DEFINE
Development of an Evaluation Framework for the Introduction of Electromobility

Electromobility+

Project:
Development of an Evaluation Framework for the Introduction of Electromobility

Deliverable 10.1: SAM and data on the energy and electricity sectors ready to impose in the general equilibrium model for the Poland-Scenario

Deliverable 10.2: Model development for Poland

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1. SAM and data on the energy and electricity sectors for the general equilibrium model for Poland

1.1. Social Accounting Matrix for Poland – Data sources

The database for the Polish model is a single-year set of data (social accounting matrix – SAM) based on national input-output table (IOT) supplemented with other data like data for stocks of capital and labour or pollution emission data. At the time of writing this report, the latest available IOT for Poland was provided by the following sources:

- IOT for 2005 prepared by the Central Statistical Office for Poland (GUS 2009c) as a product by product balance for 55 markets
- IOT for 2005, prepared by the OECD (2012) as a sector by sector balance for 37 branches
- IOT for 2007, prepared by the US-based Center for Global Trade Analysis (GTAP 2012) as a product by product balance for 57 markets
- IOT for 2011, prepared by a consortium of European research institutions (University of Groningen, IPTS, WIIW, and WIFO) under a project financed by the European Commission (WIOD 2012) as a sector by sector balance for 35 branches
- IOT for 2000, based on supply-use tables prepared by a consortium of European research institutions (NTNU, TNO, SERI and Universities Leiden) under a project financed by the European Commission (EXIOBASE 2012). The number of distinguished sectors is 129.
- IOT for 2007, based on supply-use tables prepared by consortium of European research institutions as an update of EXIOBASE project (CREEA 2013). The number of distinguished products and sectors is respectively 200 and 163.

We have selected CREEA database for our analysis, since it provides the most disaggregated structure with relatively recent data. The IOT represents the Polish economy at the end of 2007 as a product by product balance for 169 markets. In construction of Polish SAM we follow the Austrian SAM structure (Miess et al. 2014, table 3.3). Some modifications in the aggregation have been applied in the Polish version, due to different characteristics of both economies or unavailability of data. A comparison of aggregation structures between SAMs for Austria and Poland is presented in Table 1. The details of the aggregation by sectors are described in Table 2, while Table 3 summarizes our approach for the sectors disaggregation supported by external data. We use in priority public official data from Polish and European Statistical Offices, as well as reports from other institutions when necessary. The data in

Polish SAM are expressed in millions of euros in 2007. In case of missing data for 2007, we used 2008-2010 data applying GDP deflator GUS (2014): 2008/2007= 1.05; 2009/2007 = 1.07; 2010/2007 = 1.11

1.2. Products

The Classification of Products by Activity (CPA) - version 2008 - was applied for comparison of differences between both SAMs. The main differences are the following (see Table 1):

- Manufacture of metal products (25)[1] and Metal ores (7) are transferred from engineering (ENG)[2] and other (OTHER) sectors into metal (FERR) sector in order to keep joint metal sector;
- Nuclear fuels (24.46) were shifted from FERR to OTHER, because we wanted to keep FERR as a pure metal related sector.
- ENG should cover only production process, but not trade or service. Repair and installation services (33) are not directly observed with CREEA classification, since it is based on CPA 2002, where repair and installation services are included into manufacture of different products. For this reason we did not directly assign this service to any specific sector in the model;
- Part of financial leasing (64.91) contains car leasing and part of rental and it is shifted from SERV to CAR_SERV in order to keep together all services related to cars.
- Secondary raw materials (38.3) are shifted from SERV to OTHER because materials recovery is a production process, not a service.
- Electricity production (35.11) and electricity services (35.12 – 35.14) are treated separately in CREEA database. Thus we were able precisely define ELE and ELE_INF sectors for the Polish SAM, but not for the Austrian one. However, for the purpose of the model we shift final and intermediate demand on ELE (35.11) into demand on ELE_INF (except demand on ELE by sector ELE_INF), because nobody except ELE_INF should buy electricity directly from ELE. This means that no one else can produce electricity except ELE. The same approach was used for both, Austrian and Polish SAMs.
- Extraction of natural gas (6.2), petroleum gases and other gaseous hydrocarbons (19.2.3) are shifted from OIL to GAS in order to keep gas related products together.
- Refined petroleum products related to transportation (19.2.2) are shifted from OIL to FUEL in order to separate fuel use for transportation purpose only
- Part of hard coal (5.1) use for transportation purpose (steam locomotive) is shifted from COAL to FUEL
- Part of natural gas (6.2) use (in liquefied or gaseous state) for transportation purpose is shifted from GAS to FUEL

[1] The symbol indicates the CPA 2008 classification (see Table 1).
[2] The symbol indicates sectors abbreviation (see Table 1).

- There are no data for specialised construction activities (33) in CREEA database for Poland. Thus this sector was cancelled in the Polish model.

There is one more row in Table 1 that represents intermediate inputs within sector (OWNINT). It describes how much a sector consumes its own production (e.g. how much AGR use AGR products, how much FERR use FERR products etc.). This means that data in OWNINT row should be symmetric (the same values) to OWNINT column. The data comes directly from IOT.

Table 1. Comparison between Polish and Austrian aggregation in SAM

(Austrian SAM)			(Polish SAM)		
Abbreviation	Sectors Name	Classification CPA 2008	Abbreviation	Sectors Name	Classification CPA 2008
AGR	Agriculture, forestry, fishing	1; 2; 3	AGR	Agriculture, forestry, fishing	1; 2; 3
FERR	Manufacture of basic metals, Nuclear fuels	24	FERR	Mining and manufacture of basic metals and metal products	7; 24 (excl. 24.46); 25
CHEM	Chemical and pharmaceutical products	20; 21	CHEM	Chemical and pharmaceutical products	20; 21
ENG	Metal products, Engineering	25 – 28; 33	ENG	Engineering, manufacture of motor vehicles' engines	26 – 28
CPT	Vehicles production and trade	29; 45.1; 45.3	CARS	Manufacture of bodies, parts and accessories for motor vehicles, Trade of motor vehicles (excl. motorcycles)	29; 45.1; 45.3
CV	Conventional vehicle	Own calculations	CV	Conventional vehicle	Own calculations
HEV	Hybrid Electric Vehicles	Own calculations data	HEV	Hybrid Electric Vehicle	Own calculations
PHEV	Plug – in Hybrid Electric Vehicle	Own calculations	PHEV	Plug-in Hybrid Electric Vehicles	Own calculations
BEV	Battery Electric Vehicle	Own calculations	BEV	Battery Electric Vehicle	Own calculations
OVEPRO	Other transport equipment	30	VEH	Other transport equipment	30

OTHER	Other production and mining	7-18; 22-23; 31-32; 58	OTHER	Other production, Nuclear fuels	8-18; 22-23; 24.46; 31-32; 38.3; 58
BUI1	Building construction, civil engineering	41; 42	BUI1	Building construction, civil engineering	41; 42
BUI2	Specialised construction activities	43	BUI2	Specialised construction activities	43
PT	Passenger land transport	49.1; 49.3	PT	Passenger land transport	49.1; 49.3
NCST	Other passenger transport	50.1; 50.3; 51.1	NCST	Other passenger transport	50.1; 50.3; 51.1
FT	Freight transport	49.2; 49.4; 49.5; 50.2; 50.4; 51.2	FT	Freight transport	49.2; 49.4; 49.5; 50.2; 50.4; 51.2
R&D	Research and Development	72	RnD	Research and Development	72
SERV	Services	36-39; 45.4; 46-47 (excl. 47.3); 52-53; 55-56; 58-66; 68-75; 77-82 (excl. 77.1); 84-88; 90-97;	SERV	Services	36 – 39 (excl. 38.3); 45.4; 46-47 (excl. 47.3); 52-53; 55-56; 58-66 (excl. part of 64.91); 68-75; 77-82 (excl. 77.1); 84-88; 90-97
CAR_SERV	Car Services	45.2; 47.3; 77.1	CAR_SERV	Car Services	45.2; 47.3; part of 64.91; 77.1
ELE	Electricity production	part of 35.1	ELE	Electricity production	part of 35.11
ELE_INF	Electricity transmission and distribution	part of 35.1	ELE_INF	Electricity transmission and distribution	35.12 – 35.14; part of 35.11
LDH	Steam and air conditioning supply	35.3	LDH	Steam and air conditioning supply	35.3
GAS	Gas production and distribution	35.2	GAS	Extraction of natural gas and other hydro-carbons, gas production and distribution	35.2; part of 6.2; part of 19.20.3
COAL	Mining of coal and lignite	5	COAL	Mining of coal and lignite, manufacture of coke oven products	5 (excl. part of 5.1); 19.1
CRUDE	Crude oil and natural gas extraction and services, coke and petroleum products	6; 9.1; 19 (excl. fuels for transport)	OIL	Crude oil extraction and services, manufacture of refined petroleum products	6.1; 9.1; 19.20.1; 19.20.4

FUEL	Fuel for transport purposes	Own calculations based on external data	FUEL	Fuel for transport purposes	19.20.2; part of 5.1; part of 6.2; part of 19.20.3
OWNINT	Intermediate Inputs within Sector	IOT	OWNINT	Intermediate inputs within Sector	IOT

The direct assignment of sectors aggregation using CREEA IOT is presented in Table 2. This database uses modified NACE (rev.1) classification system that is equivalent to CPA (version 2002). In contrast, CPA (version 2008) is equivalent to NACE (rev. 2). The letter "p" in front of CREEA classification indicates "product" in order to emphasize that we work with a product by product balance. Since each sector in our model produces a single good, the products classification exactly matches sectors classification.

Our adjustments for some sectors, resulting from the differences performed in Table 1, are explained in the last column of the Table 2. These explanations are future supported with Table 3, where some clarifications of assumptions are provided.

- Pharmaceutical sector is not directly distinguished by CREEA, but it is covered by (p24.d)[3], i.e. chemicals nowhere else classified.
- Transport was splitted between PT (Passenger land transport), FT (Freight transport), and NCST (Other passenger transport). Details and source can be found in table 3.
- All fuels were splitted into GAS – gaseous fuels, OIL – liquids fuels, COAL – solid fuels, and FUEL – fuels use for transportation purpose. There are three types of gas use in transport:
    - CNG - compressed natural gas (part of p11.b)
    - LNG – liquefied natural gas is obtained through conversion of natural gas to liquid form for ease storage or transport since it has lower volume than gaseous form (part of p11.b)
    - LPG - liquefied petroleum gas (propane, butane) is obtained during oil refinery process (part of p23.20)

  Passenger cars consume LPG and CNG, while lorries and busses can consume all three types of gas. The market for LNG and CNG is still fledging in Poland. Busses operated under CNG (330 pieces) or LNG (13 pieces) are below 1% in Poland (CNG.AUTO 2014). The situation with passenger cars is similar, because there are only 24 CNG stations in the country (CNG.AUTO 2013). Nevertheless we respect these figures in the model, but we cannot distinguish precisely between consumption in PT (passenger land transport) and FT (freight transport) due to lack of data. Consumption of LPG, LNG and CNG were splitted between GAS and FUEL proportional (i) to consumption of gas in

[3] The symbols with "p" indicate the CREEA classification (see Table 2).

transportation relative to other purposes and (ii) to the size of p11.b (LNG, CNG) or p23.20 (LPG) sector.

- CREEA database has zero values for LNG (p11.b.1) in Poland. However, the Polish Statistical Office noticed consumption of LNG in transport (GUS 2009b, p.56). Hence we assume that LNG in CREEA is aggregated with natural gas (p11.b) and we extract the LNG for transportation purpose from p11.b according to external data.
- Gaseous fuels in CREEA, except for use in transport (refinery gas, LPG excl. transport use, ethane, natural gas excl. transport use) are shifted from OIL to GAS
- Liquid fuels in CREEA, except for use in transport (kerosene, refinery feedstock, naphtha, white spirit & SBP, lubricants, paraffin waxes and other petroleum products) are shifted from FUEL to OIL
- Solid fuels in CREEA, except for use in transport (anthracite, coking coal, bituminous coal, lignite coal, peat, coke oven coke, gas coke, coal tar, bitumen, petroleum coke) are shifted from FUEL to COAL
- CARS sector contains both production (manufacture of bodies, parts and accessories for motor vehicles) and trade (sale of motor vehicles, parts and accessories related to cars), while CARS_SERV sector covers maintenance and repair of motor vehicles, retail sale of automotive fuels, renting and leasing (including financial leasing) of motor vehicles. A trade, maintenance and repair service of motorcycles (50.4) is covered by SERV, because CARS sector has to contain only services related to cars. The same approach was used for both, Austrian and Polish SAMs.
- ENG sector contains only engineering related equipment, but CARS also covers some manufactures of engines (34.1) because pure production of engines is not explicitly distinguished due to lack of data. The same approach was used for both, Austrian and Polish SAMs.
- FUEL sector contains fuels for transportation purpose, but CARS_SERV sector contains retail sale of automotive fuels in specialized stores. The reason for putting trade services of automotive fuels (CAR_SERV) separate from the fuel sector (FUEL) is that we want to put a fuel tax only on the fuel itself, not on the providers of this fuel. Having services of automotive fuels in FUEL sector would distort the relation between fuel tax revenue and fuel purchases, i.e. the tax rates in the social accounting matrix would not correspond to the real ones.

Table 2. Sectoral details in the Polish SAM

Abbreviation	Sector Name	NACE rev. 2	CREEA classification	Comments
AGR	Agriculture, forestry, fishing	01; 02; 05	p01; p02; p05	
FERR	Mining and manufacture of basic metals and metal products	13; 27; 28	p13; p27; p28	*Added:* Manufacture of metal products (from ENG) and Mining of metal ores (from OTHER) *Removed:* Processed nuclear fuel (into OTHER)
CHEM	Chemical and pharmaceutical products	24	p24	
ENG	Engineering, manufacture of electric motors	29 – 33	p29 – p33;	*Removed:* Manufacture of metal products (into FERR)
CARS	Manufacture and trade of motor vehicles (excl. motorcycles)	34 (manufacture); 50.1 (sale of motor vehicles); 50.3 (sale of motor vehicle parts and accessories)	p34; part of p50.a (sale of motor vehicle); part of p50.a (sale of motor vehicle parts and accessories)	*Added:* Sale of motor vehicles, part and accessories (from CARS_SERV);
CV	Conventional vehicle	Own calculations	Own calculations	
HEV	Hybrid Electric Vehicle	Own calculations	Own calculations	
PHEV	Plug-in Hybrid Electric Vehicles	Own calculations	Own calculations	
EV	Electric Vehicles	Own calculations	Own calculations	
VEH	Manufacture of ther transport equipment	35	p35	
OTHER	Other production, nuclear fuels	12; 14 – 22; 23.3 (nuclear fuels); 25; 26; 36-37	p12; p14 – p22; p23.3; p25; p26; p36-p37	*Added:* Processed nuclear fuel (from FERR) *Removed:* Mining of metal ores (into FERR)
BUI1	Building construction, civil engineering	45.1; 45.2; 45.3	p45	
BUI2	Specialised construction activities	45.4; 45.5	p45.w	
PT	Passenger land transport	part of 60.1 (passenger railway); 60.21 (other scheduled passenger land transport); 60.22 (taxi operation); 60.23 (other land passenger transport)	part of p60.1; part of p60.2	
NCST	Other passenger transport	part of 61.1 (passenger sea and coastal water transport); part of	part of p61.1; part of p61.2; part of p62	

		61.2 (passenger inland water transport); part of 62 (passenger air transport)		
FT	Freight transport	part of 60.1 (freight railway); 60.24 (freight transport by road); 60.3 (transport services via pipelines); part of 61.1 (freight sea and coastal water); part of 61.2 (freight inland water); part of 62 (freight air transport)	part of p60.1; part of p60.2; p60.3; part of p61.1; part of p61.2; part of p62	
RnD	Research and Development	73	p73	
SERV	Services	41; 50.4 (services for motorcycles); 51-52; 55; 63-64; 65 (excl. 65.21); 71(excl. 71.1); 72; 74-75; 80; 85; 93; 95	p41; part of p50.a; p51-p52; p55; p63-p64; p65 (without financial leasing); p71(without renting of automobiles); p72; p7 4-p75; p80; p85; p93; p95	*Removed*: Financial leasing and renting of automobiles (into CAR_SERV);
CAR_SERV	Car Services	50.2 (sale and repair of vehicles); 50.5 (sale of fuels); 71.1 (renting of vehicles); 65.21 (financial leasing)	p50.a (without sale of motor vehicles, parts and accessories); p50.b; part of p71 (renting of automobiles); part of p65 (financial leasing)	*Added:* Financial leasing and renting of automobiles (from SERV); *Removed:* Service for motorcycles (into SERV), Sale of motor vehicles, parts and accessories (into CARS)
ELE	Electricity production	part of 40.11	part of p40.11	
ELE_INF	Electricity transmission and distribution	40.12; 40.13; part of 40.11	p40.12; p40.13; part of p40.11	
LDH	Steam and air conditioning supply	40.3	p40.3	
GAS	Extraction of natural gas and other hydrocarbons, gas production and distribution	40.2; part of 11 (natural gas extraction and services, excl. LNG and CNG for transport); part of 23.2 (gaseous fuels)	p40.2; p.11b (without LNG and CNG for transport), ; p11.c (other hydrocarbons); p23.20.h (refinery gas); p23.20.i (LPG excl. transport use); p23.20.k (ethane)	*Removed:* LPG, LNG, and CNG used for transportation purpose (into FUEL)
COAL	Mining of coal and lignite, manufacture of coke oven products	10 (excl. part of 10.1 – coal use in transport); 23.1; part of 23.2 (other than fuel uses in transport)	p10 (excl. part of p10.c – coal use in transport); p23.1.a (coke oven coke); p23.1.b (gas coke); p23.1.c (coal tar);	*Removed:* Part of coal used for transportation purposes by steam locomotive (into FUEL)

			p23.20.o (bitumen); p23.20.q (petroleum coke)	
OIL	Crude oil extraction and services, manufacture of refined petroleum products	part of 11 (extraction of crude petroleum); part of 23.2 (liquid fuels)	p11.a; p23.20.e (kerosene); p23.20.j (refinery feedstock); p23.20.l (naphtha); p23.20.m (white spirit & SBP); p23.20.n (lubricants); p23.20.p (paraffin waxes); p23.20.r (other petroleum products)	*Removed:* Extraction of natural gas and production of gaseous fuels (into GAS)
FUEL	Fuel for transport purposes	Part of 23.2 (oil use in transport); part of 10.1 (coal uses in transport); part of 11 (gas use in transport)	p23.20.a(motor gasoline); p23.20.b(aviation gasoline); p23.20.c(gasoline type jet fuel); p23.20.d(kerosene type jet fuel); p23.20.f(gas/diesel oil); p23.20.g(heavy fuel oil); part of 23.20.i (LPG for transport); part of p10.c (bituminous coal for transport); part of 11.b (LNG and CNG for transport)	*Added:* Part of coal used for transportation purposes by steam locomotive (from COAL); part of LNG, CNG and LPG used for transportation purposes (from GAS)

1.3. Transport

Following the model's assumptions, some sectors need other disaggregation than CREEA use. We use external data for this purpose. Table 3 presents the details for vehicle production and trade, fuel consumption, and transportation services.

- Vehicles sector (the model requires a separate and detailed car sector representation):
  - Manufacture of motor vehicles (p29,31,34,35) is splitted between manufacture of electric motors and generators (ENG), manufacture of cars, buses, trucks (CARS), motorcycles, bicycles, aircrafts, locomotives, etc. (VEH).
  - Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessories (p50.a) are splitted between sale of motor vehicles, related parts and accessories (CARS), sale, maintenance and repair of motorcycles related parts and accessories (SERV), and maintenance and repair of motor vehicle, excluding motorcycles (CARS_SERV)
  - Financial intermediation services, except insurance and pension funding services (p65) are splitted between financial leasing related to road transport (CAR_SERV) and rest of financial leasing (SERV)
  - Renting services (p71) is splitted between renting and operation leasing of vehicles (CAR_SERV) and rest of renting services (SERV).

- Fuel use in transport (the model requires to disaggregate non-transport and transport use of fuel):
  - Natural gas and services related to natural gas extraction, excluding surveying (p11.b) is splitted between LNG and CNG used in transport (FUEL) and rest of Natural Gas (GAS)
  - Liquefied Petroleum Gases (p23.20.i) is splitted between LPG used in transport (FUEL) and LPG used for other purposes (GAS)
  - Other bituminous coal (p10.c) is splitted between coal used in transport (FUEL) and rest of coal (COAL)

- Transportation service (the model requires to distinguish passenger and freight services):
  - Railway transportation service (p60.1) is splitted between passenger railway transport (PT) and freight railway transport (FT)

- Other land transportation service (p60.2) is splitted between freight transport by road (FT), urban and suburban passenger land transport, taxi operation and other passenger land transport (PT)
- Sea and coastal water transportation service (p61.1) is splitted between passenger water transport (NCST) and freight water transport (FT)
- Inland water transportation service (p61.2) is splitted between passenger inland water transport (NCST) and freight inland water transport (FT)
- Air transport services (p62) is splitted between passenger air transport (NCST) and freight air transport (FT)

Thus transport is divided into four categories: transportation service, vehicles production, vehicles service, and fuels. Summary of transport representation in the model (Table 4):

- Transportation services were divided into PT (Passenger land transport), FT (Freight transport) and NCST (Other passenger transport). **(category 1 in Table 4)**
- Vehicles production was divided into CARS (manufacture of bodies, engines, parts and accessories for motor vehicles), ENG (manufacture of motor batteries, generators, and other engines) and VEH (production of other vehicles). CARS sector contains manufacture of motor vehicle engines besides the chassis, because detailed data were not available. **(category 2)**
- Vehicles services was divided into CARS (trade of motor vehicles, parts and other accessories for motor vehicles), CAR_SERV (maintenance and repair of motor vehicles, renting and leasing of vehicles), SERV (services related to other vehicles). CAR_SERV refers to motor vehicle maintenance, but not for motorcycles. Hence cars renting and financial leasing is included into CAR_SERV, while services for motorcycles are included into SERV. **(category 3)**
- Fuels used for transportation purpose were divided into FUEL (motor gasoline, aviation gasoline, gasoline type jet fuel, kerosene type jet fuel, gas/diesel oil, heavy fuel oil, LPG for transport, bituminous coal for transport, LNG and CNG for transport), CAR_SERV (retail sale of automotive fuels in specialized stores), and ELE_INF (electricity transmission and distribution for electric vehicles). Fuels consumption takes into account conventional and non-conventional vehicles. Conventional vehicles are subject of fuels consumption supplied by FUEL and CAR_SERV. This specification allows to avoid excise fuel tax on fuel sellers (only fuel itself is subject of excise fuel tax). Non-conventional (electric or hybrid) vehicles are subject of electricity consumption supplied by ELE_INF. **(category 4**)

Table 3. Sector's disaggregation approach

Sector in CREEA	Sector Name	Aggregation in SAM (sectoral shares)	Source
p50.a	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessories	CARS – Sale of motor vehicles (63,7%) CARS – Sale of motor vehicle parts and accessories (23,5%) SERV - Sale, maintenance and repair of motorcycles and related parts and accessories (0,8%) CARS_SERV - Maintenance and repair of motor vehicle, without motorcycles (12%)	GUS (2009a) p.100 Data for 2008 due to lack of data for 2007
p65	Financial intermediation services, except insurance and pension funding services	CAR_SERV – financial leasing (59%) SERV – rest of financial services (41%)	GUS (2008a), p.9
p71	Renting services of machinery and equipment without operator and of personal and household goods	CAR_SERV – Renting and operation leasing of vehicles (79%) SERV – rest of renting services (21%)	GUS (2008a), p.9
p11.b	Natural gas and services related to natural gas extraction, excluding surveying	FUEL – LNG and CNG used in transport (3%) GAS – rest of Natural Gas (97%)	GUS (2009b), p.56-57
p23.20.i	Liquefied Petroleum Gases (LPG)	FUEL – LPG used in transport (73%) GAS – rest of LPG (27%)	POGP (2009), p.11 Data for 2008 due to lack of data for 2007
p10.c	Other Bituminous Coal	FUEL – Coal used in transport (0.07%) COAL – rest of coal (99.93%)	GUS (2008b), p.8
p60.1	Railway transportation service	PT – Passenger railway transport (44%) FT – Freight railway transport (56%)	EUROSTAT (2014a) Data for 2008 due to incomplete data for 2007
p60.2	Other land transportation services	FT – Freight transport by road (81%) PT – Urban and suburban passenger land transport (7%) PT – Taxi operation (2%) PT – Other passenger land transport (10%)	EUROSTAT (2014a) Data for 2008 due to incomplete data for 2007
p61.1	Sea and coastal water transportation services	NCST – Passenger water transport (7%) FT – Freight water transport (93%)	EUROSTAT (2014a) Data for 2008 due to incomplete data for 2007
p61.2	Inland water transportation services	NCST – Passenger inland water transport (43%) FT – Freight inland water transport (57%)	EUROSTAT (2014a) Data for 2008 due to incomplete data for 2007
p62	Air transport services	NCST – Passenger air transport (98%) FT – Freight air transport and space transport (2%)	EUROSTAT (2014a) Data for 2008 due to incomplete data for 2007

Table 4. Sectors directly related to transport in the model

Category	Name of the sector	Description	Related vehicles
1	PT	Passenger land transport	trains, cars, taxi, motorcycles, buses, trams, trolleybuses, funiculars, bicycles
1	NCST	Other passenger transport	ships, airplanes, helicopters
1	FT	Freight transport	rail, cars, lorries, pipelines, ships, airplanes
2	ENG	Manufacture of electric motors and generators	Bodies: tractors, off- road trucks Engines: electric motors, carburettors, pistons, engines for marine and railway, electrical parts for internal combustion engines Parts: lighting equipment
2 & 3	CARS	Manufacture of motor vehicles, (including engines, bodies, parts and accessories); Sale of motor vehicles (incl. used vehicles)[4] and accessories for them	Bodies: cars, buses, lorries Engines: starting motors, fire engines. internal combustion engines for motor vehicles and aircrafts Parts (including electrical): cars, buses, lorries Accessories (including electrical): cars, buses, lorries, trailers, semi-trailers, electrical equipment for motor vehicles Sale: cars, buses, trucks
2	VEH	Manufacture of other transport equipment	Bodies: ships, boats, airplanes, helicopters, rail locomotives, bicycles, balloons, motorcycles Engines: motorcycles Parts: motorcycles, bicycles, aircrafts, railway Accessories: motorcycles, bicycles, aircrafts
3	SERV	Services related to motorcycles	Sale: motorcycles, ships, aircrafts, trains, trams, bicycles (including parts and accessories) Repair: motorcycles
3 & 4	CARS_SERV	Services for motor vehicles (maintenance, repair, leasing, renting, sale of automotive fuels)	Repair: cars and other motor vehicles (except motorcycles)
4	FUEL	Fuels for transportation purpose	rail, cars, buses, lorries, motorcycles, ships, airplanes, helicopters
4	ELE_INF	Electricity use in transport	trams, trolley buses, trains, funiculars, pipelines, electric cars and busses

[4] Used vehicles sold by households to other households are not covered by IOT, because only single representative household is covered.

Electro mobility sector should be represented separately for the purpose of our project. Thus we implemented different vehicle types distinguishing between conventional vehicles and alternatively fuelled. Following the Austrian assumptions we distinguish four types of passenger cars:

1. CV – conventional vehicles powered by either gasoline or diesel, and gas (LPG, LNG, CNG)
2. HEV – hybrid electric vehicles powered by either gasoline or diesel or LPG, and electricity[5]
3. PHEV – plug-in hybrid electric vehicles (with rechargeable batteries) powered by gasoline and electricity (by connecting a plug to any electric power source, usually a normal electric wall socket)
4. BEV - battery electric vehicles (with rechargeable batteries) powered by electricity only

These vehicles are covered by sector CARS. Non-passenger cars (covered by CARS) and other vehicles (covered by VEH) are not disaggregated in vehicles type. The final and intermediate demand on specific type of passenger car by households and sectors is divided on the following components:

1. vehicle production (CARS + ENG)
2. repairs and service (CARS_SERV)
3. fuels (FUEL + ELE_INF)
4. taxes (TCAR + MoeSt)[6]

Such approach reflects the use of a vehicle type rather than output from the sector. We use the following external data. The stock of cars (new and used) per type is based on GUS. Then we estimate the share of inputs (CARS, ENG, CAR_SERV, ELE_INF, FUEL, and taxes) that were used by these four types of cars (CV, HEV, PHEV, BEV). The vehicles production comes mainly from CARS sector. We calculate production share per vehicle type from ENG (SAM'row) based on external data (not shares, but absolute values) and diminished this input from production cost of ENG (SAM' column) in order to balance sector's input. We calculate total production cost (ENG+CARS) per vehicle type based on external data. Once the production cost per vehicle type was splitted between CARS and ENG, we shifted the intermediate demand by sectors (company's cars) on CARS and ENG into demand by vehicles type on CARS and ENG respectively. However the final demand on ENG was left unchanged, because it is assumed that households buy new and used vehicles only through CARS. This means that there is no final demand by households on CARS in the updated SAM, but the final demand on vehicles type (see Table 1). Similar action to CARS was done for households demand on CAR_SERV and FUEL. The final demand on ELE_INF was partly shifted to vehicles type leaving some final demand by HH on ELE_INF in the matrix, because ELE_INF represents also other products..

[5] Please note that HEV do not consume ELE_INF, because electricity is produced by internal combustion engine of the vehicle and no external electricity is required.

[6] See next chapter.

The changes in the SAM are summarized in Table 5. Taxes are updated in a similar way. The consumption of FUEL is subject of MoeSt tax, while purchase of a car is subject of TCAR tax, where rates do not depend on vehicle types. The effective tax rate for MoeSt were calculated based on tax revenue (NIK 2008) and fuel consumption for transportation purporse (CREEA 2013). This means that there is no MoeSt tax payment by households in the updated SAM, but this tax was shifted into 4 vehicle types. On the other hand, TCAR tax is paid by households directly in the SAM. Companies pay only MoeSt, no TCAR tax.

Following the Austrian assumption, electro mobility (CV, HEV, PHEV and BEV) demand covers both, individual private and companies demand. Individual demand on vehicles was shifted from 9 groups of households into additional 4 groups that represent household types by vehicles. This means that updated SAM includes: (i) individual demand on vehicles per household (9 groups) per vehicle (4 types), (ii) individual demand on vehicle components (see Table 5) per vehicle (4 types).

Intermediate demand on passenger vehicles (companies' cars) was aggregated together with individual demand, according to the scheme described in Table 5. Intermediate demand on other vehicles was left without any changes. It was assumed that companies use only CV as a passenger car, thus no demand on electricity by companies' cars. Demand on FUEL and CARS_SERV by companies' vehicles represent 28% of passenger cars (demand by HH is 100% of course) and 72% other vehicles.

Table 5. Changes in SAM due to electro mobility disaggregation

Products	**Intermediate demand on passenger cars**	**Household demand on passenger cars**
ENG	Part of intermediate demand by sectors CARS on product ENG (it is 0.01% of total output ENG) were shifted into 4 types of cars	No changes
CARS	Part of intermediate demand by all sectors on product CARS (it is 4% of total output CARS) was shifted into 4 types of passenger cars	Total final demand by households on CARS (it is 13% of total output CARS) was shifted into 4 types of passenger cars
CARS_SERV	Part of intermediate demand by all sectors on product CARS_SERV (it is 20% of total output CARS_SERV) was shifted into 4 types of passenger cars	Total final demand by households on CARS_SERV (it is 23% of total output CARS_SERV) was shifted into 4 types of passenger cars
FUEL	Part of intermediate demand by all sectors on product FUEL (it is 19% of total output FUEL) was shifted into 3 types of passenger cars (CV, HEV, PHEV)	Total final demand by households on FUEL (it is 18% of total output FUEL) was shifted into 3 types of passenger cars (CV, HEV, PHEV)
ELE_INF	No changes	Part of final demand by households on ELE_INF (it is 3% of total output ELE_INF) was shifted into 2 types of passenger cars (PHEV and BEV)
TCAR	No changes	The tax was disaggregated between 4 types of passenger cars
MoeSt	Fuel tax paid by companies on fuel use in passenger vehicles was shifted in such a way to keep constant tax rate for 3 vehicle types and all agents	Total fuel tax MoeSt paid by households is shifted into 3 types of passenger cars (CV, HEV, PHEV)

1.4. Final consumption and Labour

Final demand in CREEA (2013) is represented by 6 agents, but we aggregated them into 3 agents:

- households (including non-profit organisations and for simplicity export is also added here),
- government,
- investors (gross fixed capital formation, changes in inventories and valuables).

The representative household is future disaggregated into 9 groups based on labour skills (low-, medium, high-skilled) and on urbanization level (urban, sub-urban, rural) using SILC dataset (EUROSTAT 2013a)[7]. As a result we obtain household groups differentiated by labour skills in an urbanization matrix. The disposable income of households (net of taxis and including social benefits) has to be spent on consumption only. Savings are automatically equal to investments, represented by gross fixed capital formation and changes in inventories and valuables. This means that we determine only the savings structure in the model, not the actual level (the level is determined by steady state conditions and from the capital input to production). We have also shifted savings on CARS, PT, CAR_SERV, and FUEL into public consumption following the Austrian assumption of the model calibration.
The net income patterns (shares) differ between labor sill types (Table 6). The highest share of income for labor skilled comes from rural areas, while for medium and high skilled – from urban areas. Suburban areas represent minorities for any labor skill type.

Table 6. Households' income patterns

Low skilled			Medium skilled			High skilled		
Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
33%	9%	58%	46%	13%	41%	67%	9%	24%

Following the Austrians assumption, the consumption patterns (shares) are the same for all goods because SILC dataset does not include such details (Table 7). The Austrian SAM has different shares for mobility goods, because they use mobility survey.

[7] We did not use the raw SILC data, but the data mining was done by Miess (2014).

Table 7. Final consumption patterns

	Low skilled			Medium skilled			High skilled		
	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
CV	2%	7%	5%	21%	26%	32%	3%	2%	2%
HEV	3%	4%	3%	22%	25%	33%	4%	3%	3%
PHEV	3%	4%	5%	20%	23%	35%	4%	2%	5%
BEV	3%	3%	7%	20%	24%	35%	4%	1%	3%
Other products	**3%**	**1%**	**6%**	**27%**	**6%**	**16%**	**25%**	**10%**	**6%**

Note: "Other products" depicts consumption patterns for all goods except private vehicles.

Table 8. Labour shares per sector

	Low Skilled	Medium Skilled	High Skilled
AGR	29%	68%	3%
FERR	7%	81%	12%
CHEM	7%	81%	12%
ENG	7%	81%	12%
CARS	7%	81%	13%
CV	7%	81%	12%
HEV	7%	81%	12%
PHEV	7%	81%	12%
BEV	7%	81%	12%
OVEPRO	7%	81%	12%
OTHER	7%	81%	12%
BUI1	12%	78%	10%
PT	6%	78%	16%
NCST	6%	78%	16%
FT	6%	78%	16%
SERV	5%	53%	41%
CAR_SERV	5%	59%	36%
ELE_INF	4%	80%	16%
LDH	7%	81%	12%
GAS	7%	81%	12%
COAL	7%	81%	12%
FUEL	7%	81%	12%

Other divisions underpinned by SILC consider capital income, social benefits, pension income, unemployment payments, etc. We used this information to disaggregate household revenues (labour income, capital income, and transfers) and household expenditures (on taxes and consumption).

Demand on labour per sector is represented in aggregate form in CREEA dataset. We disaggregate labour into 3 skill levels (low, medium and high-skilled) using labour shares from SILC dataset in a similar way to households' income. The shares (Table 8) reflect the labour demand in 2007 based on persons (not income). E.g. 29% of labour demand by AGR sector was generated by low skilled workers. Thus we obtained labour skill matrix with dimensions 3 x 22, because four products has zero final demand according to CREEA database (BUI2, RnD[8], OIL) or according to our assumption (ELE)[9].

Generally we based on CREEA dataset for building the private and public revenues, although we use external sources if CREEA does not cover some details. We remained coherent with Austrian approach in this case (Miess et al. 2014).

Sources of households' income:

- labour - it contains gross wages and social security contributions from both employers and employees. The data comes from CREEA (2013). For simplicity, social security contributions are not disaggregated into employers and employees. The net income contains net wages only.
- capital - it reflects capital gross income and for simplicity it contains also other taxes on production (INTTAX) and products (OTHTAX), and import. The data comes from CREEA (2013). The net income contains net capital revenue only.
- social benefits (UEBEN) – it contains unemployment benefits. The data are added to SAM from EUROSTAT (2014b)
- pension benefits (PENSION) – it reflects income for retired persons. The data are added to SAM from GUS (2012, p. 56)
- other transfers (OTHTRANS)– it contains other social benefits and transfers. The data are added to SAM from MF (2008a, p.63) and NIK (2008, p.66)

Sources of households' expenditures:[10]

- consumption of final goods taken form CREEA (2013) and EUROSTAT (2013a)
- labour tax (LTAX) – it contains PIT, social security payments by employers and employees. The effective tax rate[11] according to MF (2008b):

[8] SILC database shows positive values for RnD, while CREEA – zero values. Since SAM is based mainly on CREEA, we ignore these values in SILC database.

[9] See chapter "Products".

[10] All data were extracted from CREEA using some external sources, but no external data were just simply added to the SAM here.

[11] The net tax base was used for all taxes in the model.

	Official tax rate (gross tax base)	Effective tax rate	
		Gross tax base	Net tax base (used in the model)
Low skilled	19%	13%	15%
Medium skilled	30%	17%	20%
Hugh skilled	40%	27%	37%

- capital tax (KTAX) – it contains CIT. The effective tax rate according to EUROSTAT (2013b, p. 124) is 23%.
- net taxes on selected products (HETAX) - it contains VAT and other taxes on products from LDH, COAL, GAS, OIL. The data comes from MF (2004, p. 33). In 2007 only OIL was taxed: 0.06 EUR/litre (effective tax rate is 20%).
- net taxes on selected products (HELETAX) – it contains VAT and other taxes on ELE_INF. The data comes from MF (2004, p.40): 5.01 EUR/MWh (effective tax rate is 22%)
- net taxes on selected products (CONSTAX) – it contains VAT for selected products from AGR, FERR, CHEM, ENG, VEH, OTHER, BUI1, NCST, FT, RnD, SERV. The data comes from EUROSTAT (2013b, p.124) and the effective tax rate is 22%.
- net taxes on selected products (TCAR) – it contains VAT and other taxes on newly purchased cars from CARS, ENG. The data comes from EUROSTAT (2013b, p.124) and the effective tax rate is 22% (constant rate for all types of passenger cars).
- mineral oil tax (MoeSt) – it contains VAT and other taxes on FUEL. Fuel excise tax is applied on fuels used for transportation purpose only. It is proportional to demand on FUEL by producers and households. The data comes from NIK (2008, p.53) and the effective tax rate is 67%.
- net taxes on other products (OTHTAX) - it contains aggregated taxes on products not classified elsewhere (e.g. excise tax on tobacco and alcohol). This is a residual to balance the matrix. The effective tax rate is 1%.
- net taxes on production INTTAX – it was added to households expenditures only for balancing reason (the difference between indirect taxes and taxes on products), since capital income include this tax. The effective tax rate according to CREEA (2013) is 4%

This means that there is no specific tax on PT and CAR_SERV, while ENG is taxed twice:

- once on products that are consumed directly (CONSTAX), because someone may demand on ENG independently from CARS.
- once when cars are bought (TCAR), because CARS and ENG are complements in this case

Sources of public income:

- income tax covers LTAX and KTAX

- taxes on products cover HETAX, HELETAX, FETAX, FELETAX CONSTAX, MoeSt (also paid by sectors), OTHTAX.
- taxes on production INTTAX

FETAX is a net energy tax paid by firms when they buy COAL, GAS, LDH and OIL. FELETAX is net electricity tax paid by firms when they buy ELE_INF. The tax rates are the same for households and firms. For the modeling purpose the FETAX and FELETAX paid by energy sectors (ELE, ELE_INF, LDH, GAS, COAL, OIL and FUEL) was shifted to the other sectors (keeping total tax revenue constant) and distributed among other sectors according to the share of each sector in tax payment.

Sources of public expenditures:

- consumption of final goods taken form CREEA (2013)
- transfers to households cover PENSION, UEBEN, OTHTRANS.

1.5. Electricity Matrix for Poland

The electricity matrix is a single-year set of data that represents technologies used for electricity production in Poland. The Polish energy sector is dominated by electricity produced from bituminous coal and lignite (above 80%). These two types of energy sources have been developed due to substantial resources of coal that Poland possesses. Other sources of electricity production are oil, gas, hydro, wind, biomass, solar photovoltaic and other. The sector has been changing towards more renewable resource with diminishing dependence of coal. The total production of energy in Poland in 2007 was 159 TWh (ARE 2013) and worth 5 136,4 mio EUR 2007 (URE 2008).

CREEA (2013) distinguish 7 types of energy technologies for electricity production:

1. COAL – 91%
2. GAS – 3%
3. HYDRO – 1.4%
4. WIND – 0.3%
5. OIL – 1.6%
6. BIOMASS/WASTE – 1.6%
7. OTHER (mostly from processed gas like LPG) – 1%

There are two additional technologies (nuclear and solar) that participate in electricity supply in Poland for less than 1%, but this electricity comes only from import according to CREEA database. Consequently we build the energy matrix based on CREEA (2013) and it includes the following elements for each technology:

- intermediate consumption represented by 20 sectors (without BUI2, ELE, and OWNINT)
- labour input represented by:
    - low skilled
    - medium skilled
    - high skilled
- capital input represented by:
    - fixed capital formation
    - net operating surplus

The electricity matrix does not include international trade, it is pure domestic production. International trade of electricity is included in SAM, but in the ELE_INF sector (not ELE sector). According to our

approach described in Section "Production", ELE_INF sector accounts for all electricity networks and other infrastructure necessary for electricity distribution and provision, and it also accounts for international trade. This means that only ELE_INF sector can buy electricity (a composed of domestically produced electricity) directly from ELE, all others buy electricity (a composed of electricity imports, domestically produced electricity, and infrastructure costs) from ELE_INF. Thus electricity matrix (and ELE sector) in SAM is only a closer look at domestically produced electricity.

According to Miess (2014), intermediate consumption, labour and capital (without operating surplus) represents variable cost of electricity, leaving the rest (operating surplus) as a fixed part. In order to replicate the production cost for each technology (to calibrate supply elasticity), we disaggregate capital input into fixed (represented by net operating surplus) and variable (represented by consumption of fixed capital) part in the electricity matrix. The return to the fixed factor is net operating surplus. The amount of net operating surplus (profits) is used to replicate the merit order curve, i.e. the cheapest technology has the highest profits (return to fixed factor) per unit of electricity produced and it is used until its capacity constraints. The last technologies used in the merit order have zero profits (fixed factor is zero) and can operate below capacity constraints. This implies that the most profitable technology in the Polish economy is Wind (besides nuclear and solar energy that are imported only), i.e. it has the highest profit per unit of electricity produced. The least profitable technology is coal.

We do not use the distinction between capital types in SAM since we do not use supply elasticities here. This is necessary only to come to the real merit-order for supply curve represented by different technologies. The cost shares are average prices and so do not reflect the typical base-load and peak-load price structure. The fixed factor allows building up the merit order and is subtracted from capital.

Data in electricity matrix are presented in millions of euros for 2007, not in MWh. We calculate factors and inputs structure for the different electricity technologies based on CREEA (2013), distinguishing five actions (Table 9):

Action 1: First, we compute the total intermediate consumption data for every sector in the model per energy technology.

Action 2-4: Then we calculate import (Action 2), labour (Action 3) and capital (Action 4) inputs for the electricity sector.

Action 5: Finally, we sum all of the components to get supply of each technology. It allows to achieve overall supply of electricity.

Table 9. Algorithm for electricity matrix

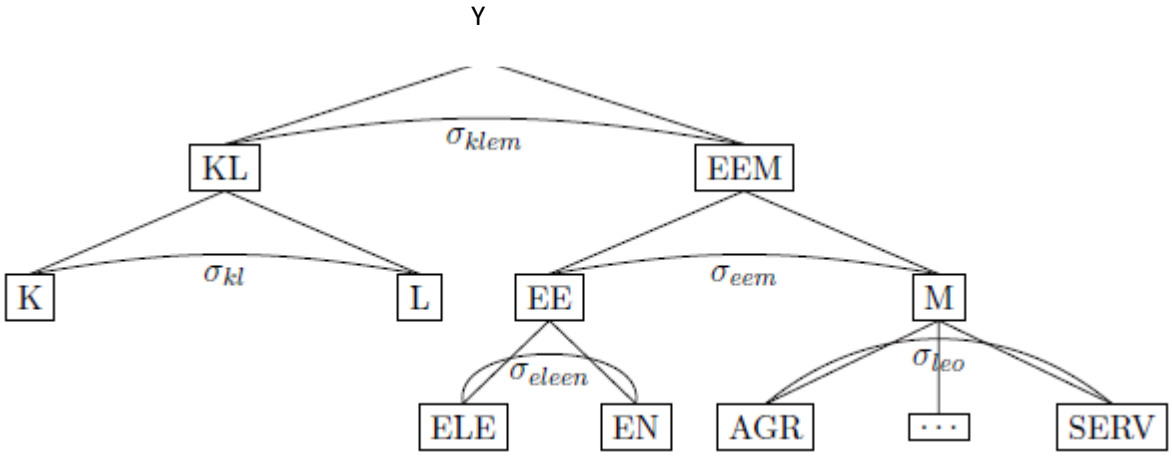
No	Action	Output [EUR]
1	Intermediate consumption by electricity sector were matched to energy technologies	**Total value of purchased goods and services per energy technology**
2	Import by electricity sector were matched to energy technologies	**Import data per technology**
3	Labour consumption by electricity sector was disaggregated into 3 skill gropes and were matched to energy technologies	**Labour data per technology**
4	Capital consumption by electricity sector was disaggregated into 2 parts and were matched to energy technologies	**Capital data per technology**
5	We sum all of the components for each technology	**Supply of energy per technology and total supply of energy**

2. CGE model development for Poland

The database for the Polish model is a single-year set of data (social accounting matrix) based on national input-output table supplemented with other data like data for stocks of capital and labour or pollution emission data. We utilised particularly CREEA database, since it provides the most disaggregated structure (169 product categories) with relatively recent data (2007). In construction of Polish SAM we follow Austrian SAM structure (Miess et al. 2014, table 3.3). Some modifications in the aggregation have been applied in the Polish version, due to different characteristics of both economies or unavailability of data. The data in Polish SAM are expressed in millions of euros in 2007.

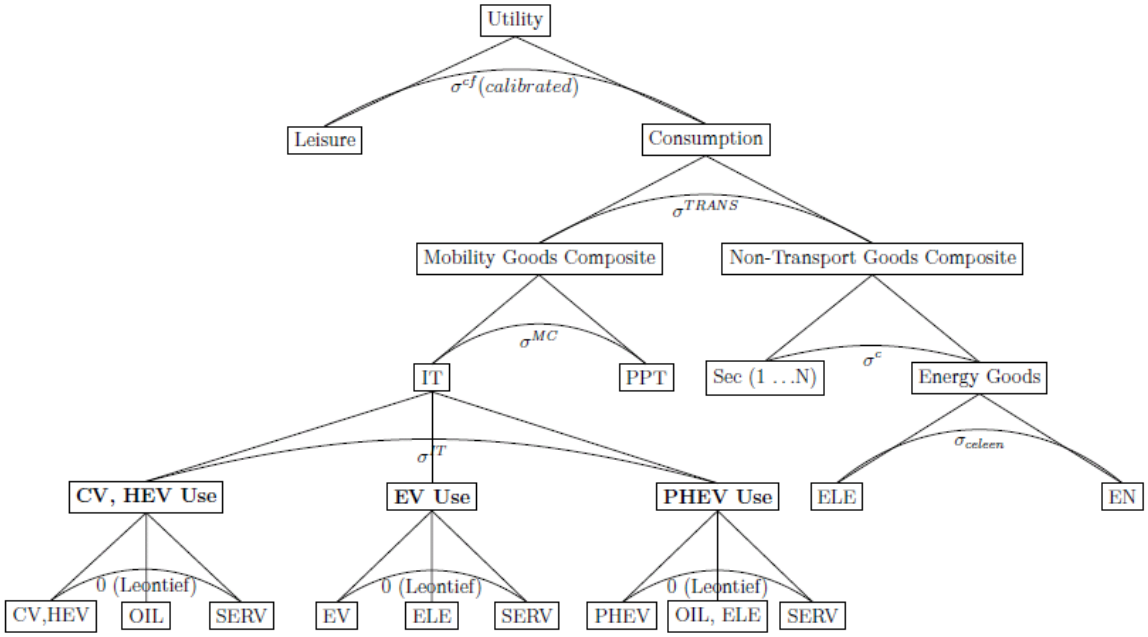
The model applied for the economy of Poland is a computational model of general equilibrium as prepared by the Austrian team that was then adapted by CASE to the Polish data. It is fully dynamic hybrid model of a closed economy. The hybrid part concerns the production of electricity, where the individual technologies are described by a step-wise curve instead of traditional smoothed production cost curve. The remaining 20 sectors are represented by the CES-Leontief nested function. Production of each of sectors requires the use of basic factors of production (capital and labor force), energy (electricity and other ELE, or thermal energy, gas, coal, liquid fuels) and materials (represented by the 14 aggregated products). The only sector that is recipient of electricity production (represented by 7 technologies) is sector distributing electricity, while other sectors can only buy electricity from the distributor.

Figure 1. CGE production function



Households are represented by 9 groups depending on where they live (urban, suburban, rural) and labor skills. Each household maximizes its utility described by nested CES-Leontief-Logit. Consumers have a choice between leisure and work. Voluntary unemployment is thus possible, but there is no involuntary unemployment allowed in the model. Household consumption is divided into 2 categories. The demand for non-transportation goods is described by using CES. Demand for transport services allows a choice between road transport and the other transportation (CES function). Consumers can choose between an individual road transport (IT) and public transport (PPT). Deciding on individual transport, consumers can choose between four types of passenger vehicles through logit function. Demand for cars is determined by the purchase of the car, fuel, and related services via Leontief function. Government collects taxes and provides public goods following Leontief function.

Figure 2. CGE utility function



Rescaling of the original model equations, as developed for the Austrian case, was needed (e.g., monetary data in the SAM for Austria are expressed in [billion] and for Poland in [million]. Polish version of the model consists of one less sector than the Austrian model. Polish version of the model also includes other electricity generation technologies. Both of these differences require appropriate

adjustments in the model. Due to the lack of data, household demand for RnD products and petroleum is set to zero.

The preparation of SAM for Poland in accordance with the assumptions of the CGE model as prepared for Austria presented the greatest difficulty in our activity. The hybrid CGE model is quite complicated and is based on a number of specific objectives, which are not directly visible until the model starts to run. Due to the lack of detailed model documentation and its assumptions during the project, many discrepancies between the prototype Austrian model and the Polish database appeared and had to be regularly solved during the whole duration of WP10.

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