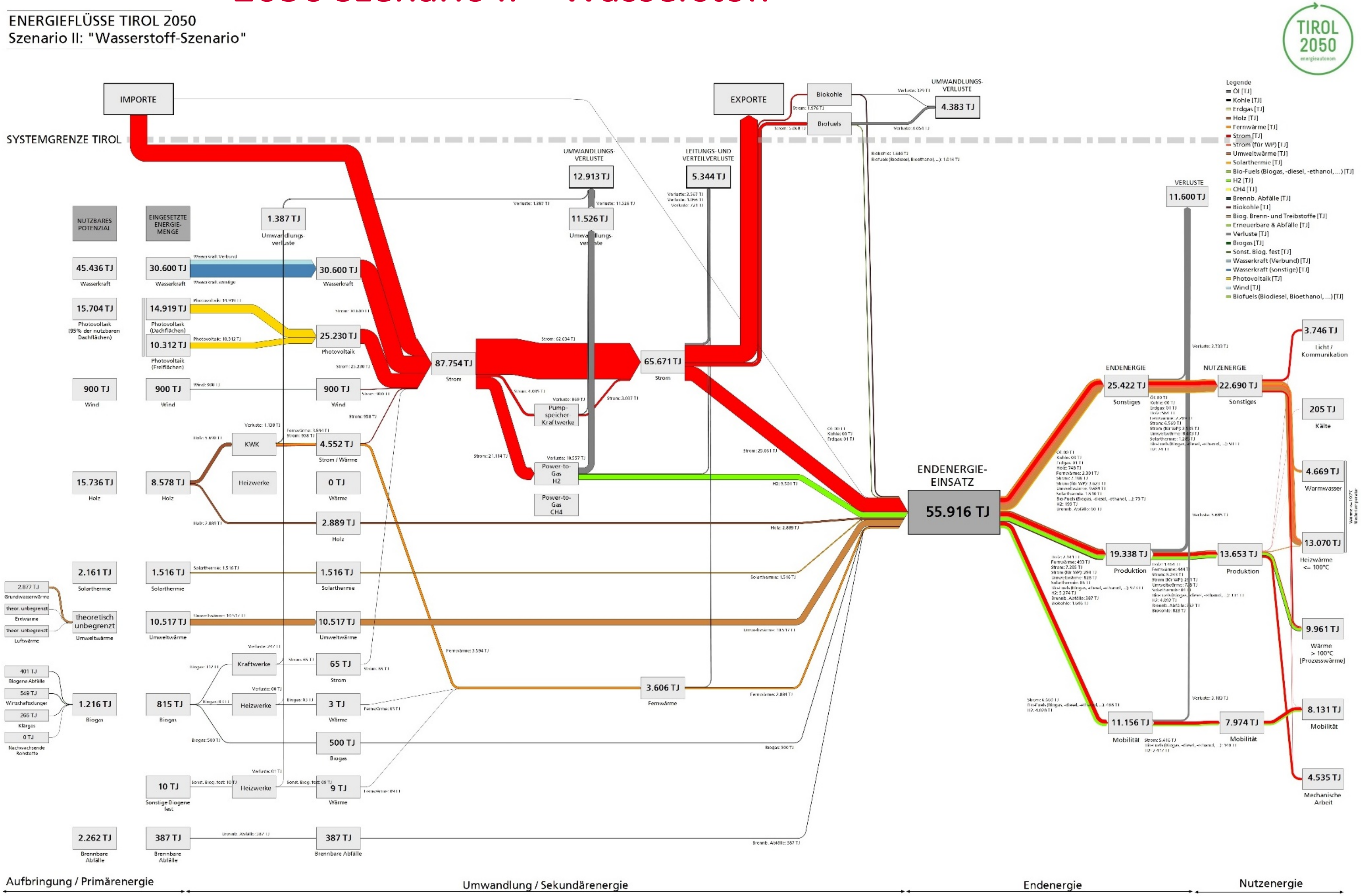
2050 Szenario I – Electricity



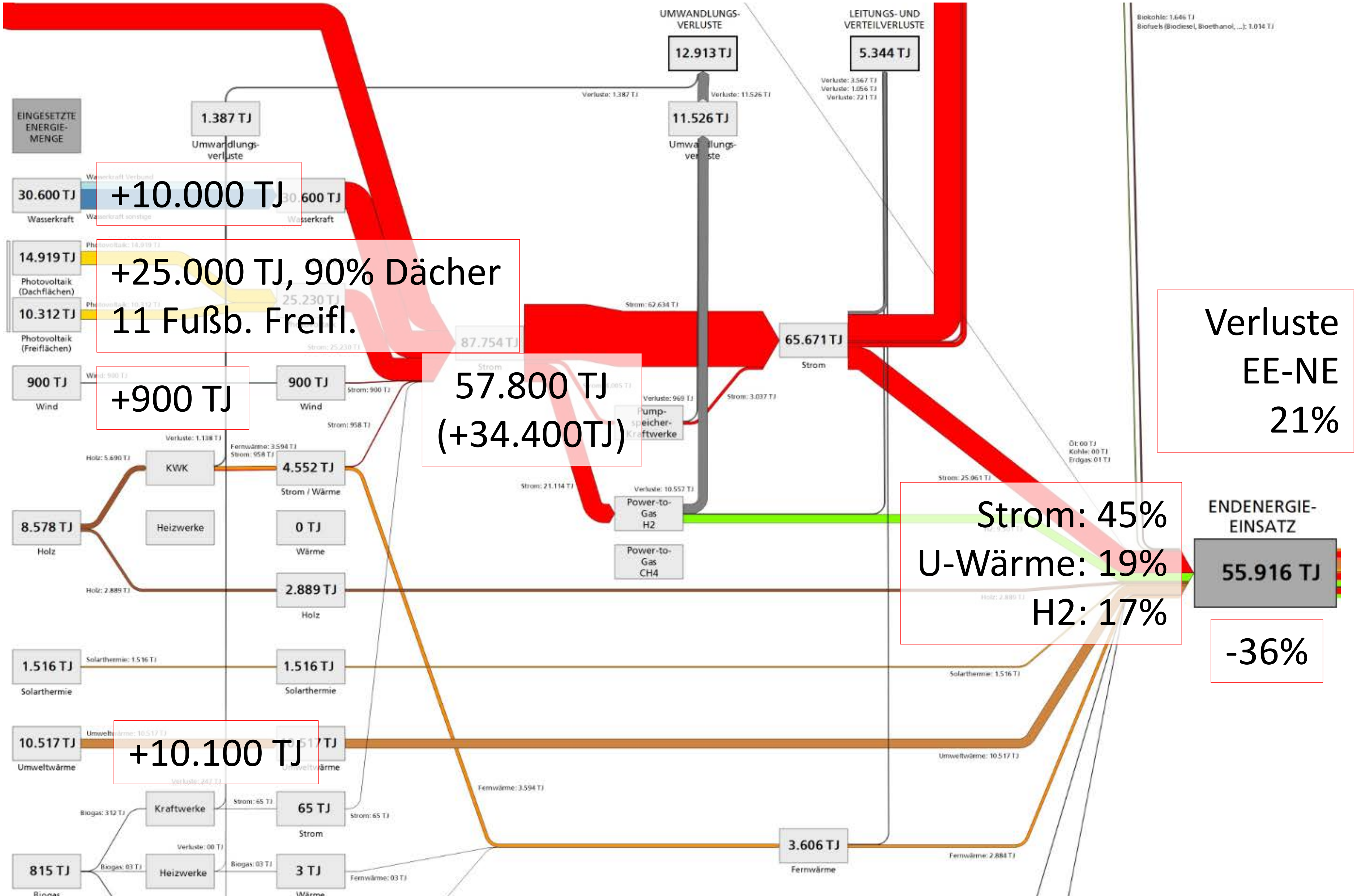
2050 Szenario I – Strom



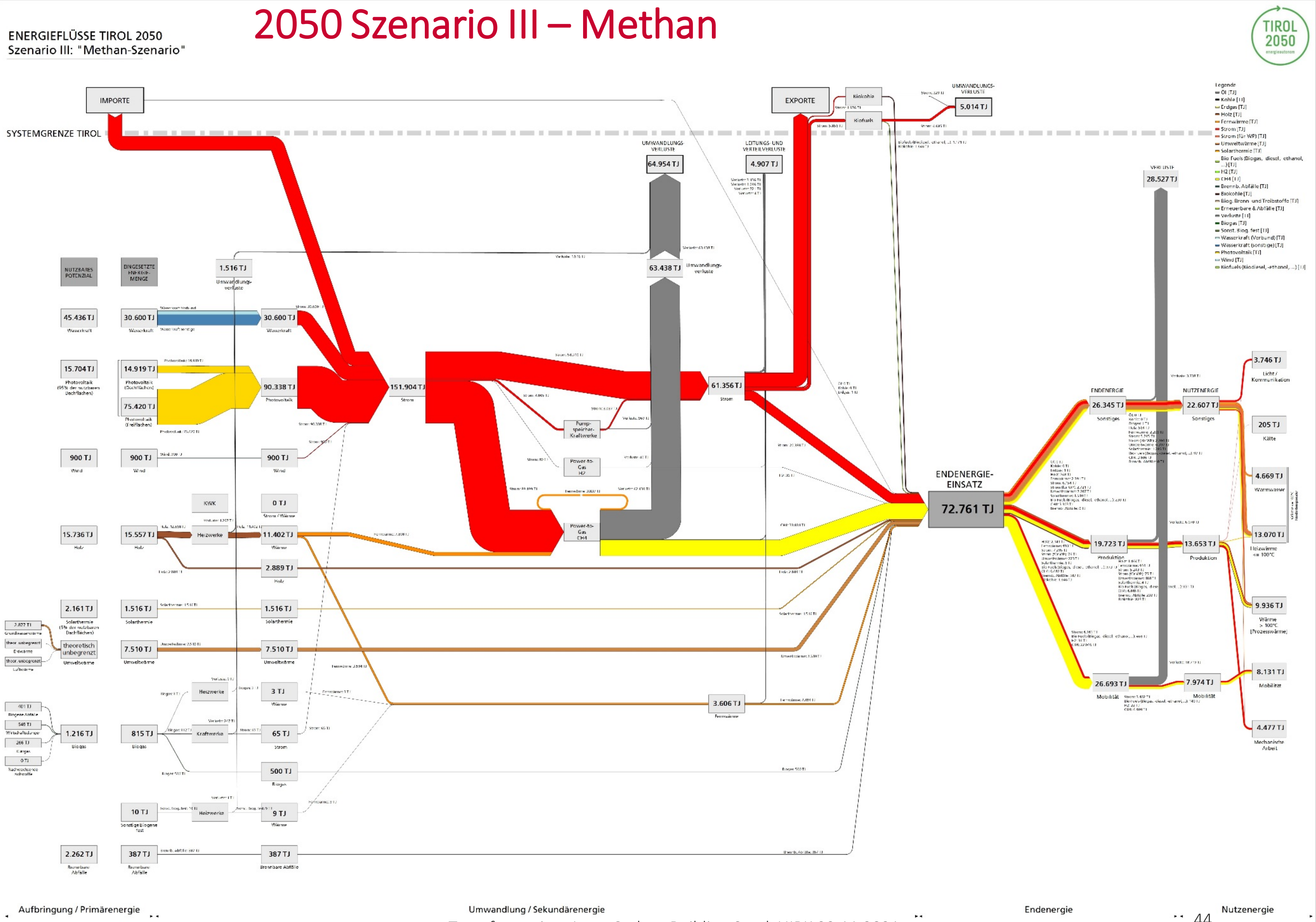
2050 Szenario II – Wasserstoff



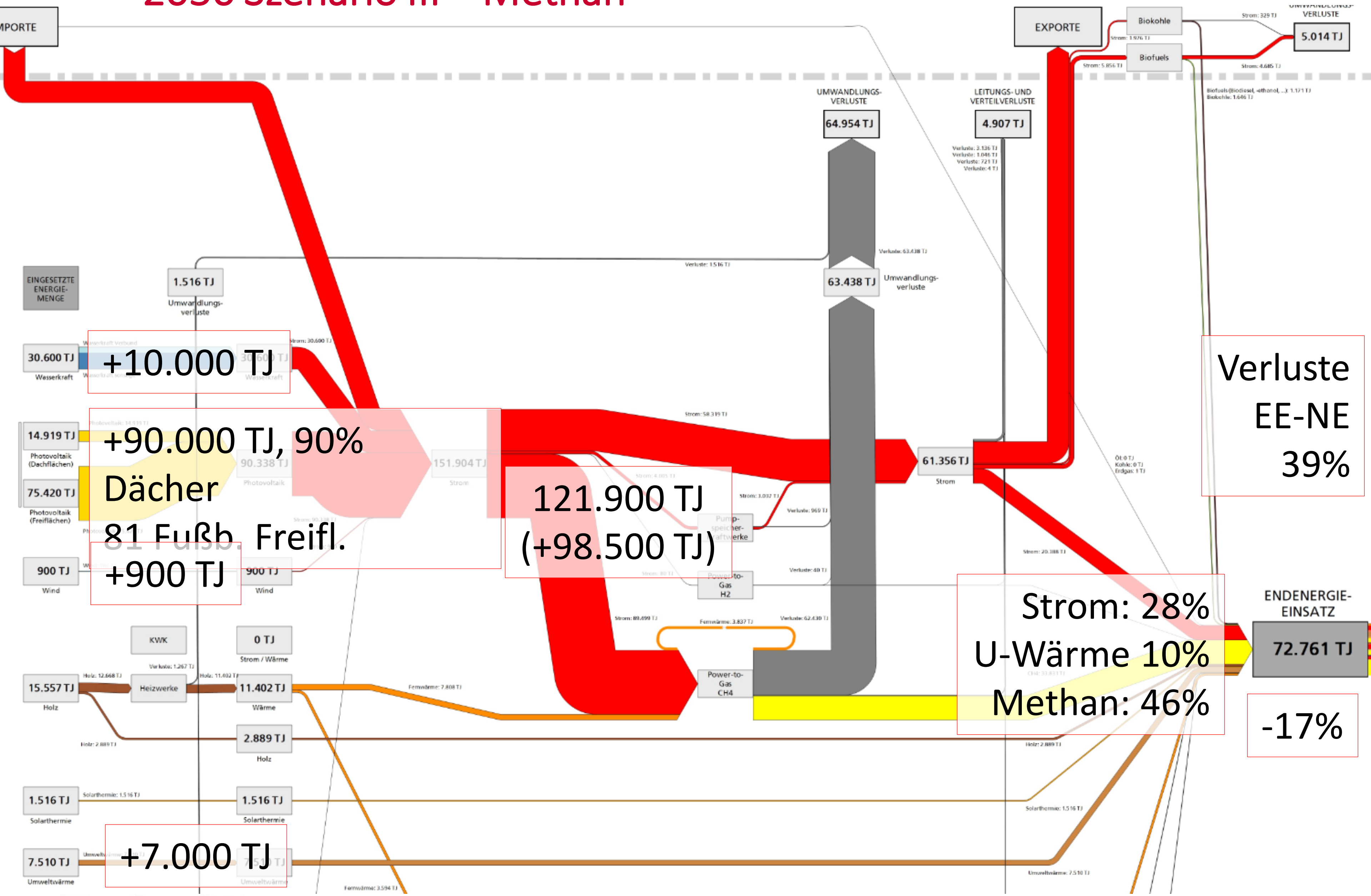
2050 Szenario II – Wasserstoff



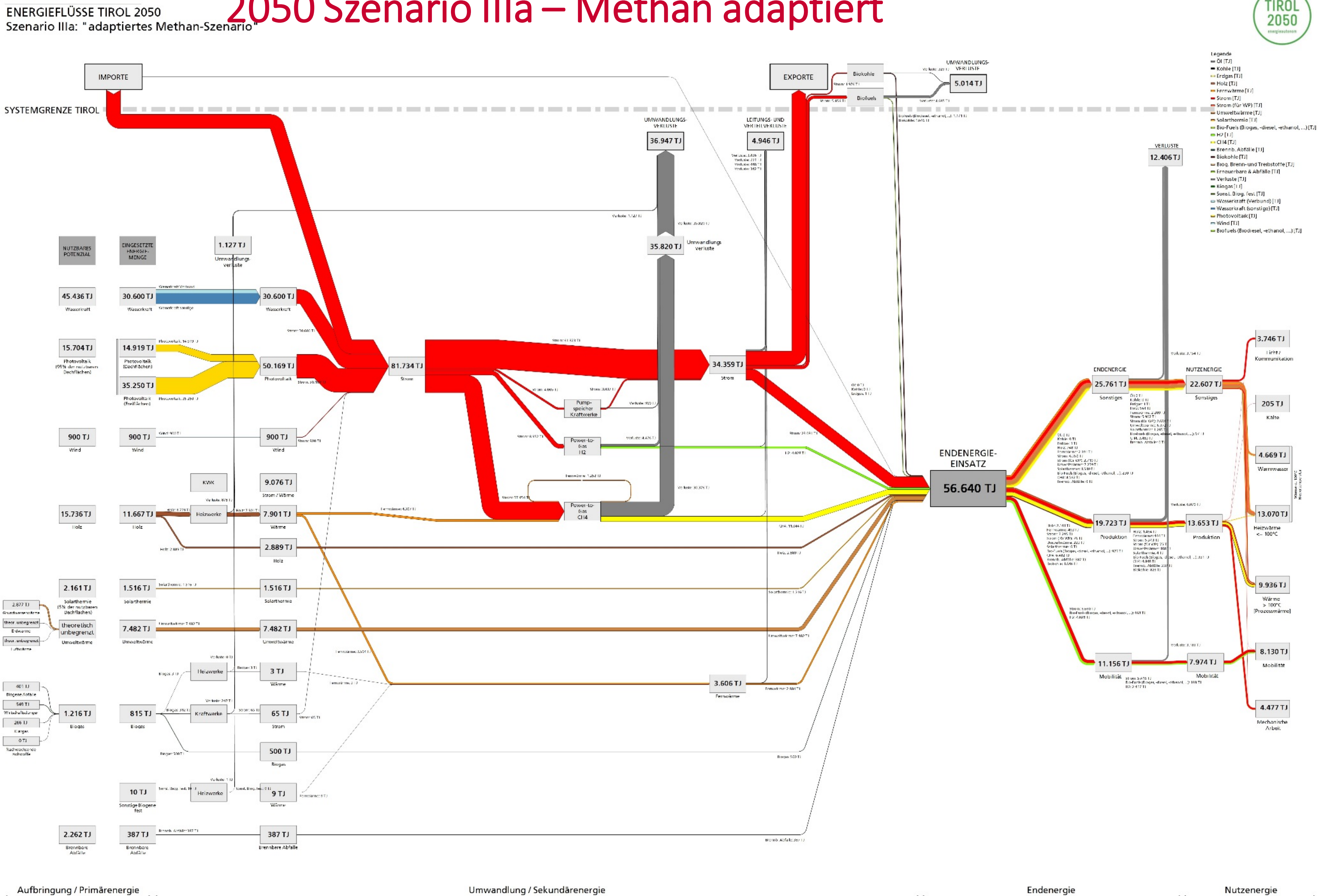
2050 Szenario III – Methan



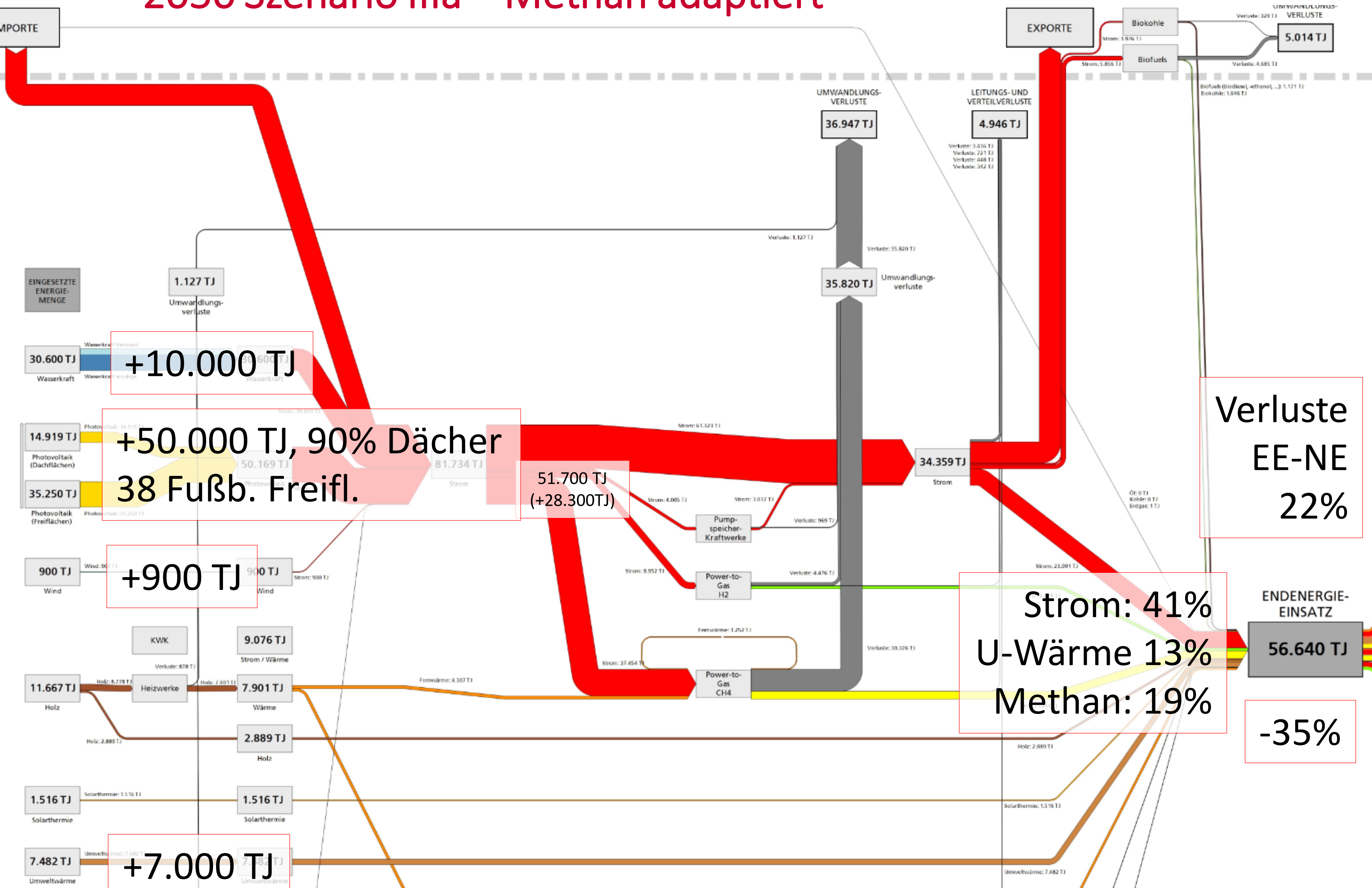
2050 Szenario III – Methan



2050 Szenario IIIa – Methan adaptiert

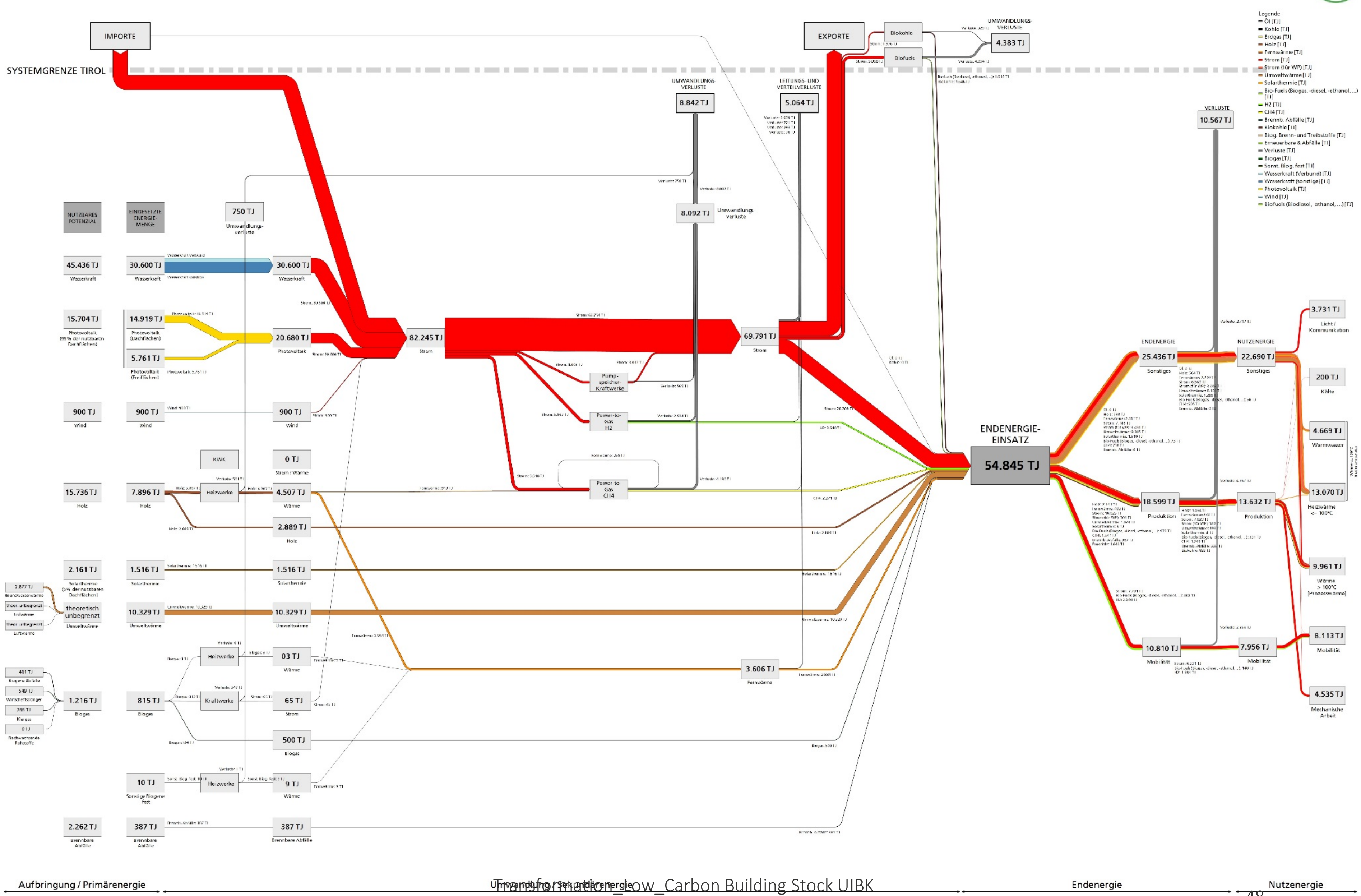


2050 Szenario IIIa – Methan adaptiert

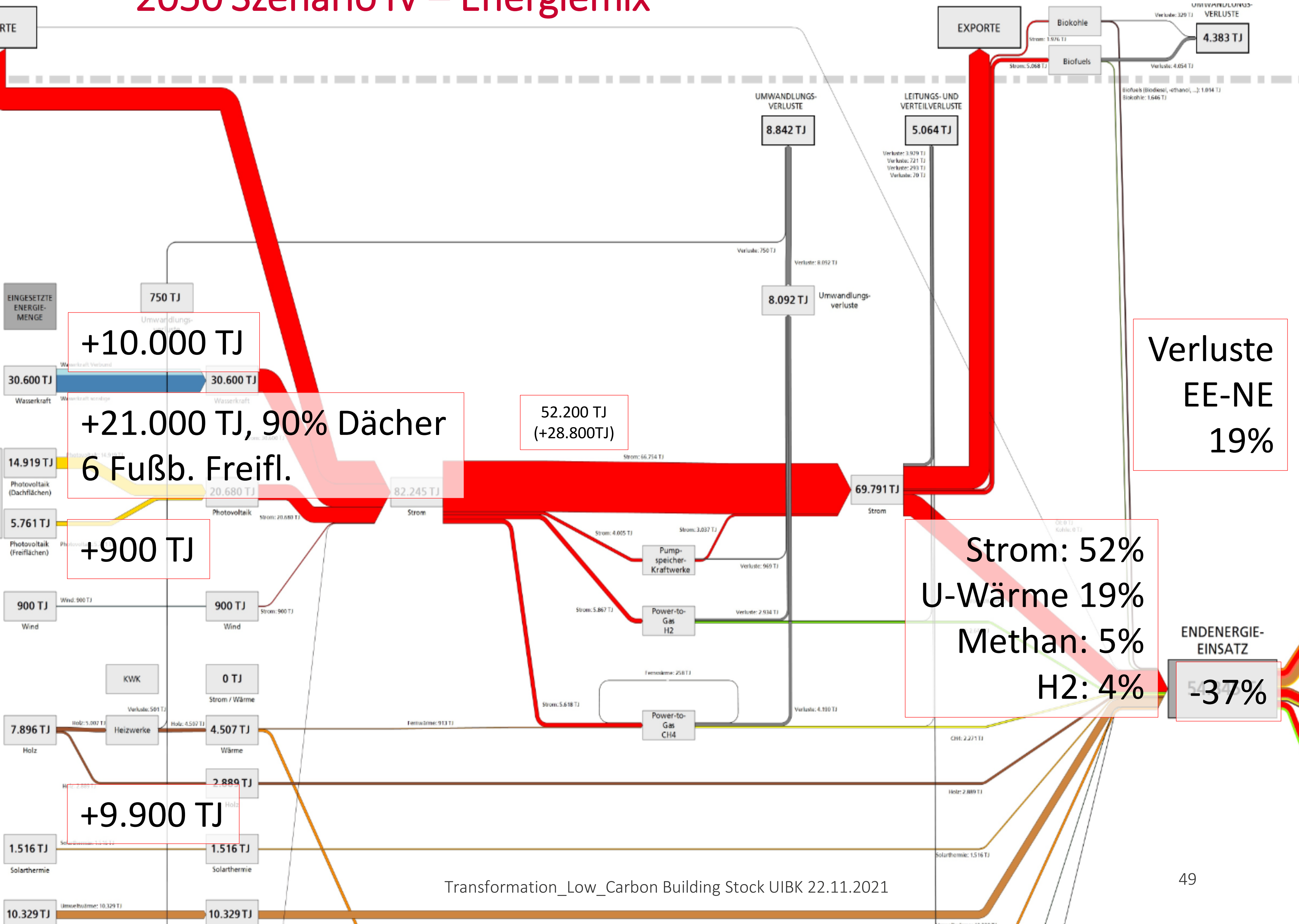


2050 Szenario IV – Energiemix

ENERGIEFLÜSSE TIROL 2050
Szenario IV: "Energiemix-Szenario"



2050 Szenario IV – Energiemix



+10.000 TJ

+21.000 TJ, 90% Dächer
6 Fußb. Freifl.

52.200 TJ
(+28.800TJ)

Verluste
EE-NE
19%

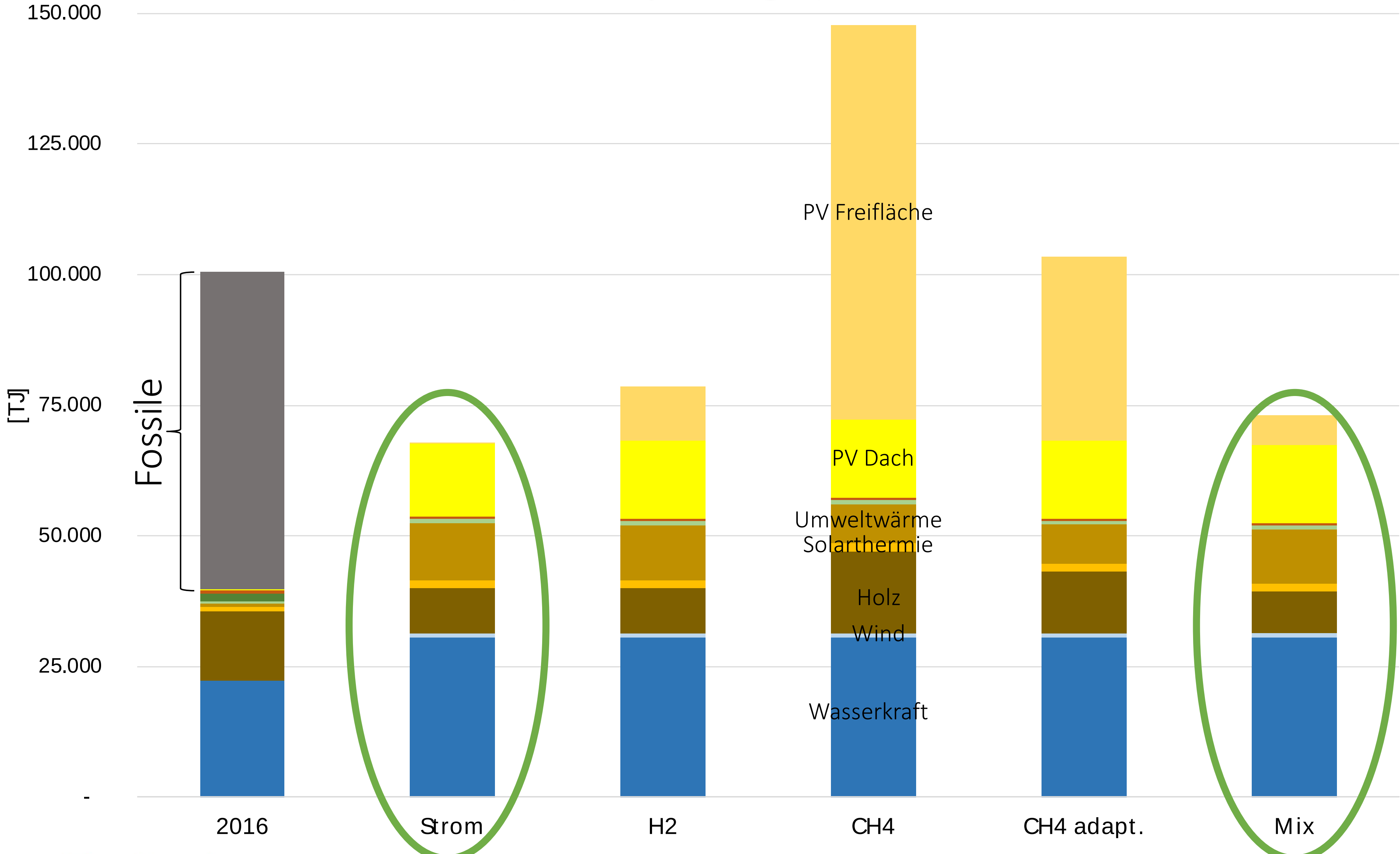
+900 TJ

Strom: 52%
U-Wärme 19%
Methan: 5%
H2: 4%

-37%

+9.900 TJ

Results
Ressource Use (Primary Energie)



Additional Need of reneable Energies for all Scenarions

Base Total Primary Energy Demand :

	Gesamt-Energieeinsatz		ggb. 2016 notwendiger **Zubau Erneuerbarer**	
	Fossile	Erneuerbare		
2005	63.555	37.910		
2016	60.565	39.916		
Sz. I (Strom)	-	67.758	+27.842	+70%
Sz. II (H_2)	-	78.555	+38.639	+97%
Sz. III (CH_4)	-	147.635	+107.719	+270%
Sz. IIIa (adapt. CH_4)	-	103.546	+63.630	+159%
Sz. IV (Mix)	-	73.133	+33.217	+83%

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

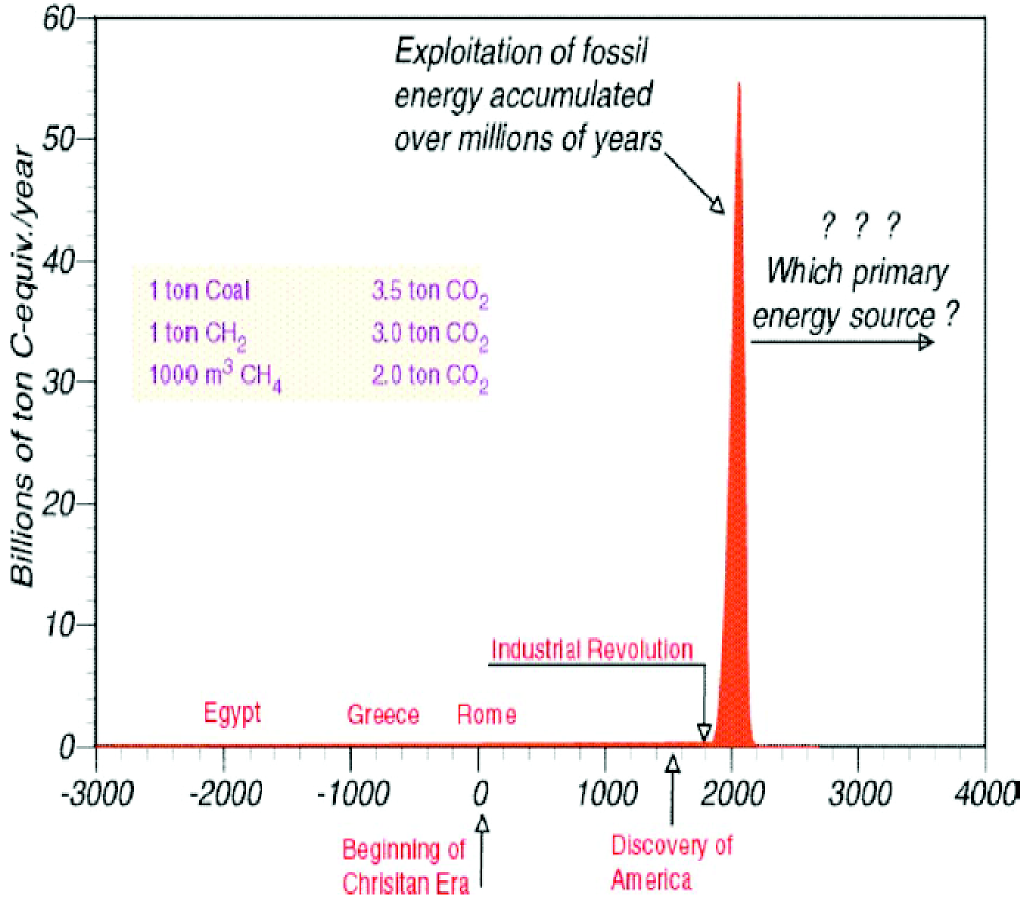
- Countries with a lot of Sun (this is you!!!), Water, Wind
- PV, Wind, Hydro
- Electric Networks
- Batteries, power-to-x
- Industrial processes (a lot has to be redesigns or newly built)
- Heat pumps
- Building industry (renovation

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