HyWays

FIRST PHASE OF THE PROJECT

DEFINITION OF MODEL DATA EXCHANGE AND MODEL INTERFACES

(DELIVERABLE D3.2)

VERSION FINAL

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Disclaimer

The results in this report are a reflection of a non-final stage of the HyWays project, with substantial stakeholder consultation still under way. Significant modifications are still due, and consequently none of the results given in this report should in any way be considered as final HyWays results.

Table of contents

1. Introduction

In this working document the model framework within HyWays will be described. Afterwards the logical and dynamic model linkage of the HyWays approach will be outlined. As in scoping report (D 3.1) mentioned variables for the sensitivity analysis with the models will be proposed. Finally the data exchange between the models will be drafted. Within the annex examples of the main data exchange instruments will be found.

2. Model Framework

The model framework is divided in four different layers: the world & EU scenario, the EU scenario, the MS scenario and the model specific scenario layer.

Consistent EU & world scenario

Within the EU & world scenario assumptions for the overall development for Europe and the world are defined. For detailed information refer to D 3.1.

EU scenario scopes

The EU scenario gives the scope of the MS specific scenarios. For detailed information refer also to D 3.1.

MS specific scenarios within the EU scope

The MS specific scenario is defined within the EU scenario and describes the MS specific situation and development, which are not yet considered in the EU scenario. For detailed information refer to D 3.3.

Model specific scenarios

Each model needs some specific assumptions. The model specific assumptions do not necessarily affect the other models and therefore will be covered by sensitivity analysis from the single models.

The model framework is illustrated schematically in figure 1.

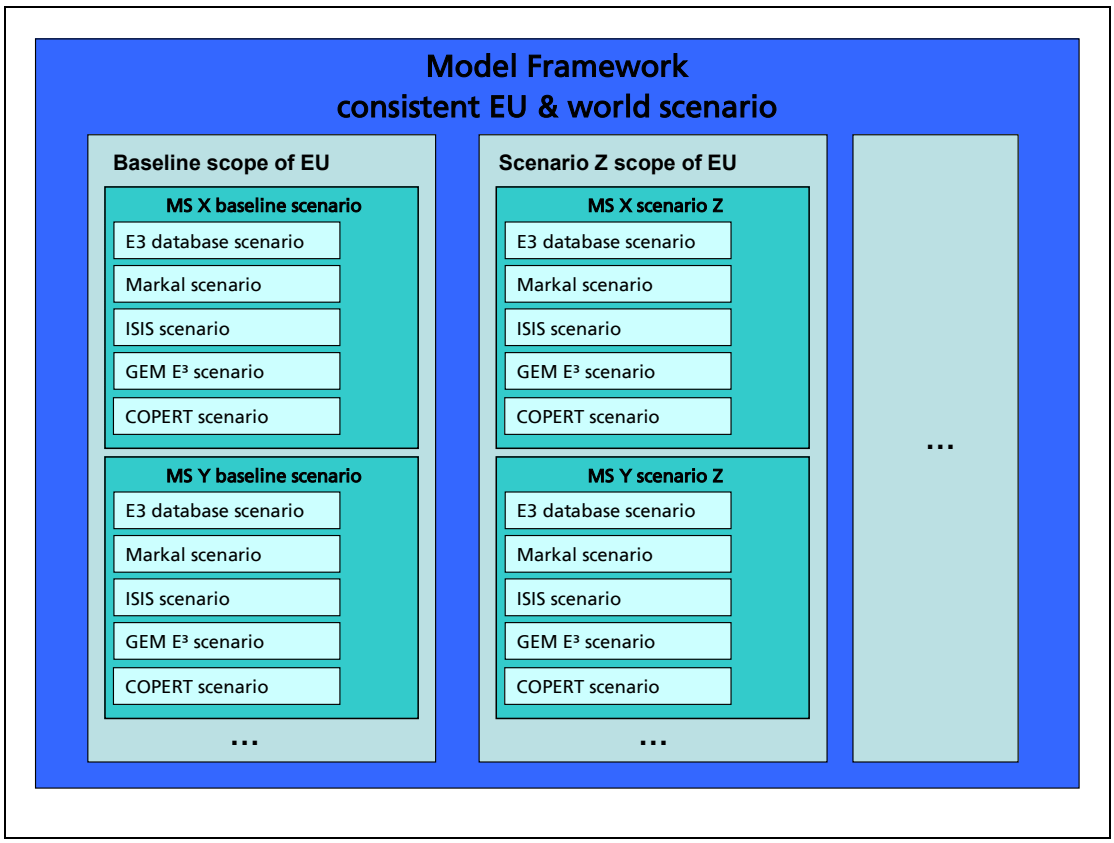

Figure 1: Model framework (Member State MS)

3. Model linkage

Overview

An overview about the logical model linkage within HyWays is given in figure 2.

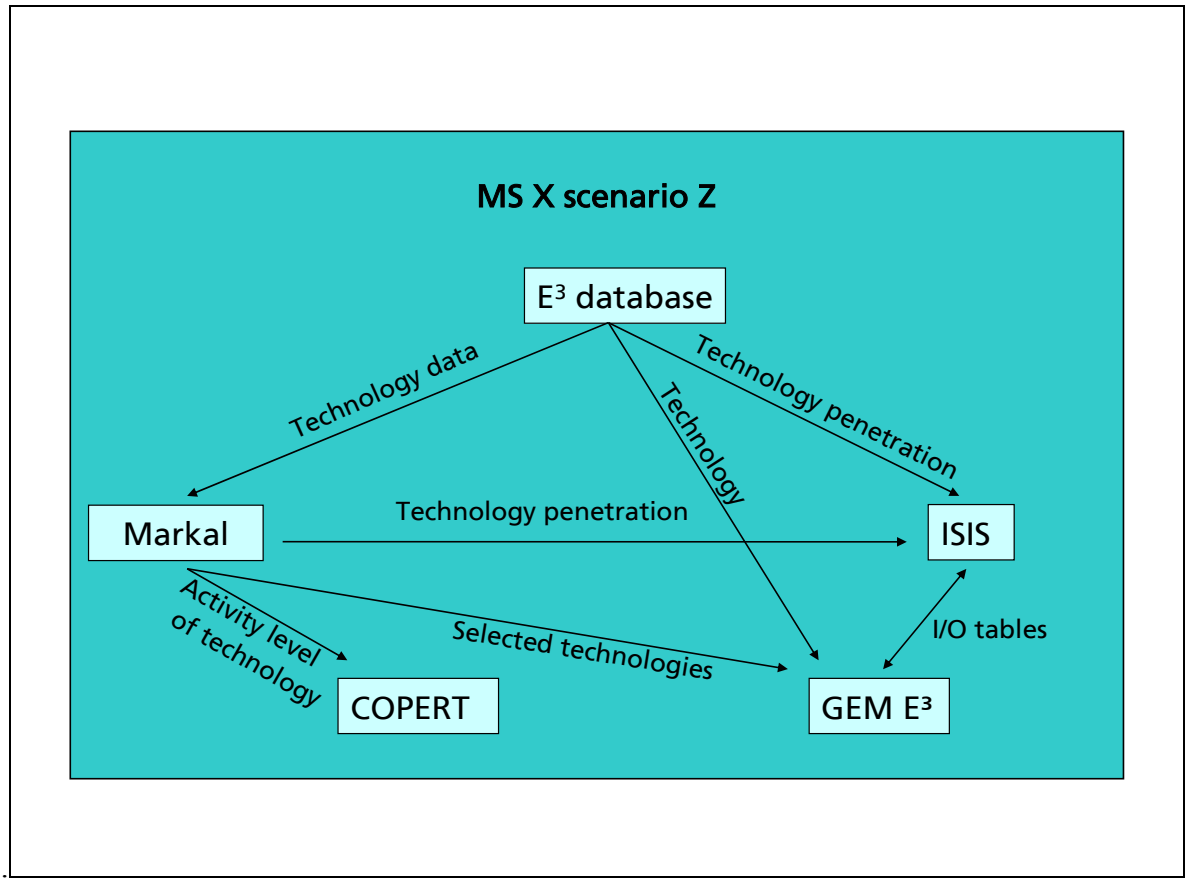

Figure 2: Logical model linkage

The models are not only logically linked. Within HyWays there is an iterative approach which mainly consists of four phases. The first phase gives the framework and MS specific scenario development with MS. The second phase represents the first round of calculation with the model framework as shown above. After these model-runs the third phase is an iteration in which the model results are checked by the MS and the industry to their plausibility. Within this iteration MS and industry have the possibility to vary the data for the models given in the first phase. In the fourth phase the adjusted boundary conditions will be considered by the models. An overview about the dynamic linkage within HyWays is given in figure 3.

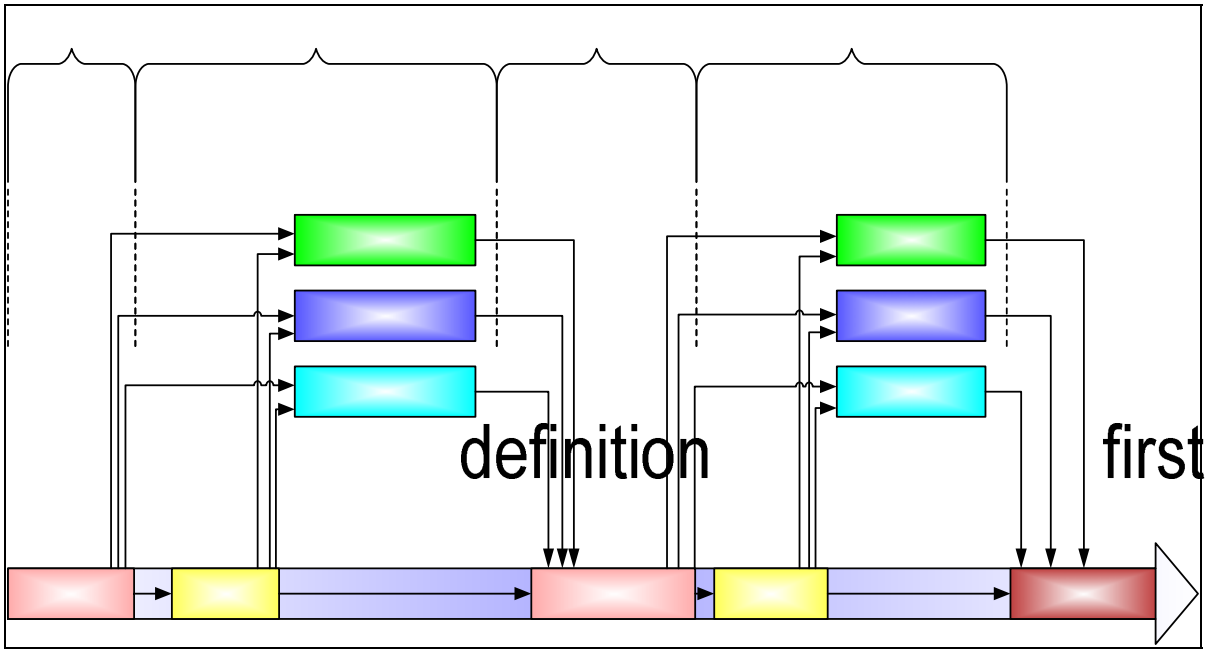

Figure 3: Dynamic model linkage

Linkage between E3 Database and Markal

The Markal Model will receive all technical data for hydrogen technologies from the E3 database. For non hydrogen technologies like power stations Markal will use its internal database.

Linkage between E3 Database and ISIS

The ISIS Model will receive all technical data for hydrogen technologies from the E3 database. Furthermore there will be direct and bilateral contact to HyWays industry partners as well as to other firms affected by a hydrogen society.

Linkage between Markal and ISIS

Markal will deliver the results from the Markal model-runs as well as the necessary input data for each MS scenario. This special version takes the different needs of the Input Output Model into account.

Linkage between Markal and COPERT

Markal will deliver the results from the Markal model-runs including the activity level of the different technologies.

Linkage between E3 database and GEM E3

The GEM E3 Model will receive all technical data for hydrogen technologies from E3 database.

Linkage between Markal and GEM E3

Markal will deliver the results from the Markal model-runs for each MS scenario in a specially prepared version of its standard output. The version takes the different needs of the Input Output Model into account.

Linkage between ISIS and GEM E3

An exchange of Input Output files and employment factors was agreed. The ISI will provide both to the ZEW.

4. Sensitivity Analysis

In the following paragraph a proposal of variables for the sensitivity analysis is made as well as a short description of what should be shown. The final set could vary inherent on the results of the first model-runs.

Markal

- Prices of fossil fuels: show the effect of fossil fuel prices on the penetration of hydrogen technologies, separately for oil and coal (gas price is coupled to oil price),
- CO2-constraint: assess the effect of various levels of CO2-constraints on the MS-dependent development of a hydrogen economy.

ISIS

- Import/Export possibilities: to show the reaction of the employment market upon lead market within a MS (low imports of H2 products, high additional export possibilities)
- H2 extra cost final demand vs. tax funded: to show the reaction of the employment market to different funding of possible extra costs for a hydrogen society.

GEM-E3

- Technology parameters (costs or capacities): analysis of for instance the results of higher production costs of hydrogen from solar.
- Production and consumption elasticities: analysis of the influence of other production functions on for instance the GDP development.

COPERT

For the COPERT model no sensitivity analysis will carried out separately. COPERT will follow the Markal sensitivity analysis, because of its straightforward character for the emission calculations.

Overview

In table 1 an overview of the foreseen sensitivity analysis is given. This table will be updated after the first model-runs to ensure consistency wherever possible. Where the same variables will be used in the models the same range of variation for the variable will be chosen.

Table 1: Variables for the sensitivity analysis

Variable	Markal	ISIS	GEM-E3	COPERT
Import/Export share		X		
H2 excess: taxation funding vs. final demand funding		X		
Fossil fuel prices	X			
CO2-constraints	X			
Technology parameter			X	
Production and consumption elasticities			X	

5. Data Interfaces

The centre of data exchange is the E3 database. This source will provide most of the technical information needed. The data exchange is organized within the LBST_FACT_SHEET in excel. All bilateral data exchanges between the models will be also provided in excel files regarding the transparency within HyWays. For examples refer to the annex.

6. Annex

Examples for bilateral data exchange between the models:

E3 database all models

Example of LBST_FACT_SHEET for hydrogen transport:

Transport / GH2 / Pipeline / Distribution (50 km)						
GH2	Input	1	kWh/kWh			
Steel	Input	1.375.384	kg			
GH2	Output	1	kWh			
Process scale	30.000	kW H2				
Investment	8.950.000	EUR				
Labor	261.000	EUR/yr				
Useful lifetime	30	yr				
Annual full load hours	8.000	h/yr				
Reference						
Tschauder, R.: Untersuchungen zum Aufbau einer Wasserstoff-Nahverkehrs in Dresden unter Berücksichtigung wirtschaftlicher Aspekte; Diplomarbeit an der Hochschule für Technik, Wirtschaft und Sozialwesen Zittau / Görlitz (FH), Fachbereich Wirtschaftswissenschaften; September 1998;						
Kußmaul, K.; Deimel, P.: Materialverhalten in H2-Hochdrucksystemen; VDI Berichte Nr. 1201, 1995; Wasserstoff-Energietechnik IV, Tagung München, 17. und 18. Oktober 1995						
Transport / GH2 / Pipeline / Distribution (5 km)						
GH2	Input	1	kWh/kWh			
Steel	Input	93.764	kg			
GH2	Output	1	kWh			
Process scale	1.000	kW H2				
Investment	895.000	EUR				
Labor	21.000	EUR/yr				
Useful lifetime	30	yr				
Annual full load hours	8.000	h/yr				
Reference						
Tschauder, R.: Untersuchungen zum Aufbau einer Wasserstoff-Nahverkehrs in Dresden unter Berücksichtigung wirtschaftlicher Aspekte; Diplomarbeit an der						
Hochschule für Technik, Wirtschaft und Sozialwesen Zittau / Görlitz (FH), Fachbereich Wirtschaftswissenschaften; September 1998;						
Kußmaul, K.; Deimel, P.: Materialverhalten in H2-Hochdrucksystemen; VDI Berichte Nr. 1201, 1995; Wasserstoff-Energietechnik IV, Tagung München, 17. und 18. Oktober 1995						
Altmann, A.; Blandow, V.; Bünger, U.; Eckstein, U.; Schindler, J.; Ludwig-Bölkow-Systemtechnik GmbH: Kostenstruktur ausgewählter Wasserstoffbereitstellungspfade für typische Anwendungen; Studie im Auftrag der Daimler Benz AG; Ottobrunn, 20. Dezember 1995						

Transport System Truck LH2 / 150 km						
Distance	Input	0,0354	tkm/kWh			
LH2	Input	1,005	kWh/kWh			
Stainless steel	Input	11000	kg			
Steel	Input	11000	kg			
LH2	Output	1	kWh			
Process scale	6.392	kW H2				
Investment	500.000	EUR				
Maintenance coefficient	2,0	% of investment/yr				
Useful lifetime	20	yr				
Annual full load hours	8.760	h/yr				
Reference						
Weber, G., R., Gardner Cryogenics, Lehigh Valley, PA, USA; quotation 07 September 1994						
Vehicle / Truck / 40t / EURO IV						
Aluminum	Input	900	kg			
Copper	Input	216	kg			
Diesel Oil	Input	0,26	kWh/tkm			
Glass	Input	80	kg			
Steel	Input	12.104	kg			
Distance	Output	1	tkm			
Process scale	193	tkm/h				
Investment	160.000	EUR				
Maintenance coefficient		% of investment/yr				
Useful lifetime	8	yr				
Annual full load hours	8.760	h/yr				
Reference						
Ökoinventar, 3. Auflage, Teil 3, Anhang B, Transporte und Bauprozesse, Juli 1996						
Gruber, Chr., MAN, pesonal communication 21 August 2003						

Markal ISIS

Example for hydrogen production data exchange:

Penetration rate				baseline					
baseline				modified primes					
ISIS scenario				no introduction					
ISIS world scenario				no lead market					
Technology		MS		2000	2010	2020	2030	2040	2050
Italy									
Mobile use	car		total number of normal cars						
	car		annual maintenance cost per normal car						
	car		total number of h2 cars						
	car		annual maintenance cost per h2 car						
	car		number of new domestic cars						
	car		average cost of normal car						
	car		number of new hydrogen cars for domestic use						
	car		average cost of h2 car						
	truck		total number of normal cars						
	truck		annual maintenance cost per normal car						
	truck		total number of h2 cars						
	truck		annual maintenance cost per h2 car						
	truck		number of new domestic cars						
	truck		average cost of normal car						
	truck		number of new hydrogen cars for domestic use						
	truck		average cost of h2 car						
	…								

ISIS GEM E3

Exchange of input output tables in Phase I for:
Italy, France, Greece, Netherlands, Germany and Norway

Clipping of an example import export table:

	HOMOGENEOUS BRANCHES		
HOMOGENEOUS BRANCHES	Products of agriculture, hunting and related services	Products of forestry, logging and related services	…
PRODUCTS (CPA)	01	02	…
	1	2	…
Products of agriculture, hunting and related services	4 684		…
Products of forestry, logging and related services	1	4	…
Fish and other fishing products; services incidental of fishing			…
Coal and lignite; peat			…

Crude petroleum and natural gas; services incidental to oil and gas extraction excluding surveying			…
Uranium and thorium ores			…
Metal ores			…
Other mining and quarrying products	1		…
Food products and beverages	2 228		…
Tobacco products			…
Textiles	12		…
Wearing apparel; furs	3	0	…
Leather and leather products	3	0	…
Wood and products of wood and cork (except furniture); articles of straw and plaiting materials	7		…
Pulp, paper and paper products	9		…
Printed matter and recorded media	2		…
Coke, refined petroleum products and nuclear fuels	296	11	…
Chemicals, chemical products and man-made fibres	1 286	2	…
Rubber and plastic products	38	5	…
Other non-metallic mineral products	64		…
Basic metals	7	9	…
Fabricated metal products, except machinery and equipment	27	1	…
Machinery and equipment n.e.c.	26	0	…
Office machinery and computers			…
Electrical machinery and apparatus n.e.c.	4		…
Radio, television and communication equipment and apparatus	2		…
Medical, precision and optical instruments, watches and clocks			…
Motor vehicles, trailers and semi-trailers	28	1	…
Other transport equipment			…
Furniture; other manufactured goods n.e.c.	1		…
Secondary raw materials			…
Electrical energy, gas, steam and hot water	426	1	…
Collected and purified water, distribution services of water	204		…
Construction work	12		…
Trade, maintenance and repair services of motor vehicles and motorcycles; retail sale of automotive fuel	123	2	…
Wholesale trade and commission trade services, except of motor vehicles and motorcycles	960	1	…
Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods	612	1	…
Hotel and restaurant services	3		…
Land transport; transport via pipeline services	511	2	…
Water transport services	19	0	…
Air transport services	2		…
Supporting and auxiliary transport services; travel agency services	2		…
Post and telecommunication services	2		…
Financial intermediation services, except insurance and pension funding services	802	5	…
Insurance and pension funding services, except compulsory social security services	61	12	…

Services auxiliary to financial intermediation	52	7	…
Real estate services	3	1	…
Renting services of machinery and equipment without operator and of personal and household goods			…
Computer and related services	2	0	…
Research and development services	2		…
Other business services	67	1	…
Public administration and defence services; compulsory social security services			…
Education services			…
Health and social work services	28		…
Sewage and refuse disposal services, sanitation and similar services	98		…
Membership organisation services n.e.c.	11		…
Recreational, cultural and sporting services			…
Other services			…
Private households with employed persons			…
Total	12 729	66	…

Markal GEM E3

Costs and participation levels of technologies included in the bottom-up description, following a similar format as that of the link between MARKAL and ISIS, possibly extended to include activity or capacity levels. For the remainder, there is no direct link between MARKAL and this model, as the input goes via ISIS.

Cost shares for the different technologies in each model region can be calculated on basis of dynamic investment analysis with techno-economical data. Table 1 gives an example of the necessary techno-economical data from MARKAL. Data on capacity constraints from MARKAL feeds also the GEM E3 model.

Table 1: Example of the necessary techno-economical data from MARKAL

Base-Load Technologies

	HCO_B	HCO_B_N	SCO	OIL_B	NGS_B_N	NGS_B_N2	NUC
Capacity (MW)	200	600	800	529	180	165	1375
Average Utilization (hours)	7069	7262	7525	7000	7665	7446	7900
Lifetime (years)	35	35	35	35	35	35	40
Investment (EUR/MW)	1387591,73	1344896,60	1333555,70	762701,28	769401,82	1012392,10	1922057,13
Removal Costs (EUR/MW)	40026,68	40026,68	40026,68	39850,13	40026,68	43665,47	270143,73
Personnel Costs (EUR/MW)	38425,62	18590,17	13875,92	7667,37	16603,66	18113,09	15525,50
Variable Costs (EUR/MWh)	7,21	5,56	5,79	3,82	2,23	2,84	4,46
other OMC (EUR/MW)	2775,18	2689,79	2667,11	1525,40	1538,80	2024,78	10091,58
Primary Energy employed	12389,00	34498,60	54036,00	31126,00	9685,50	9585,50	115014,71

Middle-Load Technologies

	HCO_M	HCO_M_N	NGS_M_N	WND	BIO	HYD
Capacity (MW)	200	600	180	0,3	1	5,1
Average Utilization (hours)	4415	4100	2602	2200	2000	5882
Lifetime (years)	35	35	35	25	35	60
Investment (EUR/MW)	1275517,01	1344896,60	769401,82	1480453,64	320213,48	4803202,13
Removal Costs (EUR/MW)	40026,68	40026,68	40026,68	0,00	0,00	0,00
Personnel Costs (EUR/MW)	38425,62	18590,17	16603,66	35579,28	10673,78	48555,25
Variable Costs (EUR/MWh)	9,03	5,56	2,23	0,00	37,36	0,00
other OMC (EUR/MW)	2551,03	2689,79	1538,80	0,00	6404,27	0,00
Primary Energy employed	7749,90	19477,31	3287,89	0,00	0,00	0,00

Peak-Load Technologies

	OIL_P	NGS_P	SOL
Capacity (MW)	156	145	1
Average Utilization (hours)	450	450	900
Lifetime (years)	35	35	20
Investment (EUR/MW)	307897,57	259483,33	8539026,02
Removal Costs (EUR/MW)	41053,01	40486,76	0,00
Personnel Costs (EUR/MW)	1368,43	1472,25	10673,78
Variable Costs (EUR/MWh)	11,46	9,46	0,00
other OMC (EUR/MW)	615,80	518,97	0,00
Primary Energy employed	813,07	711,20	0,00

Markal COPERT

Activity levels of specific technologies or groups of technologies, following a specification similar to the clipping below, giving the useful energy demand

Description	UnitDesc	T2000	T2010	T2020	…
Kerosene aircraft	billion-passenger-kilometres	301.4	459.5	671.6	…
Electric trolley bus city	billion vehicle kilometers	0.05	0.02	0	…
Improved Electric trolley bus city	billion vehicle kilometers	0	0	0	…
FC bus city	billion vehicle kilometers	0	0	0	…
Hybrid bus city	billion vehicle kilometers	0	0	0	…
Improved Hybrid bus city	billion vehicle kilometers	0	0	0	…
Diesel bus city	billion vehicle kilometers	5.04	2.15	3.94	…
Improved Diesel bus city	billion vehicle kilometers	0	3.11	1.55	…
FC bus regional	billion vehicle kilometers	0	0	0	…
Hybrid bus regional	billion vehicle kilometers	0	0	0	…
Improved Hybrid bus regional	billion vehicle kilometers	0	0	0	…
Transport bus regional	billion vehicle kilometers	20.36	8.67	15.76	…
Improved Diesel bus regional	billion vehicle kilometers	0.01	12.42	6.21	…

Electric car city	billion vehicle kilometers	0	0	0	…
Fuel cell car city	billion vehicle kilometers	0	0	0	…
Improved Fuel cell car city	billion vehicle kilometers	0	0	0	…
Hybrid car city	billion vehicle kilometers	0	0	0	…
Improved Hybrid car city	billion vehicle kilometers	0	0	0	…
…	…	…	…	…	…