IEWT 2025

Gefördert durch:

Bundesministerium
für Wirtschaft
und Klimaschutz

aufgrund eines Beschlusses
des Deutschen Bundestages

Ein Transportdatensatz unter Berücksichtigung der FAIR-Prinzipien als Basis für hochaufgelöste Energiesystemmodelle

Hedda Gardian, Fabia Miorelli, Hans Christian Gils

DLR

Überblick

Was:

- Forschungsprojekt **SEDOS** (Förderkennzeichen: 03EI1040D)
- Modellstruktur und Datensatz für Energiesystemmodelle

Fokus:

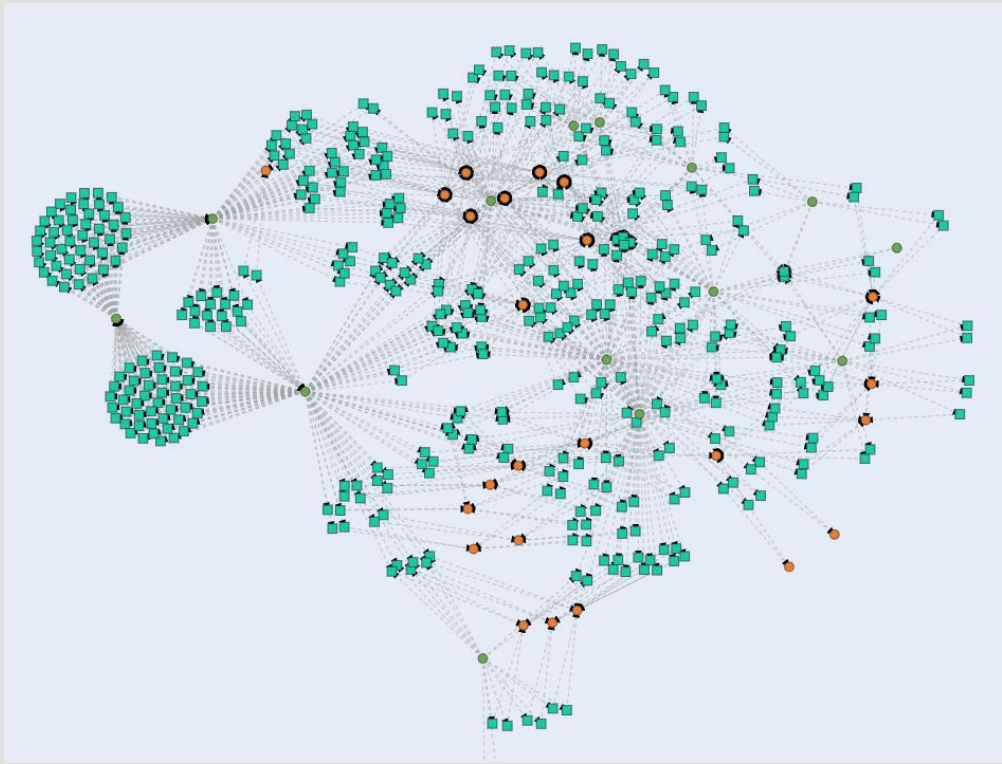
- Sektorenkopplung
- Energiewende
- Open Source
- Deutschland

Wo: Open Energy Platform (OEP)

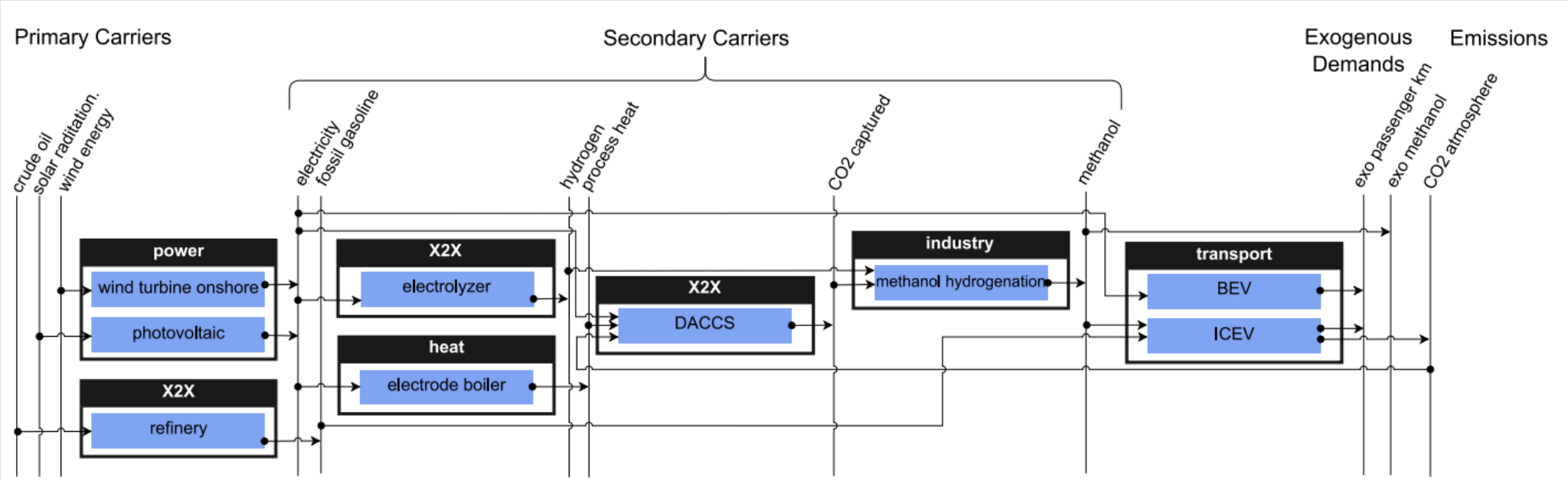
- Web-Interface für den Zugriff auf eine Datenbank, das es NutzerInnen ermöglicht, Daten mit entsprechender Dokumentation zu veröffentlichen
- Gehostet und entwickelt von: Universität Magdeburg, RLI, Öko-Institut, Fraunhofer IEE, Europa-Universität Flensburg, …

Modellstruktur

- Definition und Verknüpfung von Technologien, Commodities und Sektoren
- Daraus entsteht ein Energiereferenzsystem
- Erleichterte Nutzung/Verständnis der Daten, Unterstützung für ModelliererInnen



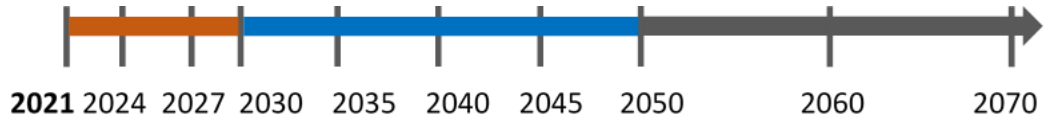
Modellstruktur



Baecker et al. (2025): Comprehensive and open model structure for the design of future energy systems with sector coupling, RSET, Vol. 6, 100094, https://doi.org/10.1016/j.rset.2024.100094.

SEDOS Bilanzgrenze

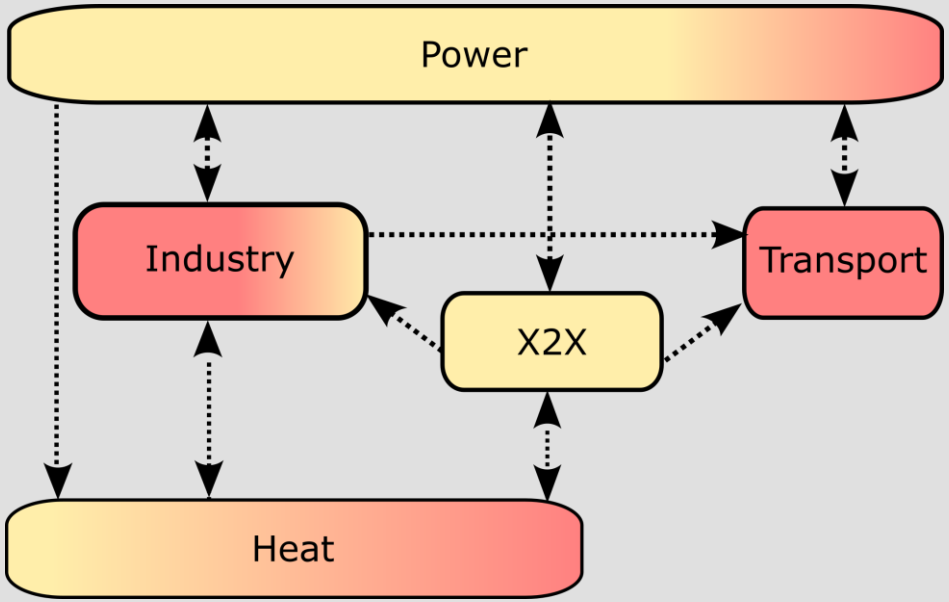
- Temporal:
  - stündliche Auflösung
  - Stützjahre: 9 + **Basisjahr**



- Räumlich:
  - Deutschland → Punktmodell (keine Netze)
  - Stromsektor auf Europa ausgeweitet

- Technologisch:
  - 5 Sektoren mit > 2000 Technologien
  - Aggregationslevel

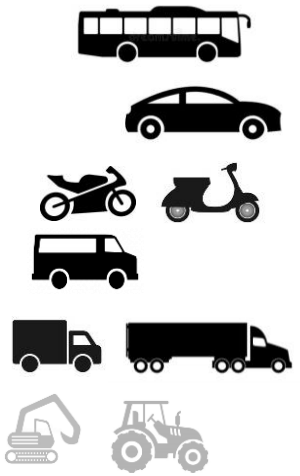
0	transport	industry	power	heat	x2x
1	distance type	process route	technology type	building types	technology type
2	vehicle size		RE type	fuel type	
3	fuel type		regional 1		
4			regional 2		



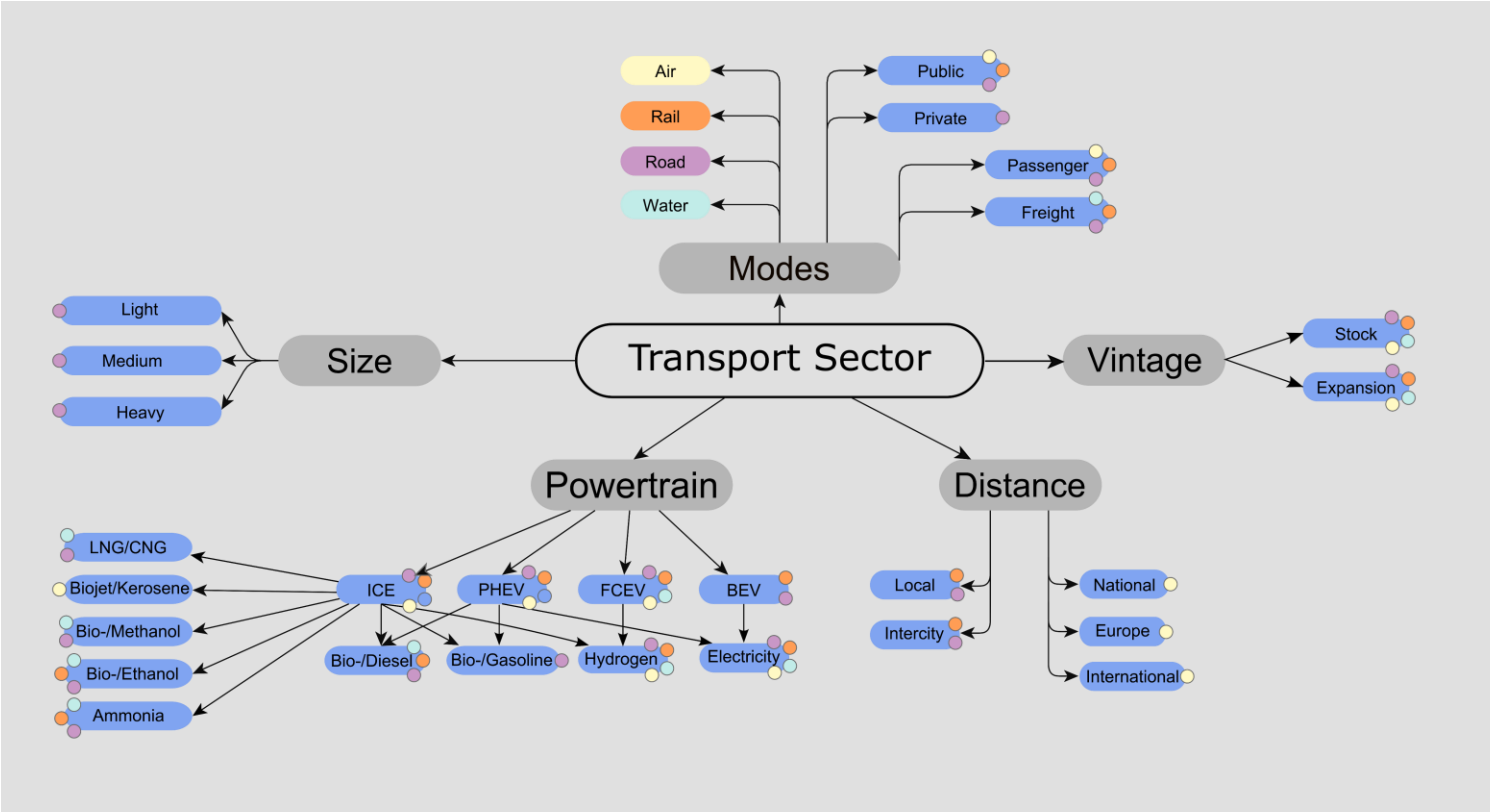
Baecker et al. (2025): Comprehensive and open model structure for the design of future energy systems with sector coupling, RSET, Vol. 6, 100094, https://doi.org/10.1016/j.rset.2024.100094.

Straßentransport Sektor

- Fahrzeuge:
  - Bus
  - PKW
  - Zweiräder
  - Transporter
  - LKW
  - Bau/Agrar



- Skalare Parameter:
  - Techno-ökonomisch
  - Jährliche Nachfragen
  - Emissionsfaktoren
- Zeitreihen(venco.py):
  - Nachfrage
  - Flexibilitätspotenzial

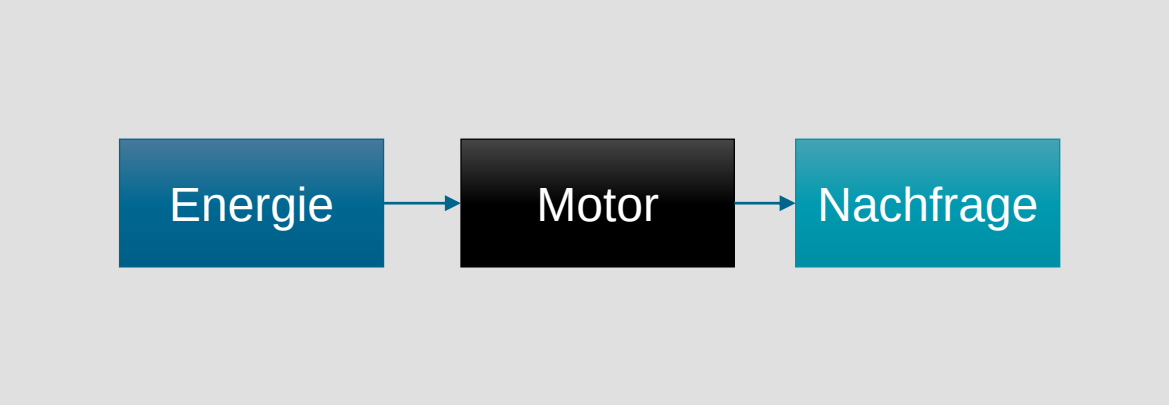


Baecker et al. (2025): Comprehensive and open model structure for the design of future energy systems with sector coupling, RSET, Vol. 6, 100094, https://doi.org/10.1016/j.rset.2024.100094.

Transportmodellierung

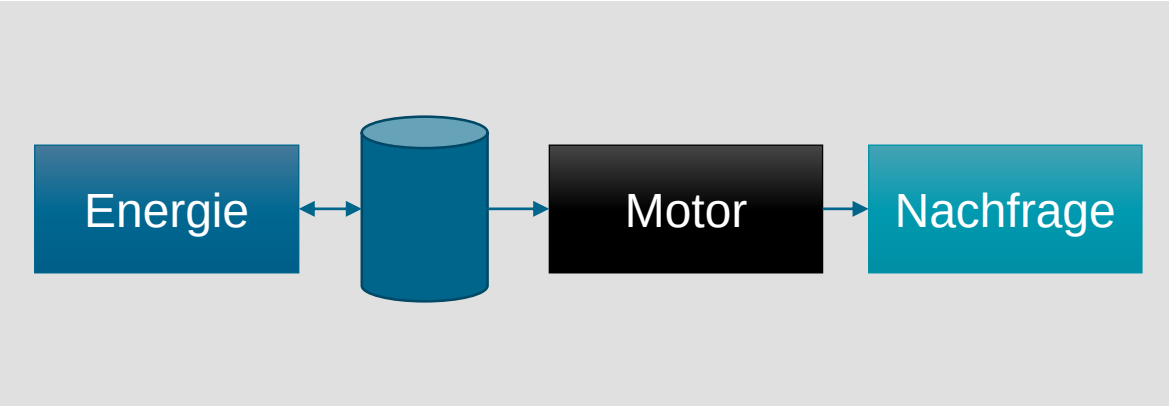
Inflexibler Ansatz

- Fixe Nachfrageprofile
- Keine Modellierung von Speichertanks
  - Große Puffer in Bereitstellungskette vorhanden
  - Tank- und Fahrprozess direkt gekoppelt

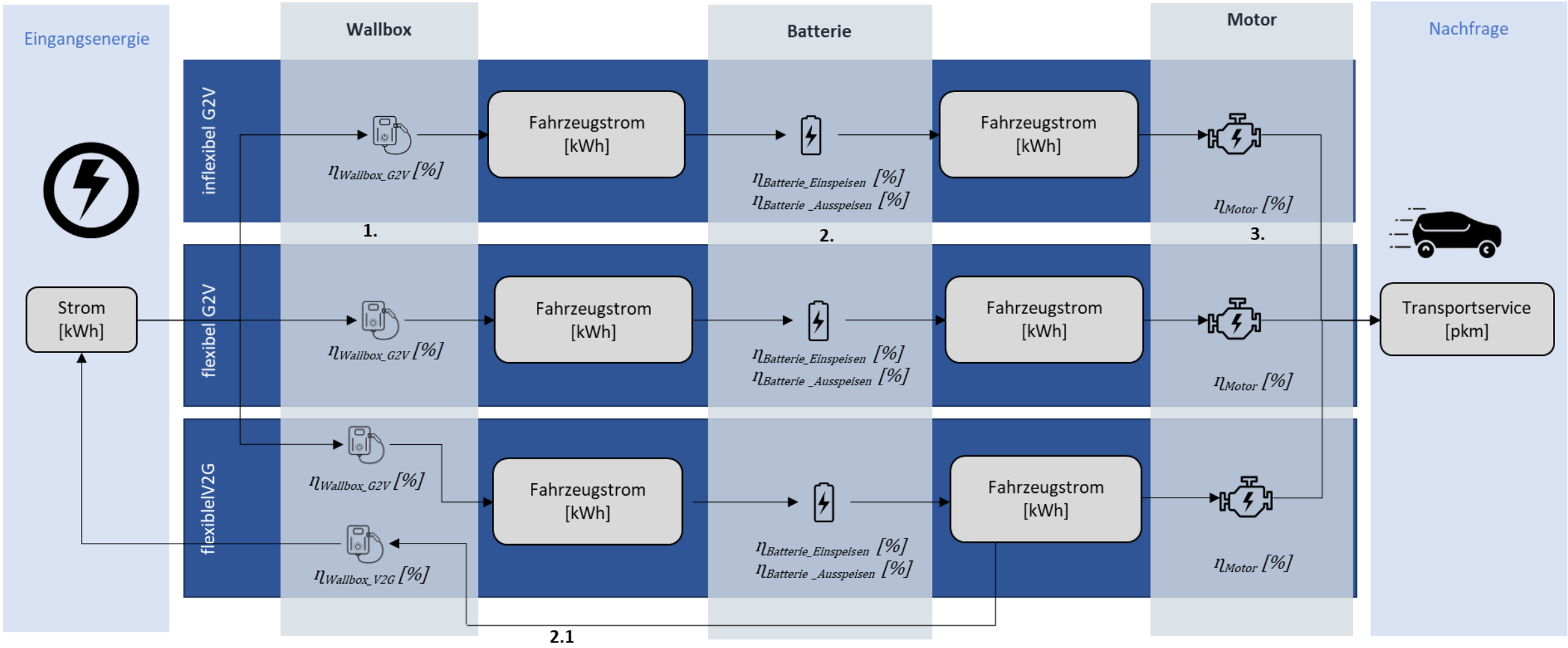


Flexibler Ansatz

- Batteriespeicher explizit abgebildet
  - Entkopplung von Laden und Fahren
  - Geringe Speicherkapazität im Stromnetz
- Modellierung von Ladeverschiebung und Rückspeisung

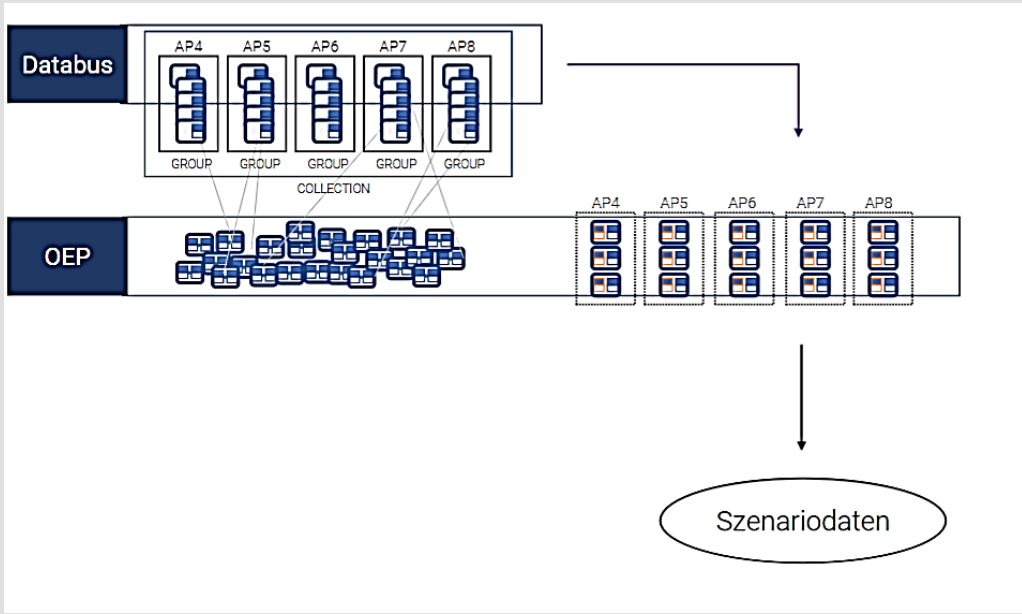


Flexible Transportmodellierung



Datenmanagement

- CSV-Tabellen und Metadaten im JSON-Format auf der OEP hochgeladen
- Metadaten im Open Energy Databus registriert
- Kollektionen und Gruppen auf dem Datenbus erzeugen Datenstruktur

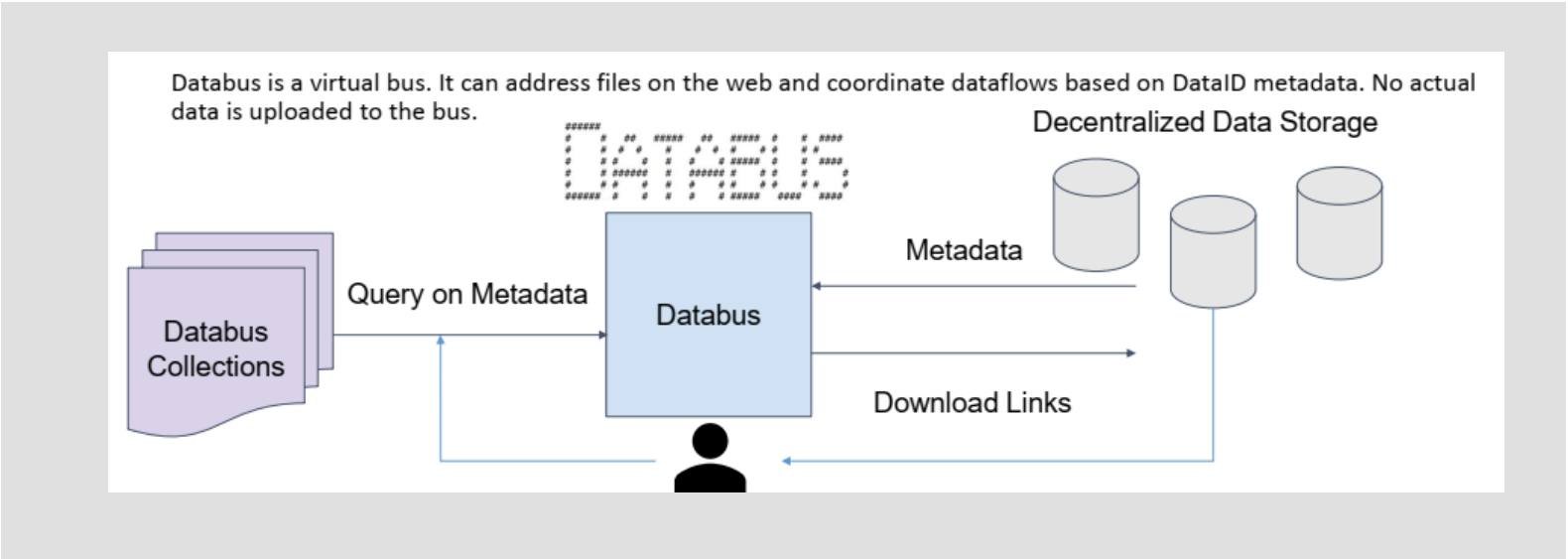


Open Energy Databus

- Eine **intelligente Plattform** zur Vernetzung und Organisation energiebezogener Daten aus verschiedenen Quellen, die das Finden, Nutzen und Teilen erleichtert.

- Der Datenbus erstellt eine **strukturierte „Karte“** aller Daten mithilfe eines Knowledge Graphs. Dieser fügt eine zusätzliche Bedeutungsebene hinzu und ermöglicht die Nachverfolgung der Herkunft und wie sie verarbeitet wurden.

- Sie erleichtert die Zusammenarbeit, stellt **zuverlässige Daten** durch eindeutige ID´s und Herkunftsnachweise sicher.



Datenformat Beispiel– mittlerer Benzin-PKW

Column names	First row
id	1
region	DE
Year	2021
type	tra_road_mcar_ice_pass_gasoline_0
capacity_tra_inst_0	15803530
conversion_factor_exo_road_mcar_pkm	156
conversion_factor_sec_gasoline	61.95441
cost_fix_tra	893.44538
cost_inv_tra	24961.9496
cost_var_tra	0.02801
ef_sec_gasoline_emi_ch4_f_tra	4.86
ef_sec_gasoline_emi_co2_f_tra	global_emission_factors.gasoline
ef_sec_gasoline_emi_n2o_f_tra	0.31
lifetime	13
mileage	11282
occupancy_rate	1.56
wacc	global_scalars.wacc
bandwidth_type	{}
version	srd_point_sedos
method	{'conversion_factor_exo_road_mcar_pkm': '100 km as a standard unit denominator (kWh/100 km) for car consumption multiplied by occupancy rate‘, 'cost_var_tra': 'Own analysis based on 8Kraft2023 and [ADAC, 2023a, 2023b] data. Divided by occupancy_rate/tonnage to convert into pkm/tkm specific value.‘ ….}
source	{'capacity_tra_inst_0': '8S&PG2023,8Kraft2021c,8DLR2023', 'conversion_factor_sec_gasoline': '8Kraft2021b,8ADAC2023', 'cost_fix_tra': '8Kraft2023,8ADAC2023,8ADAC2023b', 'cost_inv_tra': '8Kraft2021b,8ADAC2023', 'cost_var_tra': '8Kraft2023,8ADAC2023,8ADAC2023b‘, …}
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Picture source: https://www.kues-magazin.de/verbrauchswerte-mittelklasse-benziner-und-hybride/

Datenformat Beispiel– mittlerer Benzin-PKW


```
{
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    "description": "Operation independent costs for existing and new vehicle units.",
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        },
        {
            "name": "vehicle",
            "path": "http://openenergy-platform.org/ontology/oeo/OEO_00010023"
        }
    ],
```


Basierend auf Metadatenstandard: Open Energy Metadata (OEMetadata)

FAIR

- **Findability:**
  - Daten werden mit umfangreichen Metadatenstrings versehen und im Energy Databus registriert
  - (Meta-)Daten erhalten eine global eindeutige und dauerhafte ID
- **Accessibility:**
  - (Meta-)Daten sind über ihre Kennung mittels eines standardisierten Kommunikationsprotokolls abrufbar
- **Interoperability:**
  - Konzepte werden mithilfe der OEO (Ontology for Energy System Analysis) annotiert
  - (Meta-)Daten sind mit präzisen und relevanten Attributen ausführlich beschrieben
  - Einheitliches Tabellenformat
  - Öffentlich verfügbare Datenadapter
- **Reusability:**
  - Veröffentlichung unter einer offenen Lizenz


```
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 "context": {
  "contact": "Hans-Christian.Gils@dlr.de",
  "grantNo": "03EI1040D",
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  "documentation": "https://sedos-project.github.io/.github/",
  "fundingAgency": "Bundesministerium fuer Wirtschaft und Klimaschutz (BMWK)",
  "publisherLogo": "https://www.dlr.de/static/media/Logo-de.697a8e1f.svg",
  "fundingAgencyLogo": "https://en.wikipedia.org/wiki/Federal_Ministry_for_Economic_Affairs_and_Climate_Action#/media/File:BMWi_Logo_2021.svg"
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    }
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```


→ Abbau von Hürden: GUI und Dokumentation

SEDOS GUI

SEDOS

Welcome to the SEDOS GUI

Why SEDOS?

The SEDOS project supported by the BMWK provides a comprehensive open-source model structure taking into account the relevant future technologies for electricity, heat, X2X, transport, and industry in a sector-coupled energy system for Germany until 2070.
All the data has been registered in a collection on the databus for better findability. We enable barrier-free access to the data by uploading it to the OEP where the data can be downloaded as csv or with an API. The model structure and data interoperability are tested on three different optimization frameworks: TIMES, FINE, and Oemof. For easier reproducibility, the data come together with detailed metadata, which is annotated with ontological concepts from the OEP.

Why this GUI?

To improve the transparency and reproducibility of the open source structure this GUI provides a few basic functionalities to explore the derived modeling base:

- Looking into the underlying model structure of our reference energy system with the network graph.
- Exploring the underlying input data of our model with an integrated table view.
- See the aggregations steps defined in our model structure and download the different levels of detail .
- Create charts based on possible model results as an outcome of different frameworks and scenarios using the same data.

Looking for more information on SEDOS?

Explore the various offerings to find out more about the project:

See project documentation

See publication on the model structure

Explore the Model Structure

Select Model Structure

Overall System - Highest Level of Detail

Generate Networks | Look at Processes | Look at Artifacts | Aggregation Graph

Exemplary graph diagrams

Model structure selection description (relevant for the network graph):

- You can either visualize the selected model structures from our case studies.
- ..or visualize the overall system for different levels of detail (LOD), which are determined by the available aggregation levels per sector.

For more details on the derivation of LODs see the related section in the documentation.

Explore the Model results

Select Scenario

io_groups

Explore Diagrams

Exemplary result diagrams

Scenario selection description:

1. Base scenario ToKo - technology-open & cost-optimal
2. Scenario variation RIGa: Reduced import dependency for fossil gas
3. Scenario variation SienA/B: sector integration

See more details on the scenarios

SEDOS

Abbreviation Help: Enter or select abbreviation...

Current structure: SEDOS-structure-all Change selection

Network data

Sectors:

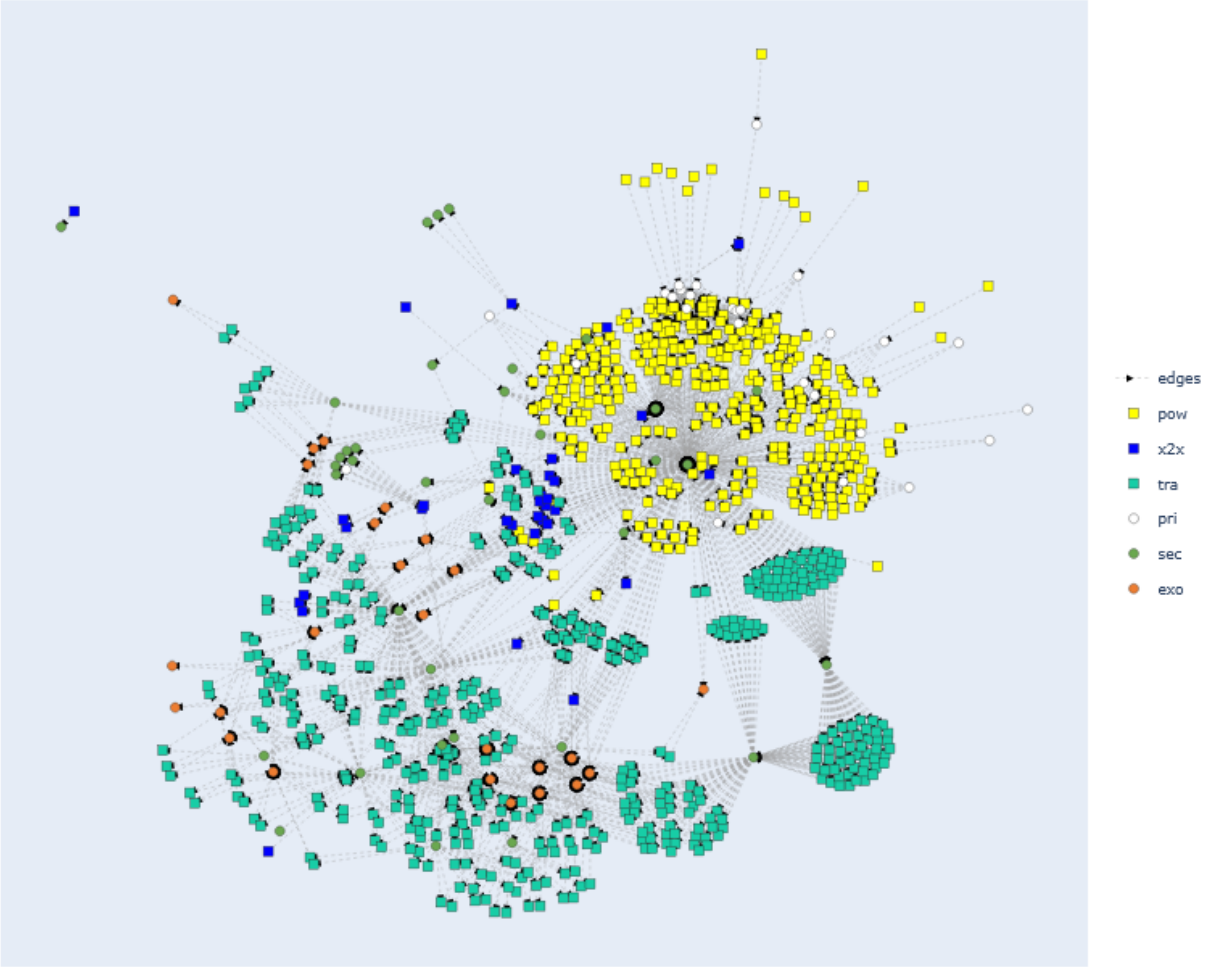
- Power
- X2X
- Industry
- Transport

Depth: full

Mapping: fr

Display specific process: Enter or select process...

Display specific commodity: Enter or select commodity...



SEDOS

Abbreviation Help: Enter or select abbreviation...

Collection "sedos-project" View collection

- ind_glass_cont_fullele_cc_2
- tra_road_truck_bev_frei_engine_infl_uni_1_ag
- helper_sink_exo_paper_lq
- tra_road_htruck_fcev_frei_ammonia_1
- ind_chemical_processes_others_cog_0
- ind_glass_flat_rege_1_ag
- ind_chemical_process_heat_elc_1
- ind_generic_boiler_heat_proc_0
- ind_chemical_mdrive_1
- ind_glass_cont_rege_0
- tra_road_hcar_bev_pass_engine_flex_bi_1
- tra_road_mcar_ice_pass_cng_1
- tra_road_htruck_ice_frei_hydrogen_1
- ind_automobile_pc_fcev_fasmbl_0
- tra_road_lcar_ice_pass_gasoline_1
- tra_timeseries
- tra_road_ltruck_bev_frei_battery_infl_uni_0
- helper_x2x_ind_meoh_hydrogen
- tra_road_truck_ice_frei_ethanol_1_ag
- ind_glass_cont_fullele_2
- ind_glass_flat_fin_1
- ind_automobile_furnace_heat_proc_gas_0
- x2x_other_lng_liquefication
- ind_glass_cont_rege_0_ag
- ind_chemical_cl2_diaph_1
- tra_road_htruck_bev_frei_wallbox_infl_uni_g2v_0
- ind_chemical_cl2_diaph_0
- ind_chemical_process_heat_lpg_1
- x2x_delivery_ethanol
- helper_sink_exo_paper_hq
- helper_pow_ind_pri_bio
- tra_road_lcar_bev_pass_engine_infl_uni_0
- ind_chemical_processes_others_bio_0
- ind_chemical_olefins_scrac_lpg_1

Process data

Related artifacts:

- tra_road_ltruck_bev_frei_battery_infl_uni_0

Scalars | Timeseries

10 entries per page Search:

	region	year	capacity_e_inst_0	efficiency_sto_in	efficiency_sto_out	lifetime	share_tra_charge_mode	sto_self_discharge	bandwidth_type	method	source
0	DE	2021	110.0	97.47	97.47	10.0	100.0	0.007	{}	▶{ 4 items }	▶{ 6 items }
1	DE	2024	110.0	97.47	97.47	10.0	100.0	0.007	{}	▶{ 4 items }	▶{ 6 items }
2	DE	2027	110.0	97.47	97.47	10.0	100.0	0.007	{}	▶{ 4 items }	▶{ 6 items }
3	DE	2030	110.0	97.47	97.47	10.0	100.0	0.007	{}	▶{ 4 items }	▶{ 6 items }
4	DE	2035	110.0	97.47	97.47	10.0	100.0	0.007	{}	▶{ 4 items }	▶{ 6 items }
5	DE	2040	110.0	97.47	97.47	10.0	100.0	0.007	{}	▶{ 4 items }	▶{ 6 items }
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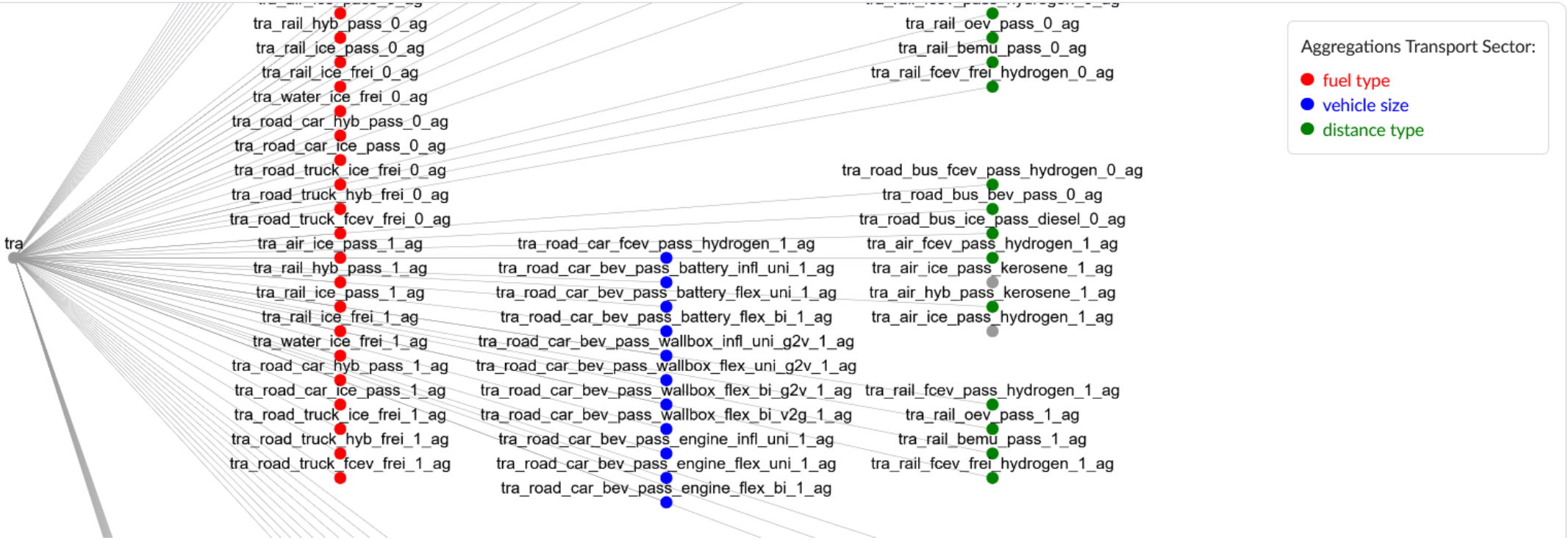
7	DE	2050	110.0	97.47	97.47	10.0	100.0	0.007	{}	▶{ 4 items }	▶{ 6 items }

SEDOS

Abbreviation Help: Enter or select abbreviation...

Aggregation Graph

Desired level of detail: 1 2 3 Sector: Power X2X Heat Industry Transport Processes from all sectors for level of detail: Download



SEDOS

Model Results

sankey_pri-sec-inputs_to_category_ | Load Filter Settings | Render chart and table | Download Data

Scenario | Other | Graph | Display

General Graph Options

Chart type:

- ○ Bar Chart
- ◉ Sankey Chart
- ○ Line Chart

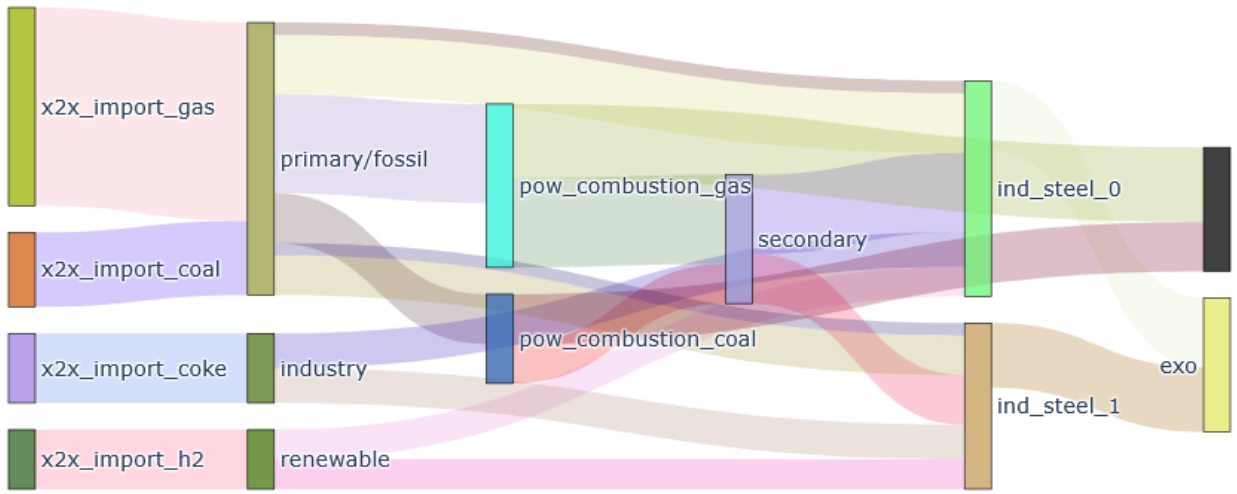
Node: process

Inflow: input_groups

Outflow: output_groups

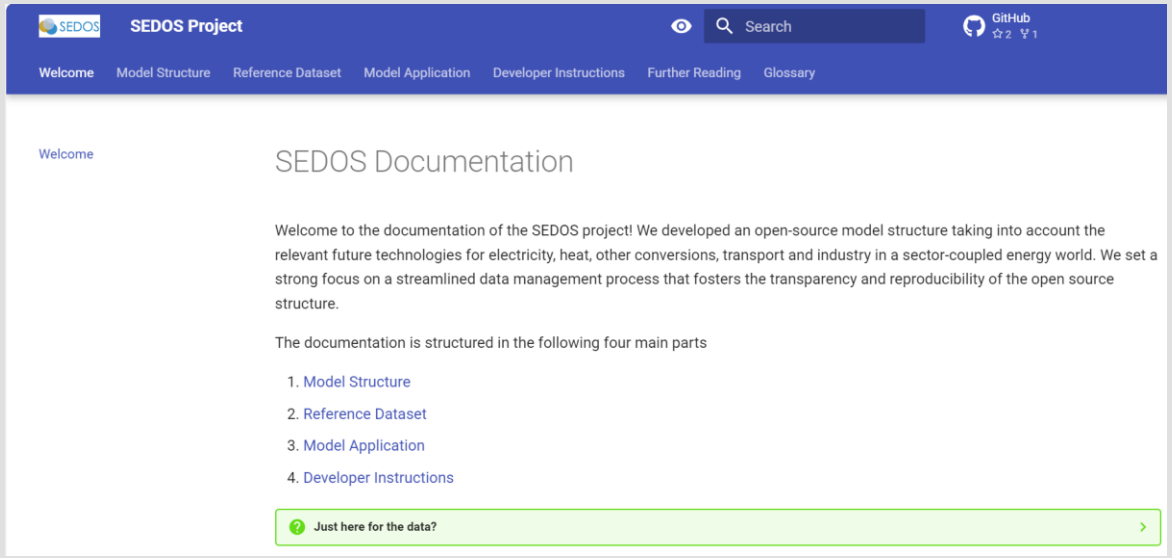
set color for:

Chart | Table



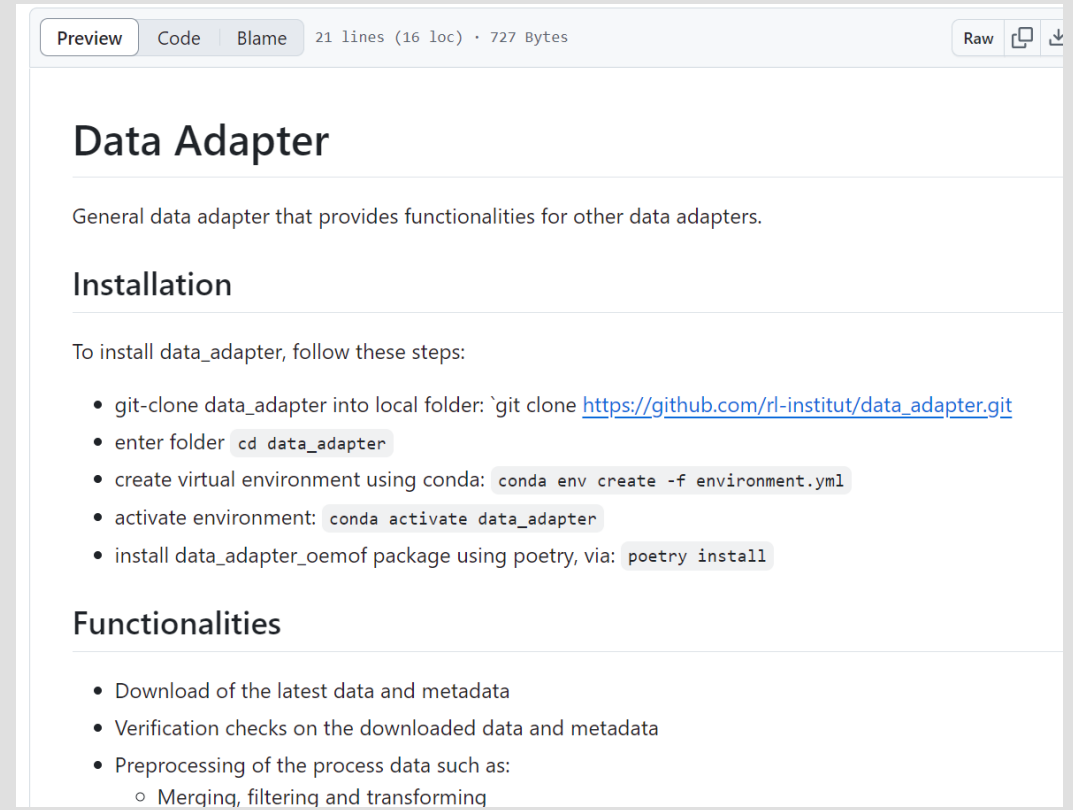
Dokumentation

- SEDOS Project
- **Inhalt:**
  - Allgemeine Informationen zur Modellstruktur/Daten
  - Informationen zu Szenarien und Nomenklatur
  - Nützliche Links
  - Anleitungen



Datenadapter

- Allgemeiner Datenadapter
  - Download
  - Einsetzen von Daten bei Verweisen
  - Umrechnung von Einheiten
- Modellspezifische Datenadapter
  - Fine
  - TIMES
  - oemof



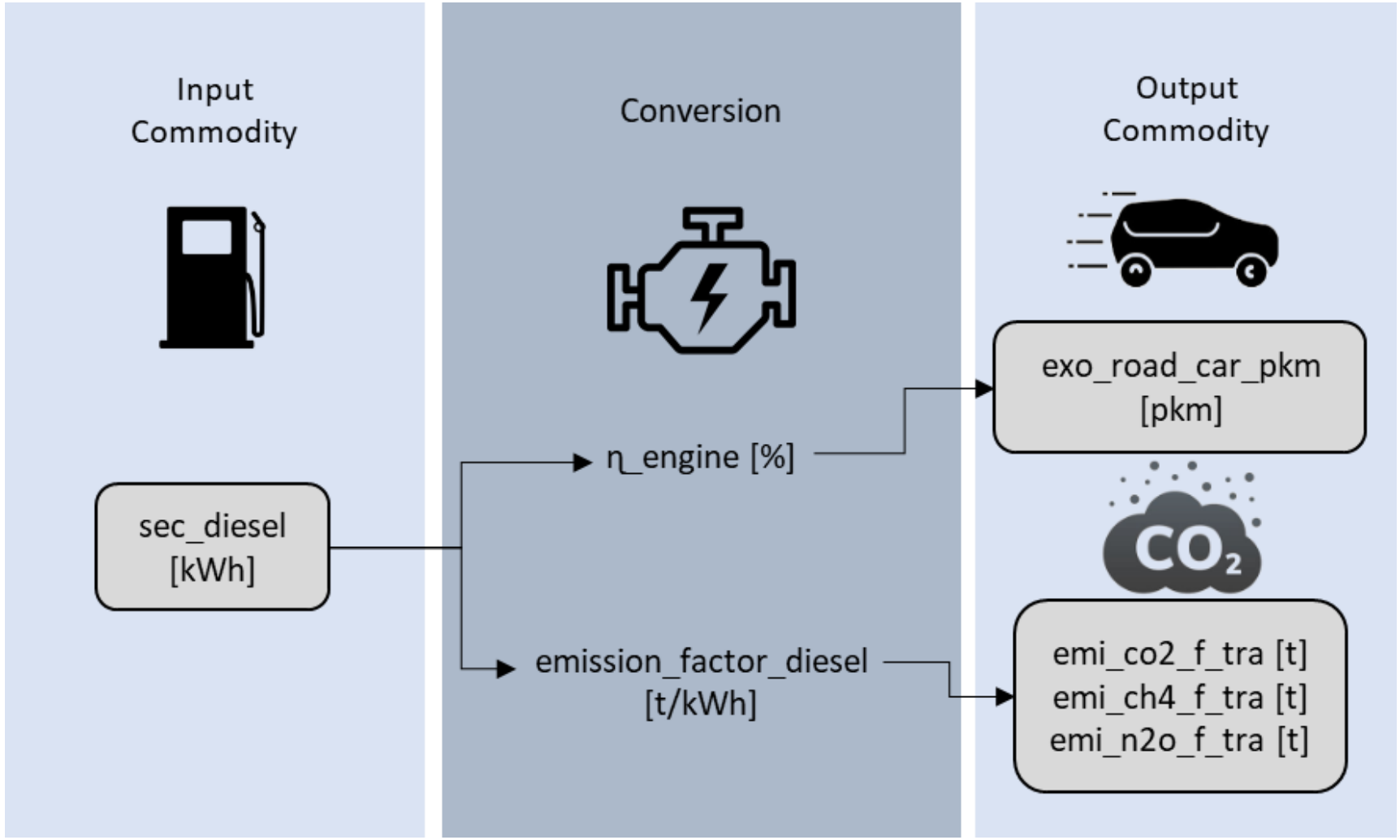
Hedda Gardian M.Sc.
Telefon +49 711 6862 8819
hedda.gardian@dlr.de

Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)

Institut für Vernetzte Energiesysteme
Energiesystemanalyse

Curiestraße 4
70563 Stuttgart

Inflexibler Ansatz



Endogen vs. exogen

Techno-economic
costs (invest/fix/var)
efficiencies
installed capacitites
expansion limits etc.

Technologies

Primary energy sources
annual/hourly potentials and prices (solar, wind, biomass, natural gas, lignite, uranium etc.)

Source

Dispatch,
capacity expansion

Political framework
renewable energy target
emission targets

Demands
(based on macroeconomic, demographic, living and usable space, passenger & freight transport performance)

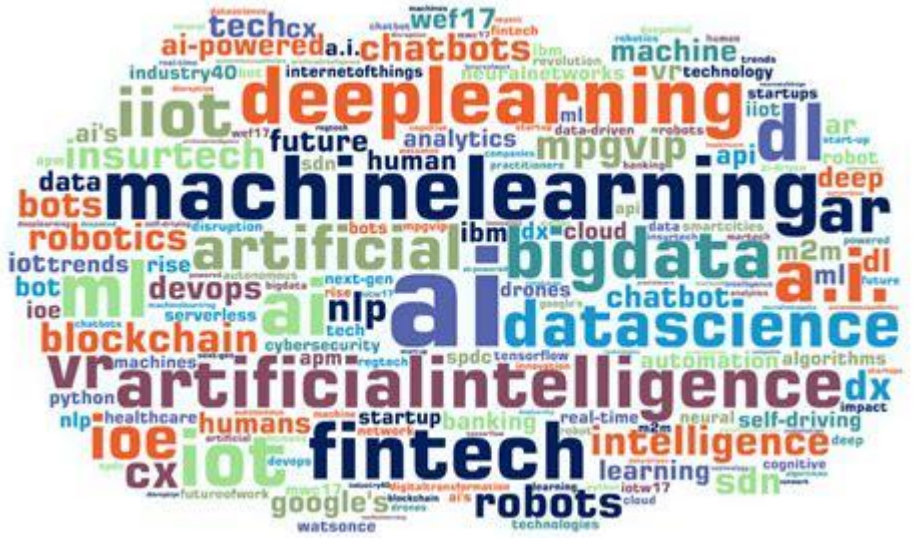
Transport: transport_service (pkm/tkm bus/truck/car …)
Heat: space heat/cooling, hot water
Power: electricity
Industry: production volumes (aluminium, automobile, cement, chemical, copper, glass, steel)

Sink

Import / Export
electricity/commodity prices of neighboring countries

SEDOS-II

- Skizze submitted
- Content:
  - Simplified application
  - Automated/assisted data adapter gerenation
  - AI-based data update
  - Focus on the near future

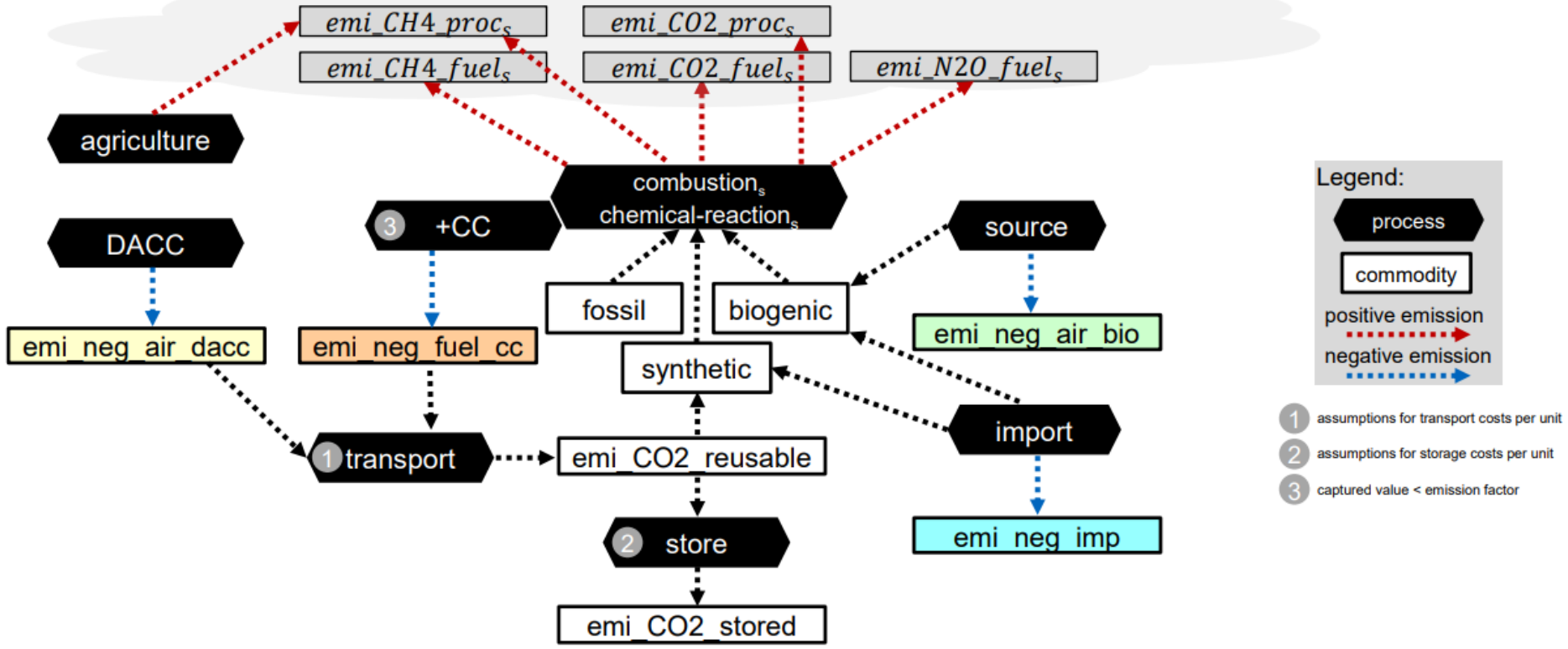


https://onalytica.com/blog/posts/artificial-intelligence-2017-top-100-influencers-brands-and-publications/

Carbon accounting concept

SEDOS Konzept Emissions-Bilanzierung

$$\Delta\varepsilon = \sum_{s \in sectors} (\varepsilon^{CO_2}_{fuel,s} + \varepsilon^{CO_2}_{proc,s}) + 28 \cdot (\varepsilon^{CH_4}_{fuel,s} + \cdot\varepsilon^{CH_4}_{proc,s}) + 265 \cdot \varepsilon^{N_2O}_{fuel,s} - (\varepsilon^{dacc}_{neg,s} + \varepsilon^{cc}_{neg,s} + \varepsilon^{bio}_{neg,s} + \varepsilon^{imp}_{neg})$$



Scenarios

- **Base scenario ToKio - technology-open & cost-optimal** Which technologies can reduce GHG emissions from energy use to a targeted level at minimum cost (e.g. climate neutrality by 2045)?
- **Scenario variation RIGa: Reduced import dependency for fossil gas** How can the dependency on fossil gas imports, including LNG imports, be reduced to a specified minimum level at minimum cost while complying with the GHG reduction targets?
- **Scenario variation SienA/B: sector integration** In which areas can sector integration make a greater contribution to GHG reduction?
- SienA: Specification of a minimum use of hydrogen or H2 derivatives.
- SienB: Specification of a minimum domestic RE electricity generation.

Demand data

- Harthan, Ralf Oliver et al. (2024): Technischer Anhang der Treibhausgas-Projektionen 2024 für Deutschland (Projektionsbericht 2024), https://www.umweltbundesamt.de/publikationen/technischer-anhang-der-treibhausgas-projektionen.