openMASTER - LightDoc

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NOTATION

PE Primary energy:

sPE	- Primary Energy Commodities
sPE_{Nuc}	- Nuclear Primary Energy Commodities
sPE_{Fossil}	- Fossil Primary Energy Commodities
sPE_{Renew}	- Renewable Primary Energy Commodities
sPE_{NUCLE}	- PE Nuclear
$sPEIMPCO$	- "PE Imported Coal"
$sPENAGAS$	- "PE Natural Gas"
$sPELNGAS$	- "PE Liquefied Natural Gas"
$sPECROIL$	- "PE Crude Oil"
$sPESWAST$	- "PE Solid Waste"
$sPEHYDRR$	- "PE Hydro Run off the River"
$sPEHYDRC$	- "PE Hydro with Reservoir Capacity"
$sPEMNHY$	- "PE Mihi Hydro"
$sPEWINON$	- "PE Wind Onshore"
$sPEWINOF$	- "PE Wind Offshore"
$sPESOLPV$	- "PE Solar Photovoltaic "
$sPESOLTE$	- "PE Solar Thermoelectric"
$sPESOLTH$	- "PE Solar Thermal"
$sPEBIOMEC$	- "PE Biomass Energy Crops"
$sPEBIOMAW$	- "PE Biomass Agriculture Waste"
$sPEBIOMFW$	- "PE Biomass Forestry Waste"
$sPEBIOETHPI$	- "PE Bioethanol Production Inputs"
$sPEBIODIEPI$	- "PE Biodiesel Production Inputs"
$sPEBIOGAS$	- "PE Biogas"
$sPEHUMANE$	- "PE Human Energy"

CE Conversion energy:

sCE	- Conversion Energy Technologies
$sCENUCLEAR$	- "CE Nuclear Power"
$sCEIMCOTRA$	- "CE Imported Coal Traditional"
$sCEIMCOIGCC$	- "CE Imported Coal Integrated Gasification Combine Cycle"
$sCEIMCOSCPC$	- "CE Imported Coal Super-critical Pulverised Coal"
$sCEIMCOSCCCS$	- "CE Imported Coal Super-critical Pulverised Coal with CCS"
$sCECCGTTRA$	- "CE Combined Cycle Gas Turbine Traditional"
$sCECCGTCCS$	- "CE Combined Cycle Gas Turbine with CCS"
$sCEOCGTTRA$	- "CE Open Cycle Gas Turbine Traditional"
$sCEOCGTCCS$	- "CE Open Cycle Gas Turbine with CCS"

$sCEFUOITRA$ - "CE Fuel Oil Traditional"
$sCEHYRURIV$ - "CE Hydro Run off the River"
$sCEHYRSCAP$ - "CE Hydro with Reservoir Capacity"
$sCEHYPSTOR$ - "CE Hydro with Pumping Storage"
$sCEMINIHYDR$ - "CE Mini Hydro"
$sCEWINDON$ - "CE Wind Onshore"
$sCEWINDOFF$ - "CE Wind Offshore"
$sCESOPHVCEWT$ - "CE Solar Photovoltaic Centralised with Tracking"
$sCESOPHVDIWOTIND$ - "CE Solar Photovoltaic Distributed without Tracking. In Industrial Sector"
$sCESOPHVDIWOTOTH$ - "CE Solar Photovoltaic Distributed without Tracking. In Other Uses Sector"
$sCESOTELCE$ - "CE Solar Thermoelectric Centralised"
$sCESOLTHDIIND$ - "CE Solar Thermal Distributed Industry"
$sCESOLTHDIOTH$ - "CE Solar Thermal Distributed Other Uses"
$sCEBIOELECE$ - "CE Biomass Electricity Centralised"
$sCESLDWAST$ - "CE Solid Waste "
$sCECOGENINDNG$ - "CE Cogeneration in Industry. Natural gas"
$sCECOGENOTHNG$ - "CE Cogeneration in Other Uses. Natural gas"
$sCECOGENINDBIO$ - "CE Cogeneration in Industry. Biomass"
$sCECOGENOTHBIO$ - "CE Cogeneration in Other Uses. Biomass"
$sCEREFINLOWC$ - "CE Refinery Low Complexity"
$sCEREFINHIGC$ - "CE Refinery High Complexity"
$sCEREFINVHIC$ - "CE Refinery Very High Complexity"
$sCEBIOETHPP$ - "CE Bioethanol Production Plant"
$sCEBIODIEPP$ - "CE Biodiesel Production Plant"
$sCEREGASIF$ - "CE Regasification Terminal"
$sPE2TE_{IMCO}$ - "Dummy CE: transform PE to TE. Imported Coal"
$sPE2TE_{NAGAS}$ - "Dummy CE: transform PE to TE. Natural Gas"
$sPE2TE_{BIOMA}$ - "Dummy CE: transform PE to TE. Biomass"
$sTE2TE_{TEELEIND}$ - "Dummy CE: transform TE to TE. Central/Distributed Electricity to ELEIND"
$sTE2TE_{TEELEOTH}$ - "Dummy CE: transform TE to TE. Central/Distributed Electricity to ELEOTH"
$sTE2TE_{TEELETRA}$ - "Dummy CE: transform TE to TE. Central/Distributed Electricity to ELETRA"
$sCEPri$ - Primary Conversion Energy Technologies with PE input
$sCESec$ - Secondary Conversion Energy Technologies with TE input
$sCESto$ - Storage Energy Technologies
sCE_{Nuc} - Nuclear Energy Technologies
sCE_{Hydro} - Coal Energy Technologies
sCE_{Coal} - CE Nuclear Power
sCE_{Var} - CE Imported Coal Traditional
sCE_{Ele} - CE Imported Coal Integrated Gasification Combine Cycle
sCE_{Ref} - -

TE Transformed Energy:

sTE - Transformed/Final Energy Commodities
$sTEELECE$ - "TE Electricity Centralised"
$sTEELEDIIND$ - "TE Electricity Distributed. in Industry"
$sTEELEDIOTH$ - "TE Electricity Distributed. in Other Uses"
$sTEHEADIIND$ - "TE Heat Distributed. in Industry"
$sTEHEADIOTH$ - "TE Heat Distributed. in Other Uses"
$sTEOPGSN$ - "TE Oil Product Gasoline"
$sTEOPDIE$ - "TE Oil Product Diesel"
$sTEOPFOI$ - "TE Oil Product Fuel Oil"

$sTEOPLPG$ - "TE Oil Product Liquefied Petroleum Gas"
$sTEOPKER$ - "TE Oil Product Kerosene"
$sTEOPOTH$ - "TE Oil Product Other"
$sTEBIOETH$ - "TE Bioethanol"
$sTEBIODIE$ - "TE Biodiesel"
$sTENAGAS$ - "TE Natural Gas"
$sTECOAL$ - "TE Coal"
$sTEBIOMA$ - "TE Biomass"
$sTEELEIND$ - "TE Electricity consumed by Industry sector"
$sTEELEOTH$ - "TE Electricity consumed by Others sector"
$sTEELETRA$ - "TE Electricity Centralised by Transport sector"
sTE_{Ele} - Transformed/Final Electricity Energy Commodities

RW Raw Materials:

sRM - Raw Materials Commodities
$sRMALBAU$ - Aluminium: Bauxite
$sRMALSCR$ - Aluminium: Scrap
$sRMISSCR$ - Iron and Steel: Scrap Iron
$sRMISQLI$ - Iron and Steel: Quick Lime
$sRMISCOG$ - Iron and Steel: Coke Oven Gas
$sRMISCOK$ - Iron and Steel: Coke
$sRMISORE$ - Iron and Steel: Ore
$sRMISPLT$ - Iron and Steel: Pellet
$sRMISOXY$ - Iron and Steel: Oxygen
$sRMISBFG$ - Iron and Steel: Blast Furnace Gas
$sRMCUORE$ - Copper: Ore
$sRMCMBFS$ - Cement: Blast Furnace Slag usable for Cement
$sRMLMSTN$ - Lime: Limestone
$sRMGHRYC$ - Glass: Recycled
$sRMPPWOO$ - Paper: Wood
$sRMPPNOH$ - Paper: Sodium Hydraxide
$sRMPPOXY$ - Paper: Oxygen
$sRMPPRYC$ - Paper: Recycled

ST Supply Technologies:

sST - Supply technologies
$sST_{DSTRA_{LNP_{CAGSN}}}$ - "ST Transp. Land. Car gasoline"
$sST_{DSTRA_{LNP_{CADST}}}$ - "ST Transp. Land. Car diesel"
$sST_{DSTRA_{LNP_{CACNG}}}$ - "ST Transp. Land. Car Compressed Natural Gas"
$sST_{DSTRA_{LNP_{CALPG}}}$ - "ST Transp. Land. Car Liquefied Petroleum Gas"
$sST_{DSTRA_{LNP_{CABIOE85}}}$ - "ST Transp. Land. Car bioethanol E85"
$sST_{DSTRA_{LNP_{CABIOD85}}}$ - "ST Transp. Land. Car biodiesel D85"
$sST_{DSTRA_{LNP_{CAGSNPIHYB}}}$ - "ST Transp. Land. Car gasoline plug-in hybrid"
$sST_{DSTRA_{LNP_{CADIEPIHYB}}}$ - "ST Transp. Land. Car diesel plug-in hybrid"
$sST_{DSTRA_{LNP_{CABEV}}}$ - "ST Transp. Land. Car battery electric vehicle"
$sST_{DSTRA_{AIR_{AIRPLANEKERO}}}$ - "ST Transp. Air. Kerosene"
$sST_{DSTRA_{SEA_{SHIPDIE}}}$ - "ST Transp. Ship. Diesel"
$sST_{DSTRA_{SEA_{SHIPFOI}}}$ - "ST Transp. Ship. FOI"
$sST_{DSTRA_{LNP_{MOPGSN}}}$ - "ST Transp. Moped Gasoline"
$sST_{DSTRA_{LNP_{BUSDST}}}$ - "ST Transp. Bus Diesel"

$sST_{DSTRA_{LNP_{BUSELE}}}$ - "ST Transp. Bus Electric"

$sST_{DSTRA_{LNP_{BUSCNG}}}$ - "ST Transp. Bus CNG"

$sST_{DSTRA_{LNP_{COADST}}}$ - "ST Transp. Coach Diesel"

$sST_{DSTRA_{LNP_{COACNG}}}$ - "ST Transp. Coach CNG"

$sST_{DSTRA_{RAIL_{URBAN}}}$ - "ST Transp. Rail urban"

$sST_{DSTRA_{RAIL_{INTER}}}$ - "ST Transp. Rail intercity"

$sST_{DSTRA_{AIRF_{AIRPLANEKERO}}}$ - "ST Transp. Air for Freight. Kerosene"

$sST_{DSTRA_{LNF_{VANSMGSN}}}$ - "ST Transp. Land freight. Van gasoline"

$sST_{DSTRA_{LNF_{VANSMELE}}}$ - "ST Transp. Land freight . Van electric"

$sST_{DSTRA_{LNF_{VANSMBIO}}}$ - "ST Transp. Land freight . Van bioethanol"

$sST_{DSTRA_{LNF_{VANSMCNG}}}$ - "ST Transp. Land freight . Van CNG"

$sST_{DSTRA_{LNF_{VANSMLPG}}}$ - "ST Transp. Land freight . Van LPG"

$sST_{DSTRA_{LNF_{TRUBIDIE}}}$ - "ST Transp. Land freight. Big truck diesel"

$sST_{DSTRA_{SEAF_{SHIPDIE}}}$ - "ST Transp. Ship. Diesel Freight"

$sST_{DSOTH_{RES_{DIEB}}}$ - "ST Residential. Diesel Boiler"

$sST_{DSOTH_{RES_{NGAB_{CONV}}}}$ - "ST Residential. Natural Gas Boiler Conventional"

$sST_{DSOTH_{RES_{NGAB_{LOWT}}}}$ - "ST Residential. Natural Gas Boiler Low Temperature"

$sST_{DSOTH_{RES_{NGAB_{COND}}}}$ - "ST Residential. Natural Gas Boiler Condensation"

$sST_{DSOTH_{RES_{LPGB_{CONV}}}}$ - "ST Residential. Liquefied Petroleum Gas Boiler Conventional"

$sST_{DSOTH_{RES_{LPGB_{LOWT}}}}$ - "ST Residential. Liquefied Petroleum Gas Boiler Low Temperature"

$sST_{DSOTH_{RES_{LPGB_{COND}}}}$ - "ST Residential. Liquefied Petroleum Gas Boiler Condensation"

$sST_{DSOTH_{RES_{ELEC}}}$ - "ST Residential. Electric Resistive"

$sST_{DSOTH_{RES_{HPCOP3}}}$ - "ST Residential. Heat Pump COP3"

$sST_{DSOTH_{RES_{HPCOP6}}}$ - "ST Residential. Heat Pump COP6"

$sST_{DSOTH_{RES_{BIOMF}}}$ - "ST Residential Heat. Biomass Furnace"

$sST_{DSOTH_{RES_{ACCOP2}}}$ - "ST Residential Cooling. Air Conditioning COP 2."

$sST_{DSOTH_{RES_{ACCOP6}}}$ - "ST Residential Cooling. Air Conditioning COP 6."

$sST_{DSOTH_{RESLIGH_{INCA}}}$ - "ST Residential. Lighting. Incandescent lightbulbs"

$sST_{DSOTH_{RESLIGH_{FLUO}}}$ - "ST Residential. Lighting. Fluorescent lightbulbs"

$sST_{DSOTH_{RESLIGH_{LED}}}$ - "ST Residential. Lighting. LED lightbulbs"

$sST_{DSOTH_{RESFRID_{CONV}}}$ - "ST Residential. Fridges Conventional"

$sST_{DSOTH_{RESFRID_{HEFF}}}$ - "ST Residential. Fridges High Efficiency"

$sST_{DSOTH_{RESOVEN_{CONV}}}$ - "ST Residential. Ovens Conventional"

$sST_{DSOTH_{RESOVEN_{HEFF}}}$ - "ST Residential. Ovens High Efficiency"

$sST_{DSOTH_{RESWAMA_{CONV}}}$ - "ST Residential. Washing Machines Conventional"

$sST_{DSOTH_{RESWAMA_{HEFF}}}$ - "ST Residential. Washing Machines High Efficiency"

$sST_{DSOTH_{RESDIWA_{CONV}}}$ - "ST Residential. Dishwashers Conventional"

$sST_{DSOTH_{RESDIWA_{HEFF}}}$ - "ST Residential. Dishwashers High Efficiency"

$sST_{DSOTH_{RESCOOK_{NGAS}}}$ - "ST Residential. Cooking with Natural Gas"

$sST_{DSOTH_{RESCOOK_{LPG}}}$ - "ST Residential. Cooking with Liquefied Petroleum Gas"

$sST_{DSOTH_{RESCOOK_{ELECONV}}}$ - "ST Residential. Cooking Electric Conventional"

$sST_{DSOTH_{RESCOOK_{ELEHEFF}}}$ - "ST Residential. Cooking Electric Induction High Efficiency"

$sST_{DSOTH_{RESOEAP_{CONV}}}$ - "ST Residential. Other Electric Appliances Conventional"

$sST_{DSOTH_{SRV_{DIEB}}}$ - "ST Services. Natural Gas Diesel Boiler"

$sST_{DSOTH_{SRV_{NGABCONV}}}$ - "ST Services. Natural Gas Boiler Conventional"

$sST_{DSOTH_{SRV_{NGAB_{LOWT}}}}$ - "ST Services. Natural Gas Boiler Low Temperature"

$sST_{DSOTH_{SRV_{NGAB_{COND}}}}$ - "ST Services. Natural Gas Boiler Condensation"

$sST_{DSOTH_{SRV_{LPGB_{CONV}}}}$ - "ST Services. Liquefied Petroleum Gas Boiler Conventional"

$sST_{DSOTH_{SRV_{LPGB_{LOWT}}}}$ - "ST Services. Liquefied Petroleum Gas Boiler Low Temperature"

$sST_{DSOTH_{SRV_{LPGB_{COND}}}}$ - "ST Services. Liquefied Petroleum Gas Boiler Condensation"

$sST_{DSOTH_{SRV_{ELEC}}}$ - "ST Services. Electric Resistive"

$sST_{DSOTH_{SRV_{HPCOP3}}}$ - "ST Services. Heat Pump COP3"

$sST_{DSOTH_{SRV_{HPCOP6}}}$ - "ST Services. Heat Pump COP6"

$sST_{DSOTH_{SRV_{BIOMF}}}$ - "ST Services Heat. Biomass Furnace"

$sST_{DSOTH_{SRV_{ACCOP2}}}$ - "ST Services Cooling. Air Conditioning COP 2. Consuming centralised electricity"

$sST_{DSOTH_{SRV_{ACCOP6}}}$ - "ST Services Cooling. Air Conditioning COP 6."

$sST_{DSOTH_{SRVLIGH_{INCA}}}$ - "ST Services. Lighting. Incandescent lightbulbs. Consumes centralised electricity"

$sST_{DSOTH_{SRVLIGH_{FLUO}}}$ - "ST Services. Lighting. Fluorescent lightbulbs"

$sST_{DSOTH_{SRVLIGH_{LED}}}$ - "ST Services. Lighting. LED lightbulbs"

$sST_{DSOTH_{SRVOEAP_{CONV}}}$ - "ST Services. Other Electric Appliances Conventional"

$sST_{DSIND_{IAL_{HH}}}$ - "ST Industry, Aluminium. Hall Heroult"

$sST_{DSIND_{IAL_{RE}}}$ - "ST Industry, Aluminium. Recycling"

$sST_{DSIND_{IIS_{BF}}}$ - "ST Industry, Iron and Steel. Blast Furnace"

$sST_{DSIND_{IIS_{EAF}}}$ - "ST Industry, Iron and Steel. EAF (Scrap)"

$sST_{DSIND_{ICU}}$ - "ST Industry, Copper"

$sST_{DSIND_{IAM}}$ - "ST Industry, Ammonia"

$sST_{DSIND_{ICL}}$ - "ST Industry, Chlorine"

$sST_{DSIND_{ICM_{COK}}}$ - "ST Industry, Cement. Coke"

$sST_{DSIND_{ICM_{BIO}}}$ - "ST Industry, Cement. Biomass"

$sST_{DSIND_{ILM_{COK}}}$ - "ST Industry, Lime. Coke"

$sST_{DSIND_{ILM_{BIO}}}$ - "ST Industry, Lime. Biomass"

$sST_{DSIND_{IGH}}$ - "ST Industry, Glass Hollow"

$sST_{DSIND_{IGH_{RE}}}$ - "ST Industry, Glass Hollow. Recycling"

$sST_{DSIND_{IGF}}$ - "ST Industry, Glass Flat"

$sST_{DSIND_{IPP_{GAS}}}$ - "ST Industry, Pulp and Paper. Natural gas"

$sST_{DSIND_{IPP_{BIO}}}$ - "ST Industry, Pulp and Paper. Biomass"

$sST_{DSIND_{IPP_{GAS_{RE}}}}$ - "ST Industry, Pulp and Paper. Recycling. Natural gas"

$sST_{DSIND_{IPP_{BIO_{RE}}}}$ - "ST Industry, Pulp and Paper. Recycling. Biomass"

sST_{Tra} - Transportation Supply Technologies

$sST_{Tra_{Car}}$ - Transportation Supply Technologies. Mode: Car

$sST_{Tra_{Moped}}$ - Transportation Supply Technologies. Mode: Moped

$sST_{Tra_{RoadFreight}}$ - Transportation Supply Technologies. Mode: Road Freight

$sST_{Tra_{Bus}}$ - Transportation Supply Technologies. Mode: Bus

$sST_{Tra_{UrbanRail}}$ - Transportation Supply Technologies. Mode: Urban rail

$sST_{Tra_{IntRail}}$ - Transportation Supply Technologies. Mode: Intercity rail

$sST_{Tra_{Air}}$ - Transportation Supply Technologies. Mode: Air

$sST_{Tra_{Sea}}$ - Transportation Supply Technologies. Mode: Sea

sST_{Oth} - Supply Technologies. Others

sST_{Ind} - Supply Technologies. Industry

sST_{Cap} - Supply Technologies measured by capacity

sST_{Uni} - Supply Technologies measured by number of units

ES Energy Service Commodities:

sES	- Energy Services Commodities
$sES_{DSTRA_{PAS_{URBN}}}$	Mvkm-urb "Transportation, Passengers. Urban (less than 50km). Includes peninsular and extrapeninsular"
$sES_{DSTRA_{PAS_{G50}}}$	Mvkm-G50 "Transportation, Passengers. Interurban longer than 50. Includes peninsular and extrapeninsular"
$sES_{DSTRA_{PAS_{G500}}}$	Mvkm-G500 "Transportation, Passengers. Continental longer than 500"
$sES_{DSTRA_{PAS_{EXP}}}$	Mvkm-EXP "Transportation, Passengers. Extra-Peninsular"
$sES_{DSTRA_{PAS_{INT}}}$	Mvkm-INT "Transportation, Passengers. International"
$sES_{DSTRA_{FRE_{URBN}}}$	Mvkm-urb "Transportation, Freight. Urban (less than 50km). Includes peninsular and extrapeninsular"
$sES_{DSTRA_{FRE_{G50}}}$	Mvkm-G50 "Transportation, Freight. Interurban longer than 50. Includes peninsular and extrapeninsular"
$sES_{DSTRA_{FRE_{G500}}}$	Mvkm-G500 "Transportation, Freight. Continental longer than 500"
$sES_{DSTRA_{FRE_{EXP}}}$	Mvkm-EXP "Transportation, Freight. Extra-Peninsular"
$sES_{DSTRA_{FRE_{INT}}}$	Mvkm-INT "Transportation, Freight. International"
$sES_{DSOTH_{RES_{HEAT}}}$	GWh-heat "Residential Buildings. Space Heating"
$sES_{DSOTH_{RES_{COOL}}}$	GWh-cool "Residential Buildings. Space Cooling"
$sES_{DSOTH_{RES_{HTWA}}}$	GWh-htwa "Residential Buildings. Hot water"
$sES_{DSOTH_{RES_{LIGH}}}$	Tlmh "Residential Buildings. Lighting"
$sES_{DSOTH_{RES_{FRID}}}$	GWh "Residential Buildings. Fridge"
$sES_{DSOTH_{RES_{OVEN}}}$	M cycles "Residential Buildings. Oven"
$sES_{DSOTH_{RES_{WAMAH}}}$	M cycles-hot "Residential Buildings. Washing machine Hot Water Cycles"
$sES_{DSOTH_{RES_{WAMAC}}}$	M cycles-cold "Residential Buildings. Washing machine Cold Water Cycles"
$sES_{DSOTH_{RES_{DIWAH}}}$	M cycles-hot "Residential Buildings. Dish washer Hot Water Cycles"
$sES_{DSOTH_{RES_{DIWAC}}}$	M cycles-cold "Residential Buildings. Dish washer Cold Water Cycles"
$sES_{DSOTH_{RES_{COOK}}}$	GWh "Residential Buildings. Cooking"
$sES_{DSOTH_{RES_{OEAP}}}$	GWh "Residential Buildings. Other Electric Appliances"
$sES_{DSOTH_{SRV_{HEAT}}}$	GWh-heat "Services Buildings. Space Heating"
$sES_{DSOTH_{SRV_{COOL}}}$	GWh-cool "Services Buildings. Space Cooling"
$sES_{DSOTH_{SRV_{HTWA}}}$	GWh-htwa "Services Buildings. Hot water"
$sES_{DSOTH_{SRV_{LIGH}}}$	Tlmh "Services Buildings. Lighting"
$sES_{DSOTH_{SRV_{OEAP}}}$	GWh "Services Buildings. Other Electric Appliances"
$sES_{DSIND_{IAL}}$	kt "Industry, Aluminium"
$sES_{DSIND_{IIS}}$	kt "Industry, Iron and Steel"
$sES_{DSIND_{ICU}}$	kt "Industry, Copper"
$sES_{DSIND_{IAM}}$	kt "Industry, Ammonia"
$sES_{DSIND_{ICL}}$	kt "Industry, Chlorine"
$sES_{DSIND_{ICM}}$	kt "Industry, Cement"
$sES_{DSIND_{ILM}}$	kt "Industry, Lime"
$sES_{DSIND_{IGH}}$	kt "Industry, Glass Hollow"
$sES_{DSIND_{IGF}}$	kt "Industry, Glass Flat"
$sES_{DSIND_{IPP}}$	kt "Industry, Pulp and Paper"
sES_{Tra}	- Energy Service Commodities. Transportation
$sModes$	- Transportation Modes
Car	- -
$Moped$	- -
Bus	- -
$UrbanRail$	- -
$IntRail$	- -
Air	- -
Sea	- -
sES_{Oth}	- Energy Service Commodities. Others
sES_{Ind}	- Energy Service Commodities. Industry

$sES_{DSIND_{INM}}$	kt "Industry, Other Non Metallic Minerals"
$sES_{DSIND_{INF}}$	kt "Industry, Non Ferrous Metals"
$sES_{DSIND_{ICH}}$	kt "Industry, Other Chemicals"

SD Service demand Commodities:

sSD	- Service Demand Commodities
$sSD_{DSTRA_{PAS_{URBN}}}$	Mpkm-urb "Transportation, Passengers. Urban (less than 50km). Includes peninsular and extrapeninsular"
$sSD_{DSTRA_{PAS_{G50}}}$	Mpkm-G50 "Transportation, Passengers. Interurban longer than 50. Includes peninsular and extrapeninsular"
$sSD_{DSTRA_{PAS_{G500}}}$	Mpkm-G500 "Transportation, Passengers. Continental longer than 500"
$sSD_{DSTRA_{PAS_{EXP}}}$	Mpkm-EXP "Transportation, Passengers. Extra-Peninsular"
$sSD_{DSTRA_{PAS_{INT}}}$	Mpkm-INT "Transportation, Passengers. International"
$sSD_{DSTRA_{FRE_{URBN}}}$	Mtkm-urb "Transportation, Freight. Urban (less than 50km). Includes peninsular and extrapeninsular"
$sSD_{DSTRA_{FRE_{G50}}}$	Mtkm-G50 "Transportation, Freight. Interurban longer than 50. Includes peninsular and extrapeninsular"
$sSD_{DSTRA_{FRE_{G500}}}$	Mtkm-G500 "Transportation, Freight. Continental longer than 500"
$sSD_{DSTRA_{FRE_{EXP}}}$	Mtkm-EXP "Transportation, Freight. Extra-Peninsular"
$sSD_{DSTRA_{FRE_{INT}}}$	Mtkm-INT "Transportation, Freight. International"
$sSD_{DSOTH_{RES_{HE}}}$	M Dwelling "M Dwelling, High Energy Efficient"
$sSD_{DSOTH_{RES_{LE}}}$	M Dwelling "M Dwelling, Low Energy Efficiency"
$sSD_{DSOTH_{SRV_{HE}}}$	km2 "km2 service/commercial surface, High Energy Efficient"
$sSD_{DSOTH_{SRV_{LE}}}$	km2 "km2 service/commercial surface, Low Energy Efficient"
$sSD_{DSIND_{IAL}}$	kt "Industry, Aluminium"
$sSD_{DSIND_{IIS}}$	kt "Industry, Iron and Steel"
$sSD_{DSIND_{ICU}}$	kt "Industry, Copper"
$sSD_{DSIND_{IAM}}$	kt "Industry, Ammonia"
$sSD_{DSIND_{ICL}}$	kt "Industry, Chlorine"
$sSD_{DSIND_{ICM}}$	kt "Industry, Cement"
$sSD_{DSIND_{ILM}}$	kt "Industry, Lime"
$sSD_{DSIND_{IGH}}$	kt "Industry, Glass Hollow"
$sSD_{DSIND_{IGF}}$	kt "Industry, Glass Flat"
$sSD_{DSIND_{IPP}}$	kt "Industry, Pulp and Paper"
sSD_{Tra}	- Service Demand Commodities
$sSD_{Tra_{Car}}$	- Service Demand Commodities. Transportation. Car
$sSD_{Tra_{Moped}}$	- Service Demand Commodities. Transportation. Moped
$sSD_{Tra_{Bus}}$	- Service Demand Commodities. Transportation. Bus
$sSD_{Tra_{UrbanRail}}$	- Service Demand Commodities. Transportation. Urban Rail
$sSD_{Tra_{IntRail}}$	- Service Demand Commodities. Transportation. Intercity Rail
$sSD_{Tra_{Air}}$	- Service Demand Commodities. Transportation. Air
$sSD_{Tra_{Sea}}$	- Service Demand Commodities. Transportation. Sea
$sSD_{Tra_{RoadFreight}}$	- Service Demand Commodities. Transportation. Road Freight
sSD_{Oth}	- Service Demand Commodities. Others
$sSD_{Oth_{HE}}$	- Service Demand Commodities. Others. High Efficiency
$sSD_{Oth_{LE}}$	- Service Demand Commodities. Others. Low Efficiency

MD Macro Data:

sMD	- Macro Data by sector
$sMD_{RES_{DWE_{ATL_{BL}}}}$	M Residential Dwelling in Atlantic climatic zone. Block building -
$sMD_{RES_{DWE_{ATL_{SH}}}}$	M Residential Dwelling in Atlantic climatic zone. Single-house -
$sMD_{RES_{DWE_{CON_{BL}}}}$	M Residential Dwelling in Continental climatic zone. Block building -
$sMD_{RES_{DWE_{CON_{SH}}}}$	M Residential Dwelling in Continental climatic zone. Single-house -

$sMD_{RES_{DWE_{MED_{BL}}}}$ M Residential Dwelling in Mediterranean climatic zone. Block building -

$sMD_{RES_{DWE_{MED_{SH}}}}$ M Residential Dwelling in Mediterranean climatic zone. Single-house -

$sMD_{SRV_{km2_{ATL}}}$ km2 commercial surface in Atlantic climatic zone -

$sMD_{SRV_{km2_{CON}}}$ km2 commercial surface in Continental climatic zone -

$sMD_{SRV_{km2_{MED}}}$ km2 commercial surface in Mediterranean climatic zone -

$sMD_{TRA_{PAS_{URB}}}$ M Passengers from urban areas -

$sMD_{TRA_{PAS_{RUR}}}$ M Passengers from rural areas -

$sMD_{TRA_{FRE}}$ Mt freight -

$sMD_{IND_{IAL}}$ kt -

$sMD_{IND_{IIS}}$ kt -

$sMD_{IND_{ICU}}$ kt -

$sMD_{IND_{IAM}}$ kt -

$sMD_{IND_{ICL}}$ kt -

$sMD_{IND_{ICM}}$ kt -

$sMD_{IND_{ILM}}$ kt -

$sMD_{IND_{IGH}}$ kt -

$sMD_{IND_{IGF}}$ kt -

$sMD_{IND_{IPP}}$ kt -

sMD_{Tra} - Macro Data by sector. Transportation

sMD_{Oth} - Macro Data by sector. Others

sMD_{Ind} - -

BM Behavioral Measures:

sBM - Behavioural Measures

$sBM_{Tra_{VAO}}$ - Bus-VAO

$sBM_{Tra_{Edu}}$ - Educational programmes

$sBM_{Tra_{Toll}}$ - Tolls

$sBM_{Oth_{Deg}}$ - 1ºC

sBM_{Tra} - Behavioural Measures in Transportation

sBM_{Oth} - Behavioural Measures in Others

DM Demand Shift Measures:

sDM - Demand shift Measures

$sDM_{Tra_{TW}}$ - Telework

$sDM_{Tra_{15M}}$ - 15 min city

$sDM_{Oth_{Ins}}$ - Thermal insulation

sDM_{Tra} - Demand shift Measures in Transportation

sDM_{Oth} - Demand shift Measures

Variables:

$vSysCost$ [G€ Total System cost

$vOpVarom$ [G€ Annual Total cost

$vTotalCost$ [G€ Annual Behavioural Measures cost

$vBMCost$ [G€ Annual Demand shift Measures cost

$vDMCost$ [G€ Annual Penalization cost

$vPenalCost$ [G€ Annual Total CE investment cost

$vInvCostCE$ [G€ Annual Total ST investment cost

$vInvCostST$ [M€ Annual Total operation cost

$vOpCost$ [k€ Annual Total Varom cost

$vQPEDom$ [GWh PE domestic consumption

$vQPEImp$	[GWh PE imports
$vQCEPriIN$	[GWh PE consumed by CE techs
$vQCEPriOUT$	[GWh TE produced in CE techs from PE energy
$vQCESecIN$	[GWh TE consumed by CE techs
$vQCESecOUT$	[GWh TE produced in CE techs from TE energy
$vQCEStoIN$	nan TE stored by Storage techs")
$vQCEStoOUT$	[GWh TE released in Storage techs from TE energy
$vCEStoLevel$	[GWh Accumulated energy stored in Storage processes
$vQTELoss$	[GWh TE losses in transportation processes
$vQSTInTE$	[GWh TE consumed by ST
$vQSTInRM$	[Tons RM consumed by ST (industrial)
$vQSTOut$	[ES units ES produced by ST
$vQESNS$	[ES units ES not supplied (slack variable)
$vQES$	[ES units ES
$vBMTra$	[ES units Behavioural Measures. Transportation
$vBMOth$	[ES units Behavioural Measures. Others
$vBMOth_{WAMAC}$	[ES units Behavioural Measures. Others. Cold cycle Washing Machine
$vBMOth_{DIWAC}$	[ES units Behavioural Measures. Others. Cold cycle Dish Washer
$vBMOth_{TW}$	[ES units Behavioural Measures. Others. Telework
$vDMTra$	[SD units Transportation SD
$vDMOth_{HE}$	[SD units Others SD
$vDMOth_{LE}$	[SD units Industrial SD
$vQSDTra$	[SD units DMTra
$vQSDOth$	[SD units DMOth HE
$vQSDInd$	[SD units DMOth LE
$vCENewCap$	[GW CE new installed capacity
$vCETotCap$	[GW CE accumulated installed capacity
$vCEDecCap$	[GW CE decommisioned capacity
$vCEActCap$	[GW Active CE capacity
$vCEHibCap$	[GW CE capacity in hibernation
$vCEDeltaActCap$	[GW Reactivation of CE inactive capacity
$vCEEleReserv$	[GW CE electricity reserves
$vEleMaxDem$	[GW Yearly maximum electricity demand in a time slice
$vSTNewCap$	[GW ST new installed capacity
$vSTDecCap$	[GW ST decommissioned capacity
$vSTTotCap$	[GW ST accumulated installed capacity
$vEmiCO2CE$	[ktCO2 CO2 emissions produced in CE processes
$vEmiCO2CEPri$	[ktCO2 CO2 emissions produced in Primary CE processes
$vEmiCO2CESec$	[ktCO2 CO2 emissions produced in Secondary CE processes
$vEmiCO2CESto$	[ktCO2 CO2 emissions produced in Storage CE processes
$vEmiCO2TE$	[ktCO2 CO2 emissions produced in the transportation of TE
$vEmiCO2STTE$	[ktCO2 CO2 emissions produced in ST due to TE consumption
$vEmiCO2STPro$	[ktCO2 CO2 emissions produced in ST due to activity processes
$vEmiCO2ST$	[ktCO2 CO2 emissions produced in ST
$vEmiCO2ESNS$	[ktCO2 CO2 emissions related to ESNS
$vEmiCO2Tot$	[MtCO2 Annual Total CO2 emissions
$vEmiCO2CapExc$	[MtCO2 Excess of CO2 emissions regarding Carbon Cap 2050 onwards (slack variable)
$vEmiCO2BudgetExc$	[MtCO2 Excess of CO2 emissions regarding Carbon Budget (slack variable)
$vEmiNOxCE$	[ktNOx NOx emissions produced in CE processes
$vEmiNOxCEPri$	[tNOx NOx emissions produced in Primary CE processes
$vEmiNOxCESec$	[tNOx NOx emissions produced in Secondary CE processes
$vEmiNOxCESto$	[tNOx NOx emissions produced in Storage CE processes

vEmiNOxSTTE [tNOx NOx emissions produced in ST due to TE consumption
vEmiNOxSTPro [tNOx NOx emissions produced in ST due to activity processes
vEmiNOxST [ktNOx NOx emissions produced in ST
vEmiNOxESNS [ktNOx NOx emissions related to ESNS
vEmiNOxTot [MtNOx Total NOx emissions produced yearly
vEmiNOxCapExc [MtNOx Excess of NOx emissions regarding cap 2050 onwards (slack variable)
vEmiSOxCE [ktSOx SOx emissions produced in CE processes
vEmiSOxCEPri [tSOx SOx emissions produced in Primary CE processes
vEmiSOxCESec [tSOx SOx emissions produced in Secondary CE processes
vEmiSOxCESto [tSOx SOx emissions produced in Storage CE processes
vEmiSOxSTTE [tSOx SOx emissions produced in ST due to TE consumption
vEmiSOxSTPro [tSOx SOx emissions produced in ST due to activity processes
vEmiSOxST [ktSOx SOx emissions produced in ST
vEmiSOxESNS [ktSOx SOx emissions related to ESNS
vEmiSOxTot [MtSOx Total SOx emissions produced yearly
vEmiSOxCapExc [MtSOx Excess of SOx emissions regarding cap 2050 onwards (slack variable)
vEmiPM25CE [ktPM25 PM25 emissions produced in CE processes
vEmiPM25CEPri [tPM25 PM25 emissions produced in Primary CE processes
vEmiPM25CESec [tPM25 PM25 emissions produced in Secondary CE processes
vEmiPM25CESto [tPM25 PM25 emissions produced in Storage CE processes
vEmiPM25STTE [tPM25 PM25 emissions produced in ST due to TE consumption
vEmiPM25STPro [tPM25 PM25 emissions produced in ST due to activity processes
vEmiPM25ST [ktPM25 PM25 emissions produced in ST
vEmiPM25ESNS [ktPM25 PM25 emissions related to ESNS
vEmiPM25Tot [MtPM25 Excess of PM25 emissions regarding cap 2050 onwards (slack variable)
vEmiPM25CapExc [MtPM25 Total PM25 emissions produced yearly
vEmiCO2CapTraExc [MtCO2 Excess of CO2 emissions regarding Carbon Cap in Transport sector (slack variable)
vEmiCO2CapEleExc [MtCO2 Excess of CO2 emissions regarding Carbon Cap in Electricity generation (slack variable)
vEmiCO2CapIndTEExc [MtCO2 Excess of CO2 emissions regarding Carbon Cap in Industrial sector (energy) (slack variable)
vEmiCO2CapIndProExc [MtCO2 Excess of CO2 emissions regarding Carbon Cap in Industrial sector (process) (slack variable)
vEmiCO2CapOthExc [MtCO2 Excess of CO2 emissions regarding Carbon Cap in Residential and Service sector (slack variable)
vEmiCO2CapRefExc [MtCO2 Excess of CO2 emissions regarding Carbon Cap in Refinery sector (slack variable)

Relational Sets:

sQCEPriIN Relational set: Input PE to Primary CE
sQCEPriOUT Relational set: Primary CE to Output TE
sQCESecIN Relational set: Input TE to Secondary CE
sQCESecOUT Relational set: Secondary CE to Output TE
sQCEStoIN Relational set: Input TE to Storage CE
sQCEStoOUT Relational set: Storage CE to Output TE
sQESSD Relational set: ES to Output SD
$sQESSDMD_{Oth}$ Relational set: ES to SD to MD. Others
sQSDMD Relational set: SD to Output MD
$sQSDMD_{Oth}$ Relational set: SD to Output MD. Others
$sQSDMD_{Res}$ Relational set: SD to Output MD.
$sQSDMD_{Tra}$ Relational set: SD to Output MD. Tra
sQSTESSD Relational set: ST to ES to SD
$sQSTESSD_{Tra}$ Relational set: ST to ES to SD. Transportation
sQSTInRM Relational set: Input RM to ST
$sQSTInRM_{Cir}$ Relational set: Input RM to ST. Circularity processes.
sQSTInTE Relational set: Input TE to ST
sQSTOUT Relational set: ST to Output ES
$sQSTOUT_{Ind}$ Relational set: ST to Output ES. Industry
$sQSTOUT_{Oth}$ Relational set: ST to Output ES. Others

$sQSTOUT_{Tra}$	Relational set: ST to Output ES. Transportation
$sQTESTES$	Relational set: TE to ST to ES
$sQTESTES_{Ele}$	Relational set: Electricity(TE) to ST to ES
$sQTESTES_{Ind}$	Relational set: Industry(TE) to ST to ES

PARAMETERS

pYr	[years] Year numbers
pYrGap	[years] Year gap
pTimeSlice	[
pNumHours	[hours] Number of hours in the time period
pDisRate	[
pGreenfield	- GreenField=1 — BrownField=0
pESNSCost	[M€ per ES units] Energy service non supplied cost
pEmiCO2Cost	[€ per tCO2] DEACTIVATED CO2 emission cost
pEmiCO2CapSectRestr	- Emission Sectorial Cap=1 — Emission Global Cap=0
pEmiCO2BudgetRestr	- CO2 emission budget =1 — CO2 emission cap=0
pCEResMar	[
pCEDemErr	[
pCEAFErr	[
pCEFailProb	[
pCEFailCap	[GW] Larger CE capacity to be considered for reserves restriction: the size, in GW, of the larger plant that can fail
pEmiCO2Budget	[MtCO2] CO2 emission budget
pEmiCO2Cap	[MtCO2 per year] CO2 emission cap per year
pEmiNOxCap	[MtNOx per year] NOx emission cap per year
pEmiSOxCap	[MtSOx per year] SOx emission cap per year
pEmiPM25Cap	[MtPM25 per year] PM25 emission cap per year
pEmiCO2CapTra	[MtCO2 per year] Transport sector emission cap per year
pEmiCO2CapEle	[MtCO2 per year] Electricity generation emission cap per year
pEmiCO2CapIndTE	[MtCO2 per year] Industry (energy) sector emission cap per year
pEmiCO2CapIndPro	[MtCO2 per year] Industry (process) sector emission cap per year
pEmiCO2CapOth	[MtCO2 per year] Residential and Commercial sector emission cap per year
pEmiCO2CapRef	[MtCO2 per year] Refinery sector emission cap per year
pEmiCO2CEPri	[tCO2 per MWh] Primary CE CO2 emission factor
pEmiCO2CESec	[tCO2 per MWh] Secondary CE CO2 emission factor
pEmiCO2CESto	[tCO2 per MWh] Storage CE CO2 emission factor
pEmiCO2STTE	[tCO2 per MWh] ST CO2 Energy emission factor
pEmiCO2STPro	[tCO2 per MWh] ST CO2 Process emission factor
pEmiCO2TE	[tCO2 per MWh] TE Transportation CO2 emission factor
pEmiCO2ESNS	[tCO2 per MWh] ENS CO2 emission factor
pEmiNOxCEPri	[kNOx per MWh] Primary CE NOx emission factor
pEmiNOxCESec	[kNOx per MWh] Secondary CE NOx emission factor
pEmiNOxCESto	[kNOx per MWh] Storage CE NOx emission factor
pEmiNOxSTTE	[kNOx per MWh] ST NOx Energy emission factor
pEmiNOxSTPro	[kNOx per MWh] ST NOx Process emission factor
pEmiNOxESNS	[kNOx per MWh] ENS NOx emission factor
pEmiSOxCEPri	[kSOx per MWh] Primary CE SOx emission factor
pEmiSOxCESec	[kSOx per MWh] Secondary CE SOx emission factor
pEmiSOxCESto	[kSOx per MWh] Storage CE SOx emission factor
pEmiSOxSTTE	[kSOx per MWh] ST SOx Energy emission factor
pEmiSOxSTPro	[kSOx per MWh] ST SOx Process emission factor
pEmiSOxESNS	[kSOx per MWh] ENS SOx emission factor
pEmiPM25CEPri	[kPM25 per MWh] Primary CE PM25 emission factor
pEmiPM25CESec	[kPM25 per MWh] Secondary CE PM25 emission factor
pEmiPM25CESto	[kPM25 per MWh] Storage CE PM25 emission factor
pEmiPM25STTE	[kPM25 per MWh] ST PM25 Energy emission factor
pEmiPM25STPro	[kPM25 per MWh] ST PM25 Process emission factor
pEmiPM25ESNS	[kPM25 per MWh] ENS PM25 emission factor

$pPECost$	[€ per MWh] PE Cost
$pPEDomCap$	[GW] PE domestic consumption capacity
$pPEImpCap$	[GW] PE importation capacity
$pCEOutShareMin$	[
$pCEOutShareMax$	[
$pCEPriEff$	[
$pCESecEff$	[
$pCEStoEff$	[
$pCELife$	[years] Life span of energy technologies
$pCEInsCap$	[GW] Previous installed capacity of CE
$pCEMaxCap$	[GW] Maximum allowed capacity of CE
$pCEStoCap$	[MWh] Storage capacity in terms of energy
$pCECapex$	[€ per kW] CAPEX of CE Conversion technologies
$pCEDecom$	[€ per kW] Decommission cost of CE
$pCEFixom$	[€ per kW] Fixed O & M costs of CE
$pCEVarom$	[€ per MWh] Variable O & M costs of CE
$pCEReact$	[€ per kW] Cost of Reactivation from hibernation of CE Conversion technologies
$pCEHiber$	[€ per kW] Cost of Hibernation of active CE Conversion technologies
$pCEAF$	[
$pCEFlex$	[
$pCEFirm$	[
$pTELoss$	[
$pRMCost$	[€ per ton] RM Raw material cost
$pRMCircular$	[
$pSTOutShareMin$	[
$pSTOutShareMax$	[
$pSTTra_{MS}$	[
$pMSMax$	[
$pTCMax$	[
$pSTEffTE$	[MWh per ES unit] TE final energy required to produce one unit of ES
$pSTEffRM$	[tons RM per ES unit] RM raw materials required to produce one unit of ES
$pSTInsCap$	[ST units] Previous installed capacity of ST
$pSTMaxCap$	[ST units] Maximum allowed capacity of ST
$pSTMaxPro$	[ES units per ST units] Maximum annual production of ST
$pSTCapex$	[M€ per ST unit] CAPEX of ST technologies
$pSTDecom$	[M€ per ST unit] Decommission cost of ST
$pSTDecProb$	[
$pSTFixom$	[€ per ST unit] Fixed O & M costs of ST
$pSTVarom$	[€ per ES unit] Variable O & M costs of ST
$pESLoad$	[
$pAFTra$	[passengers/vehicles] Occupancy rate
$pAFOth$	[ES unit per Mdwelling or km2] Representative energy service demands per dwelling
$pAFInd$	[
$pBMCost$	[G€ per AF unit] Cost of Behavioural Measures
$pDeltaAFTra$	[passengers/vehicles] Maximum improvement allowed of occupancy rate per behavioural measure
$pDeltaAFOth$	[ES unit per Mdwelling or km2] Maximum improvement allowed of energy service demand per behavioural measure
pDC	[-] Demand characterization
$pDMCost$	[G€ per unit of DC] Cost of Demand shift Measures
$pDeltaDC$	[-] Maximum improvement allowed of DC per Demand shift Measures
pTW	[ES unit per Mpkm] Remote work: Trade-off between residental energy service increase and transportation demand decrease
pMD	[MD units] Macro Data

EQUATIONS

Objective Function

Total System Cost [G€] :
$$vSysCost = \sum_{sYear \in sYear} (3) + \sum_{sYear \in sYear} (4) + \sum_{(sBM,sYear) \in sBM * sYear} (5) + \sum_{(sDM,sYear) \in sDM * sYear} (6) + pEmiCO2BudgetRestr * vEmiCO2BudgetExc \quad (1)$$

Discount Factor :
$$DF = \frac{1}{((1 + pDisRate)^{(pYrGap*(sYear.ord(sYear)-1))})} \quad (2)$$

Penalization Cost [G€] :
$$\begin{aligned} vPenalCost_{sYear} = {} & pYrGap * (2) * 1e^{-2} * pESNSCost * (\\ & + (1 - pEmiCO2CapSectRestr) * (1 - pEmiCO2BudgetRestr) * vEmiCO2CapExc_{sYear} \\ & + pEmiCO2CapSectRestr * (1 - pEmiCO2BudgetRestr) \\ & * \sum_{sYear \in sYear} (vEmiCO2CapTraExc_{sYear} + vEmiCO2CapEleExc_{sYear} + vEmiCO2CapIndTEExc_{sYear} \\ & + vEmiCO2CapIndProExc_{sYear} + vEmiCO2CapOthExc_{sYear} + vEmiCO2CapRefExc_{sYear}) \\ & + \sum_{sYear \in sYear} (vEmiNOxCapExc_{sYear} + vEmiSOxCapExc_{sYear} + vEmiPM25CapExc_{sYear})) \end{aligned} \quad (3)$$

Annual Total Cost [G€] :
$$vTotalCost_{sYear} = \sum_{sCE \in sCE} (7) + \sum_{sST \in sST} (8) + (9) \cdot 1e^{-3} \quad (4)$$

BM Cost [G€/y] :
$$\begin{aligned} vBMCost_{sBM,sYear} = {} & (2) \cdot (\\ & \sum_{\substack{sST_{Tra},sES_{Tra},sSD_{Tra} \in sQSTESSD_{Tra} \\ \forall sBM \in sBM_{Tra}}} pBMCost_{sBM,sYear} \cdot vBMTra_{sST_{Tra},sES_{Tra},sSD_{Tra},sBM,sYear} \\ & + \sum_{\substack{sES_{Oth},sSD_{Oth},sMD_{Oth} \in sQESSDMD_{Oth} \\ \forall sBM \in sBM_{Oth}}} pBMCost_{sBM,sYear} \cdot vBMOth_{sES_{Oth},sSD_{Oth},sMD_{Oth},sBM,sYear}) \end{aligned} \quad (5)$$

DM Cost [G€/y] :
$$\begin{aligned} vDMCost_{sDM,sYear} = {} & (2) \cdot (\\ & \sum_{\substack{sSD_{Tra},sMD_{Tra} \in sQSDMD_{Tra} \\ \forall sDM \in sDM_{Tra}}} pDMCost_{sDM,sYear} \cdot vDMTra_{sSD_{Tra},sMD_{Tra},sDM,sYear} \\ & + \sum_{\substack{sMD_{Oth} \in sMD_{Oth} \\ \forall sDM \in sDM_{Oth}}} pDMCost_{sDM,sYear} \cdot (vDMOth_{HE\,sMD_{Oth},sDM,sYear} - vDMOth_{HE\,sMD_{Oth},sDM,\forall sYear \neq sYear[0]}^{sYear-1})) \end{aligned} \quad (6)$$

Total CE Inv Cost [G€/y] :
$$\begin{aligned} vInvCostCE_{sCE,sYear} = {} & (2) \cdot (pCECapex_{sCE,sYear} \cdot vCENewCap_{sCE,sYear} \\ & + pCEDecom_{sCE,sYear} \cdot vCEDecCap_{sCE,sYear} + pCEReact_{sCE,sYear} \cdot vCEDeltaActCap_{sCE,sYear}) \cdot 1e^{-3} \end{aligned} \quad (7)$$

Total ST Inv Cost [G€/y] :
$$\begin{aligned} vInvCostST_{sST,sYear} = {} & (2) \cdot (pSTCapex_{sST,sYear} \cdot vSTNewCap_{sST,sYear} \\ & + pSTDecom_{sST,sYear} \cdot \sum_{\substack{sVin \in sVin \\ (sVin,sYear) \in sVinYear}} vSTDecCap_{sST,sVin,sYear}) \cdot 1e^{-3} \end{aligned} \quad (8)$$

Total Op Cost [M€/y] :
$$\begin{aligned} vOpCost_{sYear} = {} & pYrGap \cdot (2) \cdot (\sum_{sPE,sSeason,sDay,sHour} pPECost_{sPE,sYear} \cdot (\\ & vQPEImp_{sPE,sYear,sSeason,sDay,sHour} + vQPEDom_{sPE,sYear,sSeason,sDay,sHour}) \\ & + 1e^{3} \sum_{sCE \in sCE} pCEFixom_{sCE} \cdot vCEActCap_{sCE,sYear} \\ & + 1e^{3} \sum_{(\_,sRM,sST,sES,sVin,sSeason,sDay,sHour) \in sQSTInRM} pRMCost_{sRM,sYear} \cdot vQSTInRM_{sRM,sST,sES,sVin,sYear,sSeason,sDay,sHour} \\ & + 1e^{-3} \sum_{(\_,sST,sVin) \in sQSTVin} pSTFixom_{sST} \cdot vSTTotCap_{sST,sVin,sYear} \\ & + 1e^{-3} \sum_{(\_,sST,sES,sVin,sSeason,sDay,sHour) \in sQSTOUTVinTime} pSTVarom_{sST,sES} \cdot vQSTOut_{sST,sES,sVin,sYear,sSeason,sDay,sHour} \\ & + vOpVarom_{sYear}) \cdot 1e^{-3} \end{aligned} \quad (9)$$

Total Varom Cost [k€/y] :
$$\begin{aligned} vOpVarom_{sYear} = {} & \sum_{(\_,sCE,sTE,sSeason,sDay,sHour) \in sQCEPriOUT} pCEVarom_{sCE,sTE} \cdot \left(vQCEPriOUT_{sCE,sTE,sYear,sSeason,sDay,sHour}\right) \\ & + \sum_{(\_,sCE,sTE,sSeason,sDay,sHour) \in sQCESecOUT} pCEVarom_{sCE,sTE} \cdot \left(vQCESecOUT_{sCE,sTE,sYear,sSeason,sDay,sHour}\right) \\ & + \sum_{(\_,sCE,sTE,sSeason,sDay,sHour) \in sQCEStoOUT} pCEVarom_{sCE,sTE} \cdot (vQCEStoOUT_{sCE,sTE,sYear,sSeason,sDay,sHour}) \end{aligned} \quad (10)$$

Restrictions
Primary Energy (PE) Related Constraints

PE domestic production capacity [GWh] :

$$pPEDomCap_{sPE} * pNumHours * pTimeSlice_{sSeason,sDay,sHour} \geq vQPEDom_{sPE,sYear,sSeason,sDay,sHour} \quad (11)$$

PE importation capacity [GWh] :

$$pPEImpCap_{sPE} * pNumHours * pTimeSlice_{sSeason,sDay,sHour} \geq vQPEImp_{sPE,sYear,sSeason,sDay,sHour} \quad (12)$$

PE energy balance [GWh] :

$$vQPEDom_{sPE,sYear,sSeason,sDay,sHour} + vQPEImp_{sPE,sYear,sSeason,sDay,sHour} = \sum_{(,sCE)\in sQCEPriIN} vQCEPriIN_{sPE,sCE,sYear,sSeason,sDay,sHour} \quad (13)$$

Primary Conversion Energy (CEPri) related contraints

Balance for Primary CE techs (using PE commodities) [GWh]:

$$\sum_{\substack{sPE \in sPE \\ \forall (sPE, sCEPri) \in sQCEPriIN}} vQCEPriIN_{(sPE,sCEPri),sYear,sSeason,sDay,sHour} * pCEPriEff_{(sPE,sCEPri)} = \sum_{\substack{sTE \in sTE \\ \forall (sCEPri,sTE) in sQCEPriOUT}} vQCEPriOUT_{(sCEPri,sTE),sYear,sSeason,sDay,sHour} \quad (14)$$

Minimum CE output shares restriction [GWh]:

$$vQCEPriOUT_{(sCEPri,sTE),sYear,sSeason,sDay,sHour} \geq pCEOutShareMin_{(sCEPri,sTE)} \sum_{(\_,sTE) \in sQCEPriOUT_{sCEPri}} vQCEPriOUT_{(sCEPri,sTE),sYear,sSeason,sDay,sHour} \quad (15)$$

Maximum CE output shares restriction [GWh]:

$$pCEOutShareMax_{(sCEPri,sTE)} \sum_{(\_,sTE) \in sQCEPriOUT_{sCEPri}} vQCEPriOUT_{(sCEPri,sTE),sYear,sSeason,sDay,sHour} \geq vQCEPriOUT_{(sCEPri,sTE),sYear,sSeason,sDay,sHour} \quad (16)$$

Secondary Conversion Energy (CESec) related contraints

Balance for CE techs using TE commodities [GWh]:

$$\sum_{\substack{sTE \in sTE \\ \forall (sTE, sCESec) \in sQCESecIN}} vQCESecIN_{(sTE,sCESec),sYear,sSeason,sDay,sHour} * pCESecEff_{(sTE,sCESec)} = \sum_{\substack{sTE \in sTE \\ \forall (sCESec,sTE) in sQCESecOUT}} vQCESecOUT_{(sCESec,sTE),sYear,sSeason,sDay,sHour} \quad (17)$$

Minimum CE output shares restriction [GWh]:

$$vQCESecOUT_{(sCESec,sTE),sYear,sSeason,sDay,sHour} \geq pCEOutShareMin_{(sCESec,sTE)} * \sum_{(\_,sTE) \in sQCESecOUT_C E_{sCESec}} vQCESecOUT_{(sCESec,sTE),sYear,sSeason,sDay,sHour} \quad (18)$$

Maximum CE output shares restriction [GWh]:

$$pCEOutShareMax_{(sCESec,sTE)} * \sum_{(\_,sTE) \in sQCESecOUT_C E_{sCESec}} vQCESecOUT_{(sCESec,sTE),sYear,sSeason,sDay,sHour} \geq vQCESecOUT_{(sCESec,sTE),sYear,sSeason,sDay,sHour} \quad (19)$$

Storage (CESto) related contraints

Bal for sto seasonal representative-day [GWh] :

$$\sum_{\substack{(sTE,sDay,sHour) \in sTE*sDay*sHour \\ \forall (sTE,sCESto) \in sQCEStoIN}} vQCEStoIN_{(sTE,sCESto),sYear,sSeason,sDay,sHour} = \sum_{\substack{(sTE,sDay,sHour) \in sTE*sDay*sHour \\ \forall (sCESto,sTE) \in sQCEStoOUT}} vQCEStoOUT_{(sCESto,sTE),sYear,sSeason,sDay,sHour} \quad (20)$$

Storage level calculation [GWh] :

$$\begin{aligned} vCEStoLevel_{sCESto,sYear,sSeason,sDay,sHour} &= vCEStoLevel_{sCESto,sYear,sSeason,sDay,sHour-1\,(\forall sHour \neq sHour[0])} \\ &+ vCEStoLevel_{sCESto,sYear,sSeason,sDay-1,sHour[last]\,(\forall sHour=sHour[0] \wedge sDay \neq sDay[0])} \\ &+ vCEStoLevel_{sCESto,sYear,sSeason,sDay[last],sHour[last]\,(\forall sHour=sHour[0] \wedge sDay=sDay[0])} \\ &+ \sum_{\substack{sTE \in sTE \\ \forall (sTE,sCESto) \in sQCEStoIN}} vQCEStoIN_{(sTE,sCESto),sYear,sSeason,sDay,sHour} * pCEStoEff_{sTE,sCESto} \\ &- \sum_{\substack{sTE \in sTE \\ \forall (sCESto,sTE) \in sQCEStoOUT}} vQCEStoOUT_{(sCESto,sTE),sYear,sSeason,sDay,sHour} \end{aligned} \quad (21)$$

Minimum Storage output shares [GWh] :

$$vQCEStoOUT_{(sCESto,sTE),sYear,sSeason,sDay,sHour} \geq pCEOutShareMin_{(sCESto,sTE)} * \sum_{(,sTE) \in sQCEStoOUTCE} vQCEStoOUT_{(sCESto,sTE),sYear,sSeason,sDay,sHour} \quad (22)$$

Maximum Storage output shares [GWh] :

$$pCEOutShareMax_{(sCESto,sTE)} * \sum_{(,sTE) \in sQCEStoOUTCE} vQCEStoOUT_{(sCESto,sTE),sYear,sSeason,sDay,sHour} \geq vQCEStoOUT_{(sCESto,sTE),sYear,sSeason,sDay,sHour} \quad (23)$$

Storage maximum level restriction [GWh] :

$$pCEStoCap_{sCESto} \geq vCEStoLevel_{sCESto,sYear,sSeason,sDay,sHour} \quad (24)$$

Transported Energy (TE)-related constraints

$$\textbf{Balance for TE [GWh]}: \sum_{,sCE \in sQCEPriOUT} vQCEPriOUT_{(sCE,sTE),sYear,sSeason,sDay,sHour} + \sum_{,sCE \in sQCESecOUT} vQCESecOUT_{(sCE,sTE),sYear,sSeason,sDay,sHour} + \sum_{,sCE \in sQCEStoOUT} vQCEStoOUT_{(sCE,sTE),sYear,sSeason,sDay,sHour} - \sum_{(,sCE) \in sQCESecIN} vQCESecIN_{(sTE,sCE),sYear,sSeason,sDay,sHour} - \sum_{(,sCE) \in sQCEStoIN} vQCEStoIN_{(sTE,sCE),sYear,sSeason,sDay,sHour} - vQTELoss_{sTE,sYear,sSeason,sDay,sHour} \geq \sum_{(,,sST,sES,\in sSTESVin)} vQSTInTE_{sTE,sST,sES,sVin,sYear,sSeason,sDay,sHour} \quad (25)$$

$$\textbf{TE losses for transportation processes [GWh]}: vQTELoss_{sTE,sYear,sSeason,sDay,sHour} = pTELoss_{sTE} \cdot (\sum_{(,sCE) \in sQCEPriOUT} vQCEPriOUT_{sCE,sTE,sYear,sSeason,sDay,sHour} + \sum_{(,sCE) \in sQCESecOUT} vQCESecOUT_{sCE,sTE,sYear,sSeason,sDay,sHour} + \sum_{(,sCE) \in sQCEStoOUT} vQCEStoOUT_{sCE,sTE,sYear,sSeason,sDay,sHour}) \quad (26)$$

Supply Technologies (ST)-related constraints

$$\textbf{Balance for ST consumption of TE [Tra ES units]}: \sum_{(,,sTE)\in sQTESTES_{STES}} \frac{vQSTInTE_{sTE,sST_{Tra},sES_{Tra},sVin,sYear,sSeason,sDay,sHour}}{pSTEffTE_{sST_{Tra},sES_{Tra},sTE,sVin}} = vQSTOut_{sST_{Tra},sES_{Tra},sVin,sYear,sSeason,sDay,sHour} \quad (27)$$

$$\textbf{Balance for ST consumption of TE [Oth ES units]}: \sum_{(,,sTE)\in sQTESTES_{STES}} \frac{vQSTInTE_{sTE,sST_{Oth},sES_{Oth},sVin,sYear,sSeason,sDay,sHour}}{pSTEffTE_{sST_{Oth},sES_{Oth},sTE,sVin}} = vQSTOut_{sST_{Oth},sES_{Oth},sVin,sYear,sSeason,sDay,sHour} \quad (28)$$

$$\textbf{Balance for ST consumption of TE [Ind ES units]}: \sum_{(,,sTE)\in sQTESTES_{STES}} \frac{vQSTInTE_{sTE,sST_{Ind},sES_{Ind},sVin,sYear,sSeason,sDay,sHour}}{pSTEffTE_{sST_{Ind},sES_{Ind},sTE,sVin}} = vQSTOut_{sST_{Ind},sES_{Ind},sVin,sYear,sSeason,sDay,sHour} \quad (29)$$

$$\textbf{Minimum ST output shares restriction [ES units]}: vQSTOut_{sST,sES,sVin,sYear,sSeason,sDay,sHour} \geq pSTOutShareMin_{sST,sES} \cdot \sum_{(,sES)\in sQSTOUT} vQSTOut_{sST,sES,sVin,sYear,sSeason,sDay,sHour} \quad (30)$$

$$\textbf{Maximum ES output shares restriction [ES units]}: vQSTOut_{sST,sES,sVin,sYear,sSeason,sDay,sHour} \leq pSTOutShareMax_{sST,sES} \cdot \sum_{(,sES)\in sQSTOUT} vQSTOut_{sST,sES,sVin,sYear,sSeason,sDay,sHour} \quad (31)$$

Transport Modal Shift (O la relación entre ST-ES-SD-MD-AF-DC)

Minimum ST output shares restriction Cars [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{Car}} \in sQSTOUTAFTraCar} vQES_{sST_{Tra_{Car}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{Car}},sES_{Tra},sSD_{Tra_{Car}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Car}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\geq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{Car}}) \in sQSTOUTAFTraCar} vQES_{sST_{Tra_{Car}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{Car}},sES_{Tra},sSD_{Tra_{Car}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Car}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} - 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'Car',sSD_{Tra_{Car}}} \right)_{\forall sYear = sYear[0]} \quad (32)$$

Maximum ST output shares restriction Cars [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{Car}} \in sQSTOUTAFTraCar} vQES_{sST_{Tra_{Car}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{Car}},sES_{Tra},sSD_{Tra_{Car}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Car}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\leq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{Car}}) \in sQSTOUTAFTraCar} vQES_{sST_{Tra_{Car}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{Car}},sES_{Tra},sSD_{Tra_{Car}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Car}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} + 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'Car',sSD_{Tra_{Car}}} \right)_{\forall sYear = sYear[0]} \quad (33)$$

Minimum ST output shares restriction Bus [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{Bus}} \in sQSTOUTAFTraBus} vQES_{sST_{Tra_{Bus}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{Bus}},sES_{Tra},sSD_{Tra_{Bus}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Bus}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\geq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{Bus}}) \in sQSTOUTAFTraBus} vQES_{sST_{Tra_{Bus}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{Bus}},sES_{Tra},sSD_{Tra_{Bus}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Bus}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} - 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'Bus',sSD_{Tra_{Bus}}} \right)_{\forall sYear = sYear[0]} \quad (34)$$

Maximum ST output shares restriction Bus [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{Bus}} \in sQSTOUTAFTraBus} vQES_{sST_{Tra_{Bus}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{Bus}},sES_{Tra},sSD_{Tra_{Bus}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Bus}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\leq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{Bus}}) \in sQSTOUTAFTraBus} vQES_{sST_{Tra_{Bus}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{Bus}},sES_{Tra},sSD_{Tra_{Bus}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Bus}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} + 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'Bus',sSD_{Tra_{Bus}}} \right)_{\forall sYear = sYear[0]} \quad (35)$$

Minimum ST output shares restriction Moped [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{Moped}} \in sQSTOUTAFTraMoped} vQES_{sST_{Tra_{Moped}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{Moped}},sES_{Tra},sSD_{Tra_{Moped}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Moped}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\geq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{Moped}}) \in sQSTOUTAFTraMoped} vQES_{sST_{Tra_{Moped}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{Moped}},sES_{Tra},sSD_{Tra_{Moped}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Moped}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} - 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'Moped',sSD_{Tra_{Moped}}} \right)_{\forall sYear = sYear[0]} \quad (36)$$

Maximum ST output shares restriction Moped [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{Moped}} \in sQSTOUTAFTraMoped} vQES_{sST_{Tra_{Moped}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{Moped}},sES_{Tra},sSD_{Tra_{Moped}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}^{sSD_{Tra_{Moped}},sMD_{Tra}}} pDC_{sSD_{Tra_{Moped}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\leq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{Moped}}) \in sQSTOUTAFTraMoped} vQES_{sST_{Tra_{Moped}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{Moped}},sES_{Tra},sSD_{Tra_{Moped}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}^{sSD_{Tra_{Moped}},sMD_{Tra}}} pDC_{sSD_{Tra_{Moped}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} + 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'Moped',sSD_{Tra_{Moped}}} \right)_{\forall sYear = sYear[0]} \quad (37)$$

Minimum ST output shares restriction IntRail [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{IntRail}} \in sQSTOUTAFTraIntRail} vQES_{sST_{Tra_{IntRail}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{IntRail}},sES_{Tra},sSD_{Tra_{IntRail}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}^{sSD_{Tra_{IntRail}},sMD_{Tra}}} pDC_{sSD_{Tra_{IntRail}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\geq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{IntRail}}) \in sQSTOUTAFTraIntRail} vQES_{sST_{Tra_{IntRail}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{IntRail}},sES_{Tra},sSD_{Tra_{IntRail}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}^{sSD_{Tra_{IntRail}},sMD_{Tra}}} pDC_{sSD_{Tra_{IntRail}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} - 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'IntRail',sSD_{Tra_{IntRail}}} \right)_{\forall sYear = sYear[0]} \quad (38)$$

Maximum ST output shares restriction IntRail [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{IntRail}} \in sQSTOUTAFTraIntRail} vQES_{sST_{Tra_{IntRail}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{IntRail}},sES_{Tra},sSD_{Tra_{IntRail}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}^{sSD_{Tra_{IntRail}},sMD_{Tra}}} pDC_{sSD_{Tra_{IntRail}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\leq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{IntRail}}) \in sQSTOUTAFTraIntRail} vQES_{sST_{Tra_{IntRail}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{IntRail}},sES_{Tra},sSD_{Tra_{IntRail}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}^{sSD_{Tra_{IntRail}},sMD_{Tra}}} pDC_{sSD_{Tra_{IntRail}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} + 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'IntRail',sSD_{Tra_{IntRail}}} \right)_{\forall sYear = sYear[0]} \quad (39)$$

Minimum ST output shares restriction UrbRail [ES units]:

$$\frac{1e^4 * \sum_{,sES_{Tra},\in sQSTOUTAFTraUrbRail} vQES_{,sES_{Tra},sYear} * pAFTra_{,sES_{Tra},}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}^{,sMD_{Tra}}} pDC_{,sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\geq \left(\frac{1e^4 * \sum_{(,sES_{Tra},) \in sQSTOUTAFTraUrbRail} vQES_{,sES_{Tra},(sYear-1)} * pAFTra_{,sES_{Tra},}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}^{,sMD_{Tra}}} pDC_{,sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} - 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'UrbRail',} \right)_{\forall sYear = sYear[0]} \quad (40)$$

Maximum ST output shares restriction UrbRail [ES units]:

$$\frac{1e^4 * \sum_{,sES_{Tra},\in sQSTOUTAFTraUrbRail} vQES_{,sES_{Tra},sYear} * pAFTra_{,sES_{Tra},}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}^{,sMD_{Tra}}} pDC_{,sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\leq \left(\frac{1e^4 * \sum_{(,sES_{Tra},) \in sQSTOUTAFTraUrbRail} vQES_{,sES_{Tra},(sYear-1)} * pAFTra_{,sES_{Tra},}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}^{,sMD_{Tra}}} pDC_{,sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} + 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'UrbRail',} \right)_{\forall sYear = sYear[0]} \quad (41)$$

Minimum ST output shares restriction Air [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{Air}} \in sQSTOUTAFTraAir} vQES_{sST_{Tra_{Air}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{Air}},sES_{Tra},sSD_{Tra_{Air}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Air}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\geq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{Air}}) \in sQSTOUTAFTraAir} vQES_{sST_{Tra_{Air}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{Air}},sES_{Tra},sSD_{Tra_{Air}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Air}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} - 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'_{Air'},sSD_{Tra_{Air}}} \right)_{\forall sYear = sYear[0]} \quad (42)$$

Maximum ST output shares restriction Air [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{Air}} \in sQSTOUTAFTraAir} vQES_{sST_{Tra_{Air}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{Air}},sES_{Tra},sSD_{Tra_{Air}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Air}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\geq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{Air}}) \in sQSTOUTAFTraAir} vQES_{sST_{Tra_{Air}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{Air}},sES_{Tra},sSD_{Tra_{Air}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Air}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} + 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'_{Air'},sSD_{Tra_{Air}}} \right)_{\forall sYear = sYear[0]} \quad (43)$$

Minimum ST output shares restriction Sea [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{Sea}} \in sQSTOUTAFTraSea} vQES_{sST_{Tra_{Sea}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{Sea}},sES_{Tra},sSD_{Tra_{Sea}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Sea}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\geq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{Sea}}) \in sQSTOUTAFTraSea} vQES_{sST_{Tra_{Sea}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{Sea}},sES_{Tra},sSD_{Tra_{Sea}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Sea}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} - 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'_{Sea'},sSD_{Tra_{Sea}}} \right)_{\forall sYear = sYear[0]} \quad (44)$$

Maximum ST output shares restriction Sea [ES units]:

$$1e^4 * \frac{\sum_{,sES_{Tra},sST_{Tra_{Sea}} \in sQSTOUTAFTraSea} vQES_{sST_{Tra_{Sea}},sES_{Tra},sYear} * pAFTra_{sST_{Tra_{Sea}},sES_{Tra},sSD_{Tra_{Sea}}}}{\sum_{,sMD_{Tra} \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Sea}},sMD_{Tra}} * pMD_{sMD_{Tra},sYear}}$$

$$\leq \left(\frac{1e^4 * \sum_{(,sES_{Tra},sST_{Tra_{Sea}}) \in sQSTOUTAFTraSea} vQES_{sST_{Tra_{Sea}},sES_{Tra},(sYear-1)} * pAFTra_{sST_{Tra_{Sea}},sES_{Tra},sSD_{Tra_{Sea}}}}{\sum_{,sMD_{Tra}) \in sQSDMD_{Tra}} pDC_{sSD_{Tra_{Sea}},sMD_{Tra}} * pMD_{sMD_{Tra},(sYear-1)}} + 1e^4 * pMSMax \right)_{\forall sYear \neq sYear[0]}$$

$$+ \left(1e^4 * pSTTra_{MS'_{Sea'},sSD_{Tra_{Sea}}} \right)_{\forall sYear = sYear[0]} \quad (45)$$

Transport Car TC [ES units]:

$$vSTNewCap_{sST_{Tra_{Car}},sYear}$$

$$\leq \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{Car}},sVin,sYear-1} + pTCMax * \sum_{\substack{sST_{Tra_{Car}},sVin) \in sST_{Tra_{Car}} * sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{Car}},sVin,sYear-1} \right)_{\forall sYear > sYear[0]}$$

$$+ \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{Car}},sVin} + pTCMax * \sum_{\substack{(sST_{Tra_{Car}},sVin) \in sST_{Tra_{Car}} * sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{Car}},sVin} \right)_{\forall sYear = sYear[0]} \quad (46)$$

Transport Moped TC [ES units]:

$$vSTNewCap_{sST_{Tra_{Moped}},sYear}$$

$$\leq \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{Moped}},sVin,sYear-1} + pTCMax * \sum_{\substack{sST_{Tra_{Moped}},sVin) \in sST_{Tra_{Moped}} * sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{Moped}},sVin,sYear-1} \right)_{\forall sYear > sYear[0]}$$

$$+ \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{Moped}},sVin} + pTCMax * \sum_{\substack{(sST_{Tra_{Moped}},sVin) \in sST_{Tra_{Moped}} * sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{Moped}},sVin} \right)_{\forall sYear = sYear[0]} \quad (47)$$

Transport Road Freight TC [ES units]:

$$vSTNewCap_{sST_{Tra_{RoadFreight}},sYear}$$

$$\leq \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{RoadFreight}},sVin,sYear-1} + pTCMax * \sum_{\substack{sST_{Tra_{RoadFreight}},sVin) \in sST_{Tra_{RoadFreight}} * sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{RoadFreight}},sVin,sYear-1} \right)_{\forall sYear > sYear[0]}$$

$$+ \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{RoadFreight}},sVin} + pTCMax * \sum_{\substack{(sST_{Tra_{RoadFreight}},sVin) \in sST_{Tra_{RoadFreight}} * sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{RoadFreight}},sVin} \right)_{\forall sYear = sYear[0]} \quad (48)$$

Transport Bus TC [ES units]:

$$vSTNewCap_{sST_{Tra_{Bus}},sYear}$$

$$\leq \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{Bus}},sVin,sYear-1} + pTCMax * \sum_{\substack{sST_{Tra_{Bus}},sVin) \in sST_{Tra_{Bus}} * sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{Bus}},sVin,sYear-1} \right)_{\forall sYear > sYear[0]}$$

$$+ \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{Bus}},sVin} + pTCMax * \sum_{\substack{(sST_{Tra_{Bus}},sVin) \in sST_{Tra_{Bus}} * sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{Bus}},sVin} \right)_{\forall sYear = sYear[0]} \quad (49)$$

Transport UrbanRail TC [ES units]:

$$vSTNewCap_{sST_{Tra_{UrbanRail}},sYear}$$

$$\leq \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{UrbanRail}},sVin,sYear-1} + pTCMax * \sum_{\substack{sST_{Tra_{UrbanRail}},sVin) \in sST_{Tra_{UrbanRail}} * sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{UrbanRail}},sVin,sYear-1} \right)_{\forall sYear > sYear[0]}$$

$$+ \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{UrbanRail}},sVin} + pTCMax * \sum_{\substack{(sST_{Tra_{UrbanRail}},sVin) \in sST_{Tra_{UrbanRail}} * sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{UrbanRail}},sVin} \right)_{\forall sYear = sYear[0]} \quad (50)$$

Transport IntRail TC [ES units]:

$$vSTNewCap_{sST_{Tra_{IntRail}},sYear}$$

$$\leq \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{IntRail}},sVin,sYear-1} + pTCMax * \sum_{\substack{sST_{Tra_{IntRail}},sVin) \in sST_{Tra_{IntRail}} * sVin \\ \forall (sVin,sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{IntRail}},sVin,sYear-1} \right)_{\forall sYear > sYear[0]}$$

$$+ \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{IntRail}},sVin} + pTCMax * \sum_{\substack{(sST_{Tra_{IntRail}},sVin) \in sST_{Tra_{IntRail}} * sVin \\ \forall (sVin,sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{IntRail}},sVin} \right)_{\forall sYear = sYear[0]} \quad (51)$$

Transport Air TC [ES units]:

$$
\begin{aligned}
&vSTNewCap_{sST_{Tra_{Air}},sYear} \\
&\leq \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin, sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{Air}},sVin,sYear-1} + pTCMax * \sum_{\substack{sST_{Tra_{Air}},sVin) \in sST_{Tra_{Air}} * sVin \\ \forall (sVin, sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{Air}},sVin,sYear-1} \right)_{\forall sYear > sYear[0]} \\
&+ \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin, sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{Air}},sVin} + pTCMax * \sum_{\substack{(sST_{Tra_{Air}},sVin) \in sST_{Tra_{Air}} * sVin \\ \forall (sVin, sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{Air}},sVin} \right)_{\forall sYear = sYear[0]}
\end{aligned} \tag{52}
$$

Transport Sea TC [ES units]:

$$
\begin{aligned}
&vSTNewCap_{sST_{Tra_{Sea}},sYear} \\
&\leq \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin, sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{Sea}},sVin,sYear-1} + pTCMax * \sum_{\substack{sST_{Tra_{Sea}},sVin) \in sST_{Tra_{Sea}} * sVin \\ \forall (sVin, sYear-1) \in sVinYear}} vSTTotCap_{sST_{Tra_{Sea}},sVin,sYear-1} \right)_{\forall sYear > sYear[0]} \\
&+ \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin, sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{Sea}},sVin} + pTCMax * \sum_{\substack{(sST_{Tra_{Sea}},sVin) \in sST_{Tra_{Sea}} * sVin \\ \forall (sVin, sYear) \in sVinYear}} pSTInsCap_{sST_{Tra_{Sea}},sVin} \right)_{\forall sYear = sYear[0]}
\end{aligned} \tag{53}
$$

Transport Oth TC [ES units]:

$$
\begin{aligned}
&vSTNewCap_{sST_{Oth},sYear} \\
&\leq \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin, sYear-1) \in sVinYear}} vSTTotCap_{sST_{Oth},sVin,sYear-1} + pTCMax * \sum_{\substack{sST_{Oth},sVin) \in sST_{Oth} * sVin \\ \forall (sVin, sYear-1) \in sVinYear}} vSTTotCap_{sST_{Oth},sVin,sYear-1} \right)_{\forall sYear > sYear[0]} \\
&+ \left(\sum_{\substack{sVin \in sVin \\ \forall (sVin, sYear) \in sVinYear}} pSTInsCap_{sST_{Oth},sVin} + pTCMax * \sum_{\substack{(sST_{Oth},sVin) \in sST_{Oth} * sVin \\ \forall (sVin, sYear) \in sVinYear}} pSTInsCap_{sST_{Oth},sVin} \right)_{\forall sYear = sYear[0]}
\end{aligned} \tag{54}
$$

Energy Services (ES)-related constraints

$$\textbf{Balance for ES [ES units]}: \sum_{(,sVin)\in sVinYear} vQSTOut_{sST,sES,sVin,sYear,sSeason,sDay,sHour} \geq vQES_{sST,sES,sYear} \cdot pESLoad_{sES,sSeason,sDay,sHour} \quad (55)$$

Demand-related constraints

INDUSTRY

Balance for ST consumption of RM [RM units] :

$$vQSTInRM_{sRM,sST,sES,sVin,sYear,sSeason,sDay,sHour} \geq vQSTOut_{sST,sES,sVin,sYear,sSeason,sDay,sHour} * pSTEffRM_{sRM,sST,sES} \quad (56)$$

Activity Factor Industry [SD units] :

$$\sum_{(,sES_{Ind},sST_{Ind}) \in sQSTOUT\_AFInd} vQES_{sST_{Ind},sES_{Ind},sYear} * pAFInd_{sES_{Ind},sSDInd} \geq vQSDInd_{,sYear} \quad (57)$$

Demand characterization Industry [MD units] :

$$\sum_{\substack{sSDInd \in sSDInd \\ \forall (sSDInd,sMD_{Ind}) \in sQSDMD}} vQSDInd_{sSDInd,sYear} * pDC_{sSDInd,sMD_{Ind}} \geq pMD_{sMD_{Ind},sYear} \quad (58)$$

Circularity constraints [RM units] :

$$\sum_{\substack{(sST,sVin \in sST_{Ind} \\ \forall (sST,sES) \in sQSTOUT_{Ind} \\ \forall (sVin,sYear) \in sVinYear}} vQSTOut_{sST,sES,sVin,sYear,sSeason,sDay,sHour} \geq \frac{\sum_{\substack{sVin \in sVin \\ \forall (sVin,sYear) \in sVinYear}} vQSTInRM_{sRM,sST,sES,sVin,sYear,sSeason,sDay,sHour}}{pRMCircular_{sES,sRM}} \quad (59)$$

$$(60)$$

TRANSPORTATION

AF Transportation [SD units] :

$$\sum_{(,sES_{Tra},sST_{Tra}) \in sQSTOUTAFTra} vQES_{sST_{Tra},sES_{Tra},sYear} * pAFTra_{sST_{Tra},sES_{Tra},sSD_{Tra}} + \sum_{sBM_{Tra} \in sBM_{Tra}} \sum_{(,sES_{Tra},sST_{Tra}) \in sQSTOUTAFTra} vBMTra_{sST_{Tra},sES_{Tra},sSD_{Tra},sBM_{Tra},sYear} \geq vQSDTra_{sSD_{Tra},sYear} \quad (61)$$

BM in Transportation [ES units] :

$$vBMTra_{sST_{Tra},sES_{Tra},sSD_{Tra},sBM_{Tra},sYear} \leq pDeltaAFTra_{sST_{Tra},sES_{Tra},sSD_{Tra},sBM_{Tra}} * vQES_{sST_{Tra},sES_{Tra},sYear} \quad (62)$$

DC Transportation [SD units] :

$$vQSDTra_{sSD_{Tra},sYear} \geq \sum_{(,sMD_{Tra}) \in sQSDMD_{Tra}} pDC_{sSD_{Tra},sMD_{Tra}} * pMD_{sMD_{Tra},sYear} - \sum_{sDM_{Tra} \in sDM_{Tra}} \sum_{(,sMD_{Tra}) \in sQSDMD_{Tra}} vDMTra_{sSD_{Tra},sMD_{Tra},sDM_{Tra},sYear} \quad (63)$$

DM in Transportation [MD units] :

$$vDMTra_{sSD_{Tra},sMD_{Tra},sDM_{Tra},sYear} \leq pDeltaDC_{sSD_{Tra},sMD_{Tra},sDM_{Tra}} * pMD_{sMD_{Tra},sYear} \quad (64)$$

RESIDENTIAL

AF Others [ES units] :
$$\sum_{(,sST_{Oth})\in sQSTOUT_{AFOth}} vQES_{sST_{Oth},sES_{Oth},sYear} \geq \sum_{(,sSD_{Oth},sMD_{Oth})\in sQSDMD_{Oth}} vQSDOth_{sSD_{Oth},sMD_{Oth},sYear} * pAFOth_{sES_{Oth},sSD_{Oth},sMD_{Oth}}$$
$$- \sum_{sBM_{Oth}\in sBM_{Oth}} \sum_{(,sSD_{Oth},sMD_{Oth})\in sQSDMD_{Oth}} vBMOth_{sES_{Oth},sSD_{Oth},sMD_{Oth},sBM_{Oth},sYear}$$
$$+ \sum_{\substack{sBM_{Oth}\in sBM_{Oth} \\ \forall sES_{Oth}=sES_{DSOTHRES_{WAMAC}}}} \sum_{(sSD_{Oth},sMD_{Oth})\in sQSDMD_{Oth}} vBMOth_{WAMAC\,sSD_{Oth},sMD_{Oth},sBM_{Oth},sYear}$$
$$+ \sum_{\substack{sBM_{Oth}\in sBM_{Oth} \\ \forall sES_{Oth}=sES_{DSOTHRES_{DIWAC}}}} \sum_{(sSD_{Oth},sMD_{Oth})\in sQSDMD_{Oth}} vBMOth_{DIWAC\,sSD_{Oth},sMD_{Oth},sBM_{Oth},sYear}$$
$$+ \sum_{(,sSD_{Oth},sMD_{Oth})\in sQSDMD_{Oth}} vBMOth_{TW\,sES_{Oth},sSD_{Oth},sMD_{Oth},sYear} \quad (65)$$

BM in Others [SD units] :
$$vBMOth_{sES_{Oth},sSD_{Oth},sMD_{Oth},sBM_{Oth},sYear} \leq pDeltaAFOth_{sES_{Oth},sSD_{Oth},sMD_{Oth},sBM_{Oth}} * vQSDOth_{sSD_{Oth},sMD_{Oth},sYear} \quad (66)$$

BM in Others.WAMA [SD units] :
$$vBMOth_{sES_{DSOTHRES_{WAMAH}},sSD_{Oth},sMD_{Oth},sBM_{Oth},sYear} = -vBMOth_{WAMAC\,sSD_{Oth},sMD_{Oth},sBM_{Oth},sYear} \quad (67)$$

BM in Others. DIWA [SD units] :
$$vBMOth_{sES_{DSOTHRES_{DIWAH}},sSD_{Oth},sMD_{Oth},sBM_{Oth},sYear} = -vBMOth_{DIWAC\,sSD_{Oth},sMD_{Oth},sBM_{Oth},sYear} \quad (68)$$

Bm in Others. Telework [SD units] :
$$vBMOth_{TW\,sES_{Oth},sSD_{Oth},sMD_{Oth},sYear} = pTW_{sES_{Oth},sSD_{Oth},sMD_{Oth}} * \sum_{(sSD_{Tra},sMD_{Tra})\in sQSDMD_{Tra}} vDMTra_{sSD_{Tra},sMD_{Tra},sDM_{Tra_{TW}},sYear} \quad (69)$$

DC Others [SD units] :
$$vQSDOth_{sSD_{Oth},sMD_{Oth},sYear} \geq pDC_{sSD_{Oth},sMD_{Oth}} * pMD_{sMD_{Oth},sYear} + (\sum_{\substack{sDM_{Oth}\in sDM_{Oth} \\ \forall sSD_{Oth}\in sSD_{Oth_{HE}}}} vDMOth_{HE\,sMD_{Oth},sDM_{Oth},sYear} - \sum_{\substack{sDM_{Oth}\in sDM_{Oth} \\ \forall sSD_{Oth}\in sSD_{Oth_{LE}}}} vDMOth_{LE\,sMD_{Oth},sDM_{Oth},sYear}) \quad (70)$$

DM Others [SD units] :
$$vDMOth_{HE\,sMD_{Oth},sDM_{Oth},sYear} \leq \sum_{\substack{sSD_{Oth}\in sSD_{Oth_{HE}} \\ \forall (sSD_{Oth},sMD_{Oth})\in sQSDMD_{Oth}}} pDeltaDC_{sSD_{Oth},sMD_{Oth},sDM_{Oth}} * pMD_{sMD_{Oth},sYear}$$

DM in Others [SD units] :
$$vDMOth_{HE\,sMD_{Oth},sDM_{Oth},sYear} = vDMOth_{LE\,sMD_{Oth},sDM_{Oth},sYear} \quad (71)$$

DM in Others [SD units] :
$$vDMOth_{HE\,sMD_{Oth},sDM_{Oth},sYear} \geq vDMOth_{HE\,sMD_{Oth},sDM_{Oth},sYear-1} \forall sYear > sYear[0] \quad (72)$$