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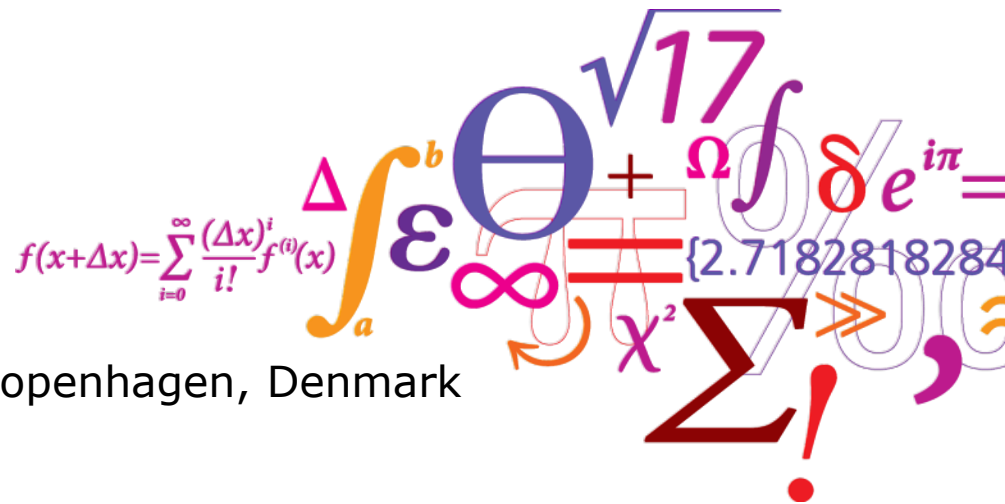
Choice of aggregated parameters for integration of electric vehicles to grid in a TIMES model for a region dominated by wind power

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Overview

- Electromobility+ EV-STEP
- Stepwise tutorial models in TIMES
- Technology model for electric vehicles
- Sifre. Model for operation of the Danish electricity system
- Users' profiles for electric vehicles
- Time slices in TIMES
- Parameters in aggregated models

Abstract

- The set of TIMES models for **stepwise introduction of new features** can be used both as tutorials and for analysis of integration of technologies into a region, where the structural data are described by the model. The current set of tutorials developed for ETSAP covers EU27 as the **model region**.
- We shall consider modelling of integration of electric vehicles into a region with **many years of experience with a day-ahead wholesale spot market for electricity**. The area prices for western Denmark have been increasingly **influenced by wind power** since 1999. The region also have strong connections to neighbouring electricity markets with available statistics for hourly prices and volumes, while internal transmission constraints are limited.
- We shall analyse the possible **values of aggregated parameters** for time-slices and structural constraints for a model of technology choice for transport for some 20 years ahead. The TIMES model will be run in parallel with **test of a new model for operation of the electric system** with combined heat and power and heat storages.

Sheet EnergyBalance in TIMES DEMO_EV

		COA	GAS	OIL	NUC	RNW	SLU	HET	ELC	
		Solid Fuels	Natural Gas	Crude Oil	Nuclear Energy	Renewable Energies	Industrial Wastes	Derived Heat	Electricity	Total
PRIMARY										
MIN	Domestic Supply	8098	7899	5379	10775	5027	0	0	0	37178
IMP	Imports	6463	13292	39960	0	113	0	0	1168	60995
EXP	Exports	-1147	-2516	-14831	0	-72	0	0	-1127	-19693
TPS	Total Primary Supply	13414	18675	30508	10775	5067	0	0	41	78480
CONVERSION										
ESC	Energy Sector Consumption	-58	-793	-1849	0	-4	-2	0	0	-2705
ELC	Electricity Plants	-9598	-5636	-1225	-10775	-1256	-33	1738	11581	-15203
HPL	Heat Plants	-161	-301	-50	0	-140	-2	659	0	5
REF	Petroleum Refineries			-31736						-31736
	Total Conversion	-9817	-6730	-34859	-10775	-1400	-36	2396	11581	-49640
FINAL										
RSD	Residential	357	5160	2289	0	1294	0	865	2872	12837
COM	Commercial	57	1752	855	0	67	1	255	2527	5514
IND	Industry	1897	4437	2016	0	722	117	634	4088	13911
AGR	Agriculture	44	201	797	0	63	0	16	19	1141
TRA	Transport	1	21	14851	0	131	0	0	266	15270
OTH	Other	1189	0	393	0	1390	0	627	650	4249
NEN	Non Energy	52	634	4073		0	0	0	0	4759
BNK	Bunkers	0	0	2111		0	0	0	0	2111
TFC	Total Final Consumption	3597	12205	27385	0	3667	118	2396	10423	59791

Data used in the template to build the model

Column B (rows 5 - 24) is used to set up the technology and commodity names and descriptions in the model.

Row 2 and Row 5 are used to build technology and commodity names and descriptions in the model.

	COA	GAS	OIL
Domestic Supply Curve Share - Step 1	75%	50%	80%
Domestic Supply Curve Share - Step 2	25%	50%	20%

This share is used to split the total domestic production in more than one step. In this way it is possible to set up in the model a supply curve defined by the maximum production and cost

		COA	GAS	OIL	NUC	RNW	SLU	HET	ELC
		Solid Fuels	Natural Gas	Crude oil	Nuclear Energy	Renewable Energies	Industrial Wastes	Derived Heat	Electricity
Break-out by end-use									
RSD	SH								
RSD	AP								
RSD	OT		1						
COM	D1								
COM	D6								
TRA	D1			1					
TRA	D2								1

Space Heating
Appliances
Other
Demand 1
Demand 6
Demand 1
Demand 2

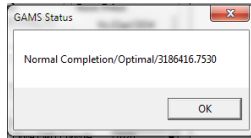
		CO2	Nox	VOC
		Carbon dioxide	NOX	VOC
RSD	1			
TRA	1			
OTH	1			
ELC	1			

Added for EV version

Sheet RES&OBJ in TIMES DEMO_EV

Objective Function

Run name: DemoS_004



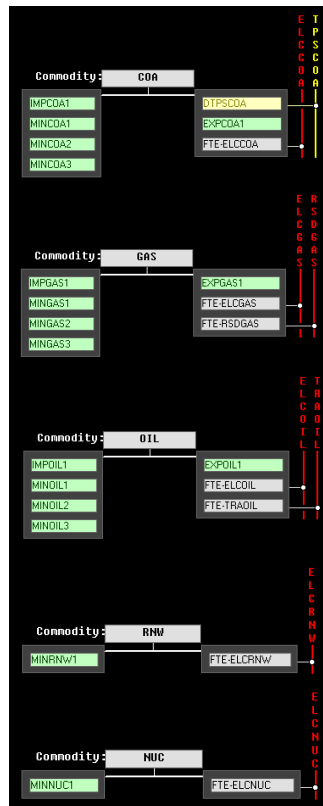
Objective Function by Scenario _SysCost VEDA-BE table

Attribute	Region	Total
Scenario	REG1	
DemoS_004	3,186,416.75	3,186,416.75
DemoS_004a	3,188,469.26	3,188,469.26
DemoS_004b	3,188,469.26	3,188,469.26

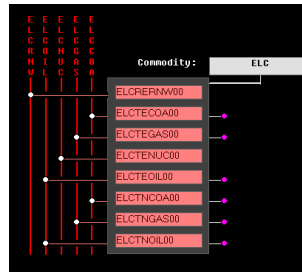
Reference Energy System (from VEDA-FE Go-To RES feature)

Primary Supply (Mining, Import/Export)

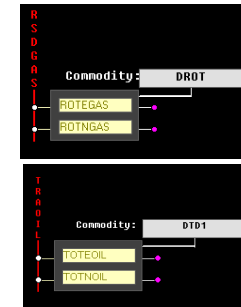
Commodity	Process
MENDF	DMD
ANREI	ELE
TVGMN	CHP
	PRE/PRW
	IRE
	HPL



Conversion (Power Sector)



Demand Sectors



Sheet SectorFuels in TIMES DEMO_EV

Sector Name	Commodity	Description	Default unit	Currency Existing
	Sector Fuel PJ			ME2005 E

-FI_Comm

Csets	Region	CommName	CommDesc	Unit	LimType	CTSLvl	PeakTS	Ctype
*Commodity Set	Region				Sense of the			Electricity
Membership	Name	Commodity Name	Commodity Description	Unit	Balance EQN.	Timeslice Level	Peak Monitoring	Indicator
NRG		RSDGAS	Residential Natural Gas	PJ				
		TRAOIL	Transport Crude Oil	PJ				
		TRAELEC	Transport Electricity	PJ		DAYNITE		
		TRAELECEV	Transport Electricity for EV cars	PJ				
		ELCCOA	Electricity Plants Solid Fuels	PJ				
		ELCGAS	Electricity Plants Natural Gas	PJ				
		ELCOIL	Electricity Plants Crude Oil	PJ				
		ELCRNW	Electricity Plants Renewable Energies	PJ				
		ELCNUC	Electricity Plants Nuclear Energy	PJ				

-FI_T

TechName	Comm-IN	Comm-OUT	STOCK	EFF	LIFE
	Output	Existing Installed			
*Technology Name	Input Commodity	Commodity	Capacity	Efficiency	Lifetime
*Units			PJa		Years
FTE-RSDGAS	GAS	RSDGAS		1.00	30
FTE-TRAOIL	OIL	TRAOIL		1.00	30
FTE-TRAELEC	ELC	TRAELEC	20	1.00	50
FTE-TRAELECEV	CEV	TRAELECEV		1.00	50
FTE-ELCCOA	COA	ELCCOA		1.00	30
FTE-ELCGAS	GAS	ELCGAS		1.00	30
FTE-ELCOIL	OIL	ELCOIL		1.00	30
FTE-ELCRNW	RNW	ELCRNW		1.00	30
FTE-ELCNUC	NUC	ELCNUC		1.00	30

-FI_Process

Sets	Region	TechName	TechDesc	Tact	Tcap	Tslvl	PrimaryCG	Vintage
*Process Set	Region			Activity		TimeSlice level of	Primary Commodity	Vintage
Membership	Name	Technology Name	Technology Description	Unit	Capacity Unit	Process Activity	Group	Tracking
PRE		FTE-RSDGAS	Sector Fuel Existing Residential Sector- Natural Gas	PJ	PJa			
		FTE-TRAOIL	Sector Fuel Existing Transport Sector- Crude Oil	PJ	PJa			
		FTE-TRAELEC	Sector Fuel Technology Existing Transport Electricity	PJ	PJa			
		FTE-TRAELECEV	Sector Fuel Technology Existing Transport Electricity for EV cars	PJ	PJa			
		FTE-ELCCOA	Sector Fuel Technology Existing Electricity Plants Solid Fuels	PJ	PJa			
		FTE-ELCGAS	Sector Fuel Technology Existing Electricity Plants Natural Gas	PJ	PJa			
		FTE-ELCOIL	Sector Fuel Technology Existing Electricity Plants Crude Oil	PJ	PJa			
		FTE-ELCRNW	Sector Fuel Technology Existing Electricity Plants Renewable Energies	PJ	PJa			
		FTE-ELCNUC	Sector Fuel Technology Existing Electricity Plants Nuclear Energy	PJ	PJa			

User inputs

Linked to the Energy Balance

Declare sectoral energy commodities (FI_COMMtable) and define each sectoral fuel technology option (FI_Process table).

Construct a fuel technology to convert the fuel commodity name from the supply sector to a sectoral specific fuel commodity (e.g. from GAS to RSDGAS)

Sheet DemSect_TRA in TIMES DEMO_EV

Sector Name	Description	Type	Default Unit	Secondary Unit	Currency Unit	Capacity	Existing	New
TRA	Transport	Technologies PJ		Million_Pkm MVKms	MC2005	000_Units	E	N

Previous version c:\VEDA\VEDA_Models\DEMO_S004\VT_REG_PRI_V04.xls modified by Konstantinos Genikonsakis, DeustoTech, Bilbao, Spain, October 2013.
Updated to current version by Paul Erik Grohnheit, DTU, April 2014

-FI T									
TechName	Comm-IN	Comm-OUT	STOCK	EFF	AFA	INVCOST	FIXOM	LIFE	ENV_ACT
*Technology Name	Input Commodity	Output Commodity	Existing Installed Capacity	Efficiency	Utilisation Factor	Investment Cost	Fixed O&M Cost	Lifetime	Activity Emission Coefficient
*Units			PJa			MC2005/PJ	MC2005/PJa	Years	kt
TOTEOL	TRAOL	DTD1	16666	1.00	0.90		0.20	10	
		TRACO2							65.0
TOTNOIL	TRAOL	DTD1		1.10	0.90	10	0.20	15	2006
		TRACO2							59.1

User inputs
Linked to the Energy Balance
Added for EV version

Proposed modelling of passenger cars

-FI T											
TechName	Comm-IN	Comm-OUT	STOCK	EFF	AFA	ACTFLO	Cap2Act	INVCOST	FIXOM	LIFE	ENV_ACT
*Technology Name	Input Commodity	Output Commodity	Existing Installed Capacity	Efficiency		Max Ann Km	Passenger/Car	Investment Cost	Fixed O&M Cost	Remaining Lifetime	Activity Emission Coefficient
*Units			0	/				MC2005/	a	Years	kt
TOTNOIL00	TRAOL	DTD2	22565	412.82	15000	1.5	0.001	20	0.4	8	
		TRACO2									65
TOTNOIL00	TRAOL	DTD2		433.47	15000	1.5	0.001	20	0.4	12	2006
		TRACO2									65
TOTNELCV2Guse01	TRAECEV	DTD2	1666.67	15000	1.5	0.001	23	0.46	15	2015	

V2G storage

-FI T											
TechName	Comm-IN	TimeSlice	Comm-OUT	STOCK	AFA	INVCOST	FIXOM	LIFE	START	ENV_ACT	NSTTS
*Technology Name	Input Commodity	TimeSlice(s)	Output Commodity	Existing Installed Capacity	Utilisation Factor	Investment Cost	Fixed O&M Cost	Remaining Lifetime	Activity Emission Coefficient	Charging TimeSlices	Storage Efficiency
*Units				a		MC2005/PJ	MC2005/PJa	Years	kt		
TOTNV2Gstorage01	TRAECEV	SN_WN	TRAECEV ELC					15	2015		0.98
											1

Conversion factors

ktoe to PJ	0.041868
ktoe to Lt	PJ to Lt
TRADST	1123469
TRAGSL	1198179
TRALPG	1631858
TRAELE	11630000
TRAELE	27777778

Average Vehicle Efficiency per 100k

TRAOL	6.5 Lt
TRAELE	16.7 kWh

-FI Comm

Sets	Region	CommName	CommDesc	Unit	LimType	CTSLvl	PeakTS	Ctype
*Commodity Set	Region	Commodity Name	Commodity Description	Unit	Sense of the Balance EQN	Timeslice Level	Peak Monitoring	Electricity Indicator
DEM		DTD1	Demand Transport Sector - Demand 1	PJ				
DEM		DTD2	Demand Transport Sector - Demand 2	Million_Pkm		DAYNITE		
ENV		TRACO2	Transport Carbon dioxide	kt				

-FI Process

Sets	Region	TechName	TechDesc	Tact	Tcap	Tslvl	PrimaryCG	Vintage
*Process Set	Region	Technology Name	Technology Description	Unit	Capacity Unit	Timeslice level of Process Activity	Primary Commodity Group	Vintage Tracking
DMD		TOTEOL	Demand Technologies Transport Sector - Existing - Crude Oil	PJ	PJa			
		TOTNOIL	Demand Technologies Transport Sector - New - Crude Oil	PJ	PJa			
		TOTNOIL00	Demand Technologies Transport Sector - Existing - Crude Oil	MVKm	0			
		TOTNOIL00	Demand Technologies Transport Sector - New - Crude Oil	MVKm	0			
		TOTNELCV2Guse01	Demand Technologies Transport Sector - New - EV use Electricity	MVKm	0			
DMD,NST		TOTNV2Gstorage01	Demand Technologies Transport Sector - New - EV storage Electricity	PJ	PJa	DAYNITE		

TOTNELC01	Demand Technologies Transport Sector - New Demand 2 - Electricity	MVKm 000_Units
TOTNELC	Demand Technologies Transport Sector - New Demand 1 - Electricity	PJ PJa

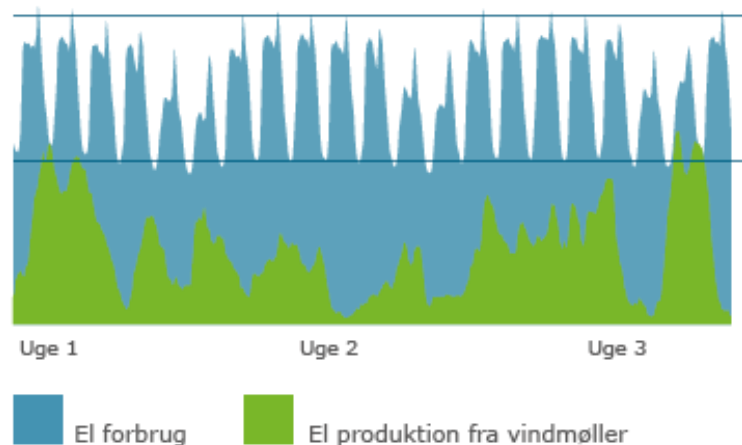
Declare demand car transport sector a demand commodity and transport carbon dioxide an environmental commodity (FI_COMM table) and define demand technology options (FI_Process table).

Construct demand technologies to deliver the transport car demand.

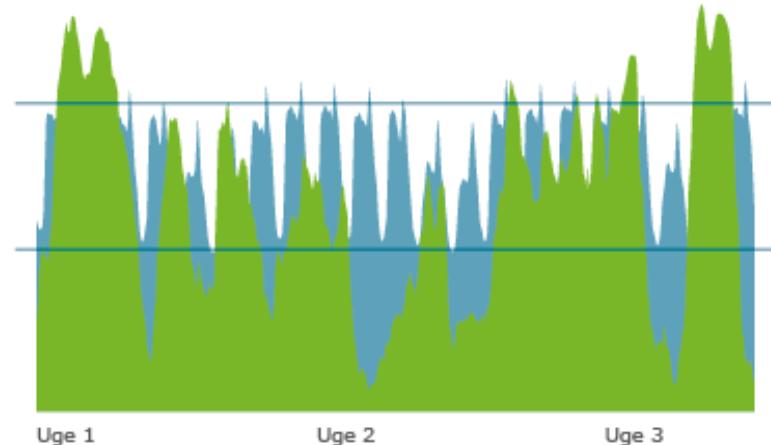
Challenges of more wind power

Wind power generation and consumption on different times

2013

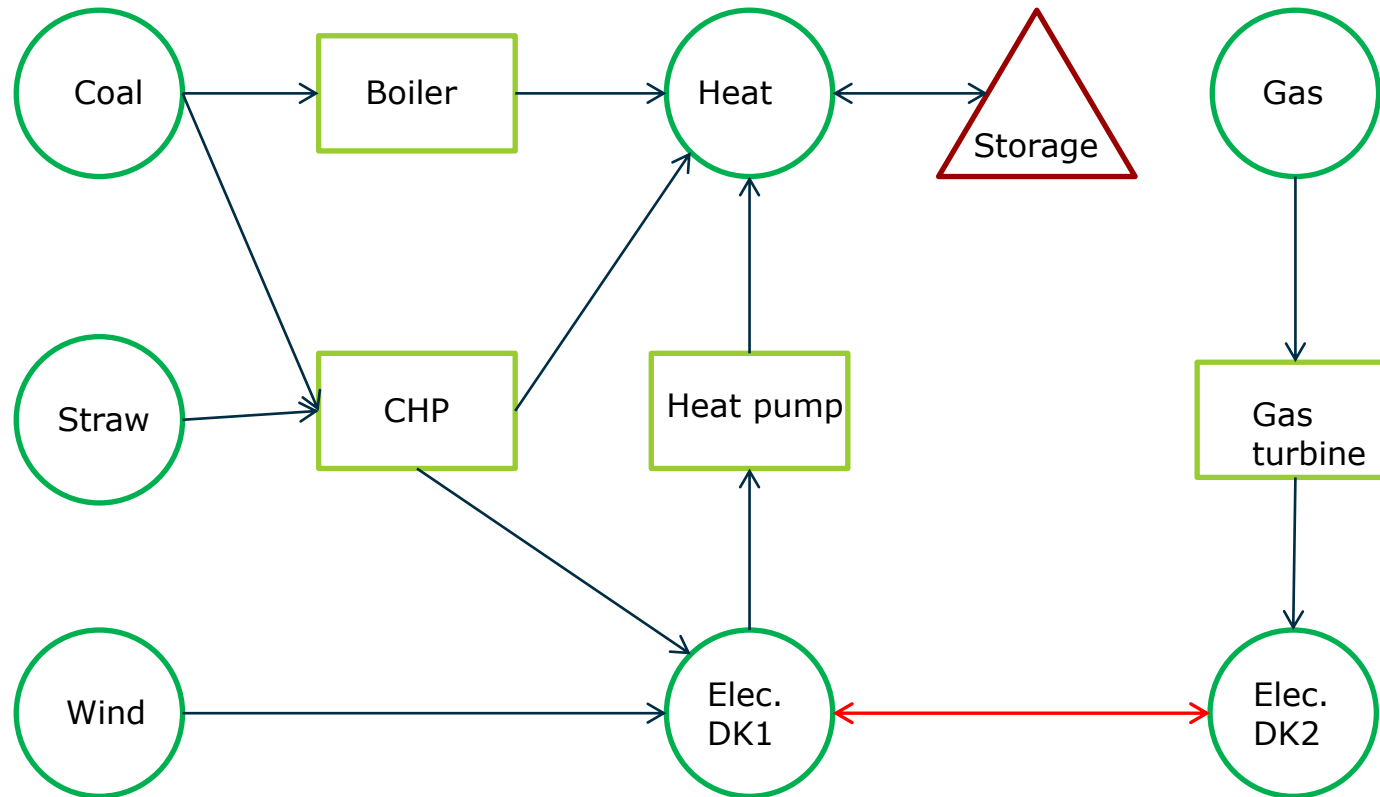


2035



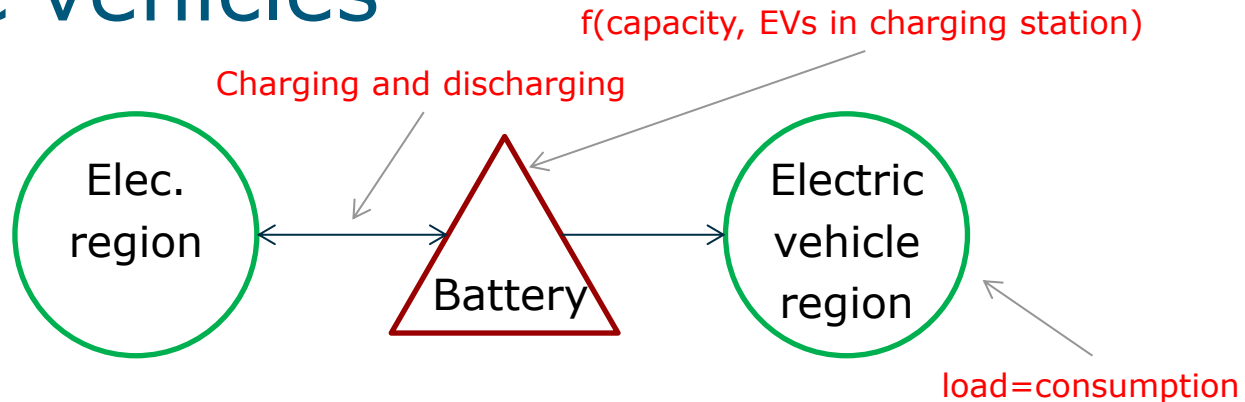
Translated from Sifre presentation Energinet.dk 27 August 2014

Example of an energy system in Sifre



Translated from Sifre presentation Energinet.dk 27 August 2014

Electric vehicles

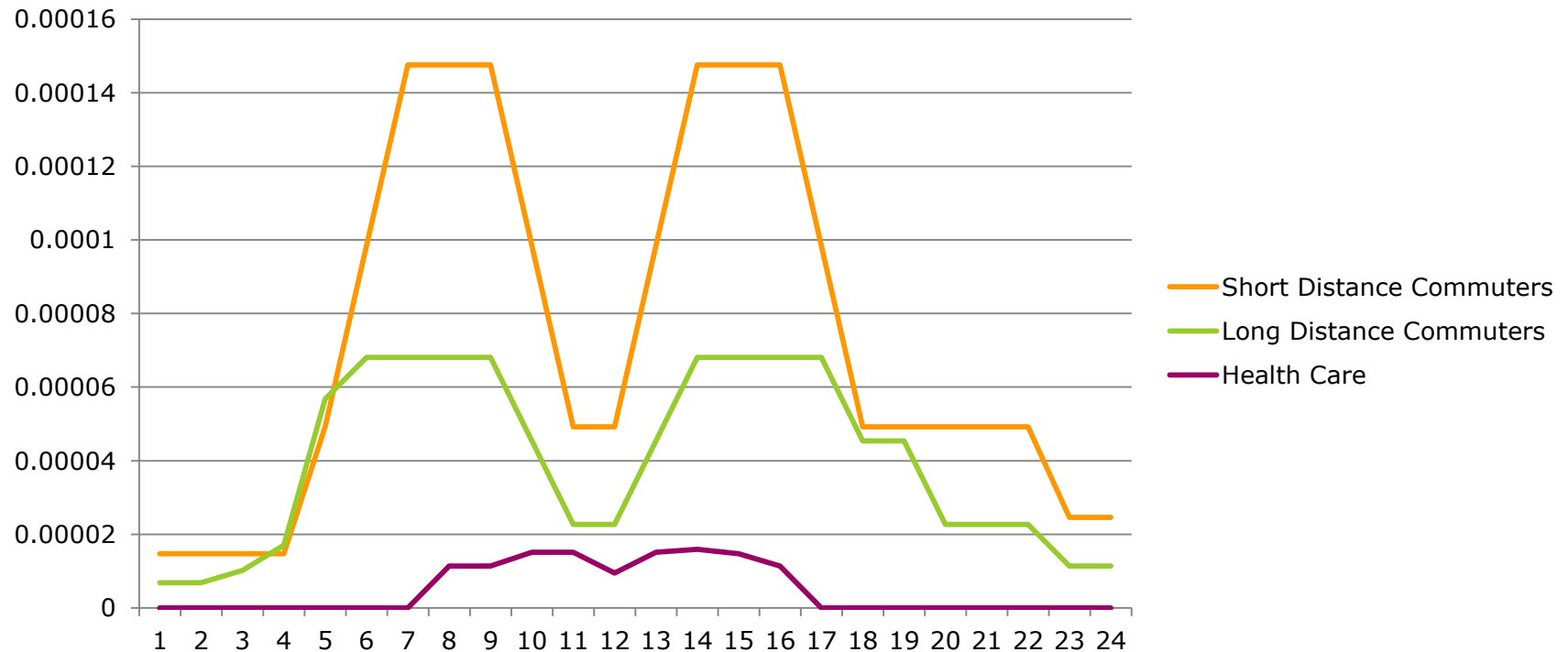


- Aggregated representation: Electric vehicle region is a large number of EVs
- Data requirements:
 - EV hourly electric consumption
 - Capacity of the aggregated EV battery
 - Charging and discharging rates
 - Relation between EV electric consumption and utilisation of EVs in charging station – Modeled by a reduced share of EVs in charging when EV consumption is high

Translated from Sifre presentation Energinet.dk 27 August 2014

EVs users profiles - qualitative description

EVs users categories

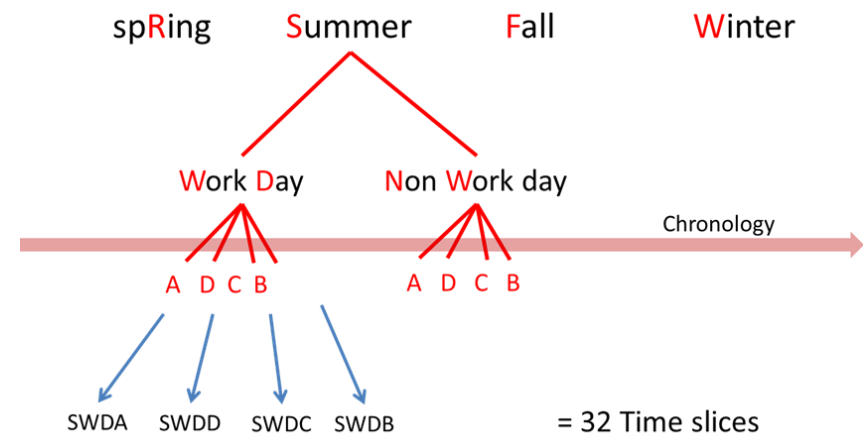


EVs users profiles - qualitative description

- Short distance commuters
 - Driving less than one hour to work
- Long distance commuters
 - Driving more than one hour to work
 - Produce thicker tails in the load curve
- Health Care Services
 - Drive mainly between 8 and 17 (working hours)
 - Moderate load decrease during lunch time
- Vehicle-to-grid
 - Short distance commuter seem the primary target
 - Only moderate availability for discharging should be expected from long distance commuters and health care services
 - Hybrid vehicles users could however be more available for discharging

Aggregation of parameters

- Operation model – Sifre or SIVAEL
 - Exogenous technology capacities
 - Chronological simulation of hours
- Optimisation model – TIMES or Balmorel
 - Technology choice as optimisation result
 - Time slices – aggregation of chronological data
- Macroeconomic model – IMACLIM or other CGE models
 - Single aggregated parameter for utilisation time for electric vehicles



Definition of time slices in TIMES-DK

References

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- Key Technologies for Electromobility, EV-STEP Deliverable D2.2, April 2014
- Energinet.dk (2014), SIMulating Flexible and Renewable Energy sources. Sifre Workshop, Energinet.dk, Ballerup 27 August 2014.
- Genikomsakis, Konstantinos N.; Gargiulo, Maurizio; Grohnheit, Poul Erik; (2013), TIMES demo models, EFDA-TIMES and ETSAP-TIAM
- EV-STEP: Electric Vehicles in TIMES. EV-STEP Research Note for Deliverable D3.1