The models in PSO use data defined per libraries and inputs as data tables. This appendix provides a brief description of each of the input files of the model in the PSO 2.6.3 version. There are three variants (scenarios): the base scenario, the uncoordinated charging, and the coordinated charging.

Model Setup (MS)

This input provides a quick list of setups that will be in use in the libraries defining the model.

- DateFormat defines the date format in the time series data. This format ensures data is readable by AIMMS.
- SlackBusName (PN) defines the slack bus or reference bus in the system.
- NoCaseFile (PC) states that the model does not store core topology.
- MipGap (MC) specifies the convergence tolerance for the optimization problem.
- UserSeed (TS) ensures replicability by given a seed to the random number generator. This seed applies if the model creates data (random schedules) used in a given scenario, not the case here but specified if further modeling is added.
- NoLoadShed (ED) ensures violation of unserved energy (load shed) should be removed from the solution of the model.

Table 1 Model Setup (MS) input parameters provide a quick list of parameters that defines the PSO model.

//OptionName	OptionValue
DisplayCount	1
DateFormat	%c%y.%m.%d %H:%M
MipGap	1.00E-04
UserSeed	9
SlackBusName	D
NoCaseFile	1
NoLoadShed	1

Model Definition (MDL_ID)

This input table specifies the time unit in the model and dates consider for solving the model. Note table is transposed to fit the page. The original input file provides the field (rows) as columns. The name of the model changes according to the scenario.

Table 2 Model Definition (MDL_ID) specifies the unit of time and temporal length covered in the model

//Name	**NAU 5 BUS Groundhog EV Uncoordinated Charging 7days**
MajorRelease	2
MinorRelease	6
BranchRelease	3
TimeUnit	minute
IntervalLength	1
MaxInterval	0
StartInterval	0
StopInterval	0
MinDate	2020.01.01 00:00
MaxDate	2020.12.31 00:00
StartDate	2020.01.29 00:00
StopDate	2020.02.04 23:00

Model Configuration (MC)

This library defines the data for the rolling-horizon model, the cycles, periods, and look ahead of each horizon.

Cycle ID (CYC_ID)

Note table is transposed to fit the page. The original input file provides the field (rows) as columns. The model has a single cycle DA. DeltaTime defines the solution time of each horizon in the cycle, 1440 minutes for a day.

Table 3 Cycle ID (CYC_ID) defines the solution time of the horizons contemplated in the cycle.

//Cycle	**DA**
Name	
DeltaTime	1440
LeadTime	0
DecisionTime	0
OrderTime	0
MipGap	0
MaxSolveTime	0
MaxIterations	0

Cycle Period ID (CYC_PRD_ID)

The DA cycle has 24 periods of 60 minutes that define the solution time (1440 minutes), plus the look ahead of 12 periods with a coarser length of 120 minutes (1440 minutes).

Table 4 Cycle Period ID (CYC_PRD_ID) defines the resolution of horizons and their look ahead.

//Cycle	**Period**	**Length**
DA	1	60
DA	2	60
DA	3	60
DA	4	60
DA	5	60
DA	6	60
DA	7	60
DA	8	60
DA	9	60
DA	10	60
DA	11	60
DA	12	60
DA	13	60
DA	14	60
DA	15	60
DA	16	60
DA	17	60
DA	18	60
DA	19	60
DA	20	60
DA	21	60

DA	22	60
DA	23	60
DA	24	60
DA	25	120
DA	26	120
DA	27	120
DA	28	120
DA	29	120
DA	30	120
DA	31	120
DA	32	120
DA	33	120
DA	34	120
DA	35	120
DA	36	120

Scenario Cycle (SCN_CYC)

Every Cycle requires at least a scenario to associate the Time Series Data.

Table 5 Scenario Cycle (SCN_CYC) specifies the scenario of the PSO model.

//Scenario	Cycle	Weight	Reference
ScnDA	DA	0	0

Time Series Data (TS)

This library identifies the schedule data, like the forecast for load and VRE energies. Moreover, schedules define availability and limits for generation and load resources.

Schedule Attributes (SCH_ATT)

This table specifies that the time series data repeat every week, like a simplification to model with a small fraction of data.

Table 6 Schedule Attributes (SCH_ATT) provides characteristics of the model's Time Series Data (TS).

Schedule	RepeatTime	StepChange	Cycle	Periodic	UseMin	UseMax	UseFirst	UseLast
AvgLoad	10080	0		0	0	0	0	0
Evload	10080	0		0	0	0	0	0
WIND	10080	0		0	0	0	0	0
PV	10080	0		0	0	0	0	0
RTPV	10080	0		0	0	0	0	0

Schedule Time-point (SCH_TMP)

This table provides the time series data. Instead of giving the whole data, the first ten items provide insight into the input structure.

Table 7 Schedule Time-point (SCH_TMP) provides the time series data in the model.

//Schedule	Time	Value	Enforce
AvgLoad	2020.01.29 00:00	9.00E+02	1
AvgLoad	2020.01.29 01:00	9.01E+02	1
AvgLoad	2020.01.29 02:00	9.15E+02	1
AvgLoad	2020.01.29 03:00	9.57E+02	1
AvgLoad	2020.01.29 04:00	1.07E+03	1
AvgLoad	2020.01.29 05:00	1.22E+03	1
AvgLoad	2020.01.29 06:00	1.27E+03	1
AvgLoad	2020.01.29 07:00	1.22E+03	1
AvgLoad	2020.01.29 08:00	1.15E+03	1
AvgLoad	2020.01.29 09:00	1.10E+03	1

Economic Dispatch (ED)

This library is the minimum to use for modeling power systems

Scenario Area Load (SCN_ARA_LOD)

There is a single data set for load, and the scenario “zero” implies common data to all scenarios. Scale factor adjusts the data set to fit the model capacity.

Table 8 Scenario Area Load (SCN_ARA_LOD) specifies the data the model uses as system load.

//Scenario	Area	Load	Enforce	ScaleFactor	Schedule	Sequence
0	0	0	0	0.52	AvgLoad	

Injector ID (INJ_ID)

This table defines the economic dispatch parameters of the injectors. Injectors are generators or loads and are located in a single location. This table is transposed to fit the page. This table exemplifies a couple of the injectors. This table constrains the max MW and identifies if an injector is a load. See EV. The EV fleet is assumed very flexible and can go to max power or down to zero in just a minute.

Table 9 Injector ID (INJ_ID) defines the economic dispatch parameters of the injectors (generation or load resources) in the model.

//Injector	118_CC_1	113_CT_2	102_CT_1	101_STEAM_3	121_NUCLEAR_1	EV
Name	118_CC_1	113_CT_2	102_CT_1	101_STEAM_3	121_NUCLEAR_1	
Area						
LoadFlag	0	0	0	0	0	1
Link	0	0	0	0	0	0
MaxMw	355	55	20	76	200	160
MinMw	0	0	0	0	0	0
RaiseRR	0	0	0	0	0	160
LowerRR	0	0	0	0	0	160
RampCapOnly	0	0	0	0	0	0
EnergyCost	0	0	0	0	0	0
CostAdder	0	0	0	0	0	0
RampUpCost	0	0	0	0	0	0
RampDnCost	0	0	0	0	0	0

Injector in Service (INJ_INS)

This table allows disabling injectors. The EV injector is not in service for the base case with no EV in the table below. For the uncoordinated charging scenario, the Unavailable value is zero.

Table 10 Injector in Service (INJ_INS) specifies the injectors disabled in the base model.

//Injector	Unavailable	InstallDate	RetireDate
EV	1		

Scenario Injector Dispatch (SCN_INJ_DSP)

This table informs PSO to follow a schedule for a giving injector at a specified scenario. The table below provides the expected uncoordinated EV charging. Thus this table is not part of the input for the coordinated charging scenario.

Table 11 Scenario Injector Dispatch (SCN_INJ_DSP) defines fixed schedules for a given set of injectors.

//Scenario	Injector	Dispatch	Enforce	ScaleFactor	Schedule	Sequence
ScnDA	EV	0	0	1	Evload	

Scenario Injector Max-MW (SCN_INJ_MAX)

In the particular case of the base scenario, this table provides maximum limits for the VRE dispatch passed as time series. Thus, PSO can withdraw that level or less. Moreover, it allows scaling the VRE resource to fit the target penetration of the NAU-5 Bus System.

Table 12 Scenario Injector Max-MW (SCN_INJ_MAX) specifies the maximum power limits of a set of injectors passed as a time series.

//Scenario	Injector	MaxMw	Enforce	ScaleFactor	Schedule	Sequence
ScnDA	WIND	0	0	0.04	WIND	
ScnDA	PV	0	0	0.19	PV	
ScnDA	RTPV	0	0	0.72	RTPV	

Unit Commitment (UC)

This library provides information for the commitment constraints and commitment scenario for the conventional fleet.

Injector Commit (INJ_CMT)

This table provides the commitment constraints for the injectors. At least a minimum dispatch should be offered here to enforce the constraints. This table is transposed to fit the page and exemplifies a couple of the injectors.

Table 13 Injector Commit (INJ_CMT) provides the commitment constraints for the model's injectors.

//Injector	118_CC_1	113_CT_2	102_CT_1	101_STEAM_3	121_NUCLEAR_1
MinDispatch	170	22	8	30	198
MinOn	0	0	0	0	0
MinOff	0	0	0	0	0
BaseCost	0	0	0	0	0
HotStartCost	0	0	0	0	0
WarmStartCost	0	0	0	0	0
ColdStartCost	30303	6121	120	8600	31600
TimeToWarm	0	0	0	0	0
TimeToCold	0	0	0	0	0
HotUpTime	0	0	0	0	0
WarmUpTime	0	0	0	0	0
ColdUpTime	0	0	0	0	0

Cycle System Commitment (CYC_SYS_CMT)

This table informs PSO to solve the commitment in all the periods of a cycle if solve has a value of one.

Table 14 Cycle System Commitment (CYC_SYS_CMT) specifies to solve the commitment in a given cycle.

//Cycle	Solve	HoldCycle	PricingCycle	IgnoreBaseCost	EnforceStartCost
0	1		0	0	0
DA	1		0	0	0

Power Network (PN)

This library allows defining the power network and its constraints.

Branch ID (BRN_ID)

This table defines the branches or transmission lines of the power network. Also, this table provides the power flow constraints of the power lines.

Table 15 Branch ID (BRN_ID) defines the parameters of the transmission lines in the model.

//Branch	AB	AD	AE	BC	CD	DE
Name						
FrEnode	A	A	A	B	C	D
ToEnode	B	D	E	C	D	E
Circuit						
Voltage	0	0	0	0	0	0
Resistance	0.00281	0.00304	0.00064	0.00108	0.00297	0.00297
Reactance	0.0281	0.0304	0.0064	0.0108	0.0297	0.0297
NormalLimit	400	0	0	0	0	240
CtgLimit	0	0	0	0	0	0
Solve	0	0	0	0	0	0
Enforce	1	0	0	0	0	1
Monitor	0	0	0	0	0	0
Switchable	0	0	0	0	0	0
Penalty	0	0	0	0	0	0
AngleLimit	0	0	0	0	0	0
Hvdc	0	0	0	0	0	0
CID						

Electrical Node ID (NDE_ID)

This table provides the Busbar or Substation name of the nodes in the power network.

Table 16 Electrical Node ID (NDE_ID) specifies the nodes (substations) in the power network.

//Enode	Name	Busbar	Substation	ReportNode
A1		A		0
A2		A		0

BL	B	0
CL	C	0
DL	D	0

Injector Network (INJ_NET)

This table identifies the physical (node) location of the injectors to the transmission network.

Table 17 Injector Network (INJ_NET) identifies the nodal location of each injector.

//Injector	Node	PhysicalArea	LossFactor	IgnoreLoss
107_CC_1	E		0.00E+00	0
118_CC_1	E		0.00E+00	0
213_CC_3	C		0.00E+00	0
113_CT_1	D		0.00E+00	0
113_CT_2	D		0.00E+00	0
113_CT_3	C		0.00E+00	0
113_CT_4	C		0.00E+00	0
102_CT_1	A1		0.00E+00	0
101_STEAM_3	A1		0.00E+00	0
121_NUCLEAR_1	A2		0.00E+00	0
EV	B		0.00E+00	0
WIND	E		0.00E+00	0
PV	A1		0.00E+00	0
RTPV	D		0.00E+00	0

Power Flow States (PF)

This library provides power flow data from an external source like state estimator data.

State Electrical Node MW (STE_NDE)

In the particular model of the NAU-5 Bus System, this table provides the load distribution factors (LoadMW).

Table 18 State Electrical Node MW (STE_NDE) provides the load distribution factors for the model.

//State	Enode	GenMw	LoadMw	GenNode	LoadNode
0	BL	0	0.9	0	0
0	CL	0	0.9	0	0
0	DL	0	1.2	0	0

Power Constraints (PC)

For this library, the only option is the no case file from the MS. Therefore, all the transmission constraints are enforced.

Heat Dispatch (HD)

This library allows modeling the conventional fleet based on their thermal characteristics.

Injector Heat (INJ_HEA)

This input table is for modeling the nuclear injector, which runs as baseload. Therefore, a simplified representation is enough because the unit is not cycling. The table provides the base heat and the incremental heat of the nuclear injector.

Table 19 Injector Heat (INJ_HEA) provides a simplified heat representation for modeling the baseload nuclear generator.

//Injector	HeatCost	IncHeat	BaseHeat	HotStartHeat	WarmStartHeat	ColdStartHeat
121_NUCLEAR_1	0.8	10	1980	0	0	0

Heat Curve Attribute (HCV_ATT)

This table provides the Base Heat of the coal, natural gas, and oil generators. Base heat is MMBtu/h at 0 MW, the intercept of with Y-axis of the input-output curve.

Table 20 Heat Curve Attribute (HCV_ATT) provides the Base Heat for the model's dispatchable generators.

//HeatCurve	TotalHeat	BaseHeat	NonConvex
101_STEAM_3	0	398.1	0
102_CT_1	0	117.112	0
107_CC_1	0	1227.74	0
113_CT_1	0	288.75	0
113_CT_2	0	288.75	0
113_CT_3	0	288.75	0
113_CT_4	0	288.75	0
118_CC_1	0	1233.69	0
213_CC_3	0	1330.08	0

Heat Curve Points (HCV_PNT)

This table provides the definitions of the incremental-heat rates of the fossil-fueled units in the model.

Table 21 Heat Curve Points (HCV_PNT) provides the incremental heat rate curve for the model's dispatchable generators.

//HeatCurve	Point	X	Y
101_STEAM_3	1	45.333	6.713
101_STEAM_3	2	60.667	8.028
101_STEAM_3	3	76	8.549
102_CT_1	1	12	8.597
102_CT_1	2	16	9.147
102_CT_1	3	20	9.622
107_CC_1	1	231.667	5.97
107_CC_1	2	293.333	6.892
107_CC_1	3	355	7.854
113_CT_1	1	33	6.899
113_CT_1	2	44	7.602
113_CT_1	3	55	7.797
113_CT_2	1	33	6.899
113_CT_2	2	44	7.602
113_CT_2	3	55	7.797
113_CT_3	1	33	6.899
113_CT_3	2	44	7.602
113_CT_3	3	55	7.797
113_CT_4	1	33	6.899
113_CT_4	2	44	7.602
113_CT_4	3	55	7.797
118_CC_1	1	231.667	5.808

118_CC_1	2	293.333	7.14
118_CC_1	3	355	8.351
213_CC_3	1	231.667	6.334
213_CC_3	2	293.333	6.979
213_CC_3	3	355	8.749

Injector Heat Curve (INJ_HCV)

This table relates the heat curve with the injector.

Table 22 Injector Heat Curve (INJ_HCV) associates the heat curves with the model's injectors

//Injector	**HeatCurve**
107_CC_1	107_CC_1
118_CC_1	118_CC_1
213_CC_3	213_CC_3
113_CT_1	113_CT_1
113_CT_2	113_CT_2
113_CT_3	113_CT_3
113_CT_4	113_CT_4
102_CT_1	102_CT_1
101_STEAM_3	101_STEAM_3

Fuel Dispatch (FD)

This library provides the fuel definition in the model

Fuel ID (FUE_ID)

This table defines the thermal units and cost of the generator's fuels.

Table 23 Fuel ID (FUE_ID) defines the thermal units and cost of the generator's fuels.

//FuelType	**Name**	**Quantity**	**Heat**	**Cost**
Coal		MMBtu	1	2.8
NG		MMBtu	1	4.2
Oil		MMBtu	1	23.9

Fuel Thermal Unit (FUE_UTH)

This table links the fuel with the injectors.

Table 24 Fuel Thermal Unit (FUE_UTH) associates the fuel with the injectors.

//FuelType	ThermalUnit	FuelFactor	Cost	CostAdder
Coal	101_STEAM_3	1	0	0
NG	107_CC_1	1	0	0
NG	118_CC_1	1	0	0
NG	213_CC_3	1	0	0
NG	113_CT_1	1	0	0
NG	113_CT_2	1	0	0
NG	113_CT_3	1	0	0
NG	113_CT_4	1	0	0
Oil	102_CT_1	1	0	0

Specialized Injector Energy Limited (EL)

Energy Limited (EL) resources are part of the PSO specialized injectors library. This library defines the parameters for modeling the coordinated EV charging as a limited energy resource. An EL resource has a limited capacity of withdrawing or injecting power in a given time window. Therefore, the model for coordinated charging does not use the table INJ_DSP. Instead, the schedule Evload set the charging requirement for 24 h, constrained with the maximum charging availability Evloadmax schedule.

Injector Energy Limits (INJ_ELM)

This table provides the time window for the EL injector, the coordinated EV charging. Thus, this table is part only of the coordinated EV charging scenario. AvgMax should be less than the MaxMW, and AvgMin defines the minimum energy requirement, in this case, minimum charging in 24 h (1440 minutes).

Table 25 Injector Energy Limits (INJ_ELM) provides the time window for accomplishing the coordinated EV charging.

//Injector	TimeWindow	AvgMax	AvgMin
EV	1440	5	1.95

Scenario Injector Min-Energy (SCN_INJ_EMN)

This table is associated with INJ_ELM. It identifies the AvgMin in the Day-Ahead Scenario. Thus, the Evload schedule defines the daily charging requirement in MWh for the EV injector.

Table 26 Scenario Injector Min-Energy (SCN_INJ_EMN) defines the schedule for determining the EV charging requirement.

//Scenario	Injector	AvgMin	Enforce	ScaleFactor	Schedule
ScnDA	EV	0	0	1	Evload

Scenario Injector Max-MW (SCN_INJ_MAX)

This version of the SCN_INJ_MAX applies only for coordinated EV charging. The schedule Evloadmax (first data row of the table) defines the maximum charging availability per hour in the DA scenario (ScnDA) for the EV injector.

Table 27 Variant of the Scenario Injector Max-MW (SCN_INJ_MAX) defines the maximum charging availability for the coordinated EV charging.

//Scenario	Injector	MaxMw	Enforce	ScaleFactor	Schedule	Sequence
ScnDA	EV	0	0	1	Evloadmax	
ScnDA	WIND	0	0	0.04	WIND	
ScnDA	PV	0	0	0.19	PV	
ScnDA	RTPV	0	0	0.72	RTPV	