

Loosely Coupled System

Input Parameter

- i). *Time resolution or number of time steps (e. g. ,288,8760 or arbitrary) = $t_{resolution}$*
- ii). *Simulation period total length (# of hours) = t_{sim_period}*
- iii). *One time instant length (#hour) = $t_{inst_length} = t_{sim_period} / t_{resolution}$*
- iv). *SMR annualized CAPEX + Fixed O&M $\left(\frac{\$}{MW/yr} \right) = SMR_capex_fixed_cost$*
- v). *Wind annualized CAPEX + Fixed O&M $\left(\frac{\$}{MW/yr} \right) = wind_capex_fixed_cost$*
- vi). *Solar annualized CAPEX + Fixed O&M $\left(\frac{\$}{MW/yr} \right) = solar_capex_fixed_cost$*
- vii). *Non – electric of specified Type facility annualized CAPEX + Fixed O&M $\left(\frac{\$}{MW/yr} \right) = nonelc_capex_fixed_cost_{Type}$*
- viii). *SMR variable + fuel O&M $\left(\frac{\$}{MWh} \right) = SMR_fuel_var_cost$*
- ix). *Wind variable O&M $\left(\frac{\$}{MWh} \right) = wind_var_cost$*
- x). *Solar variable O&M $\left(\frac{\$}{MWh} \right) = solar_var_cost$*
- xi). *Non – electric facility annualized variable O&M $\left(\frac{\$}{MWh} \right) = nonelc_var_cost$*
- xii). *SMR Min. stable level of operation (% of installed capacity) = $smr_min_gen_lvl$*
- xiii). *SMR ramp up limit $\left(\frac{\% \text{ of installed capacity}}{hour} \right) = r_up_limit$*
- xiv). *SMR ramp down limit $\left(\frac{\% \text{ of installed capacity}}{hour} \right) = r_down_limit$*
- xv). *SMR capacity upper limit (MW) = smr_max_mw*
- xvi). *Wind capacity upper limit (MW) = $wind_max_mw$*
- xvii). *Solar capacity upper limit (MW) = $solar_max_mw$*
- xviii). *SMR capacity lower limit (MW) = smr_min_mw*
- xix). *Wind capacity lower limit (MW) = $wind_min_mw$*
- xx). *Solar capacity lower limit (MW) = $solar_min_mw$*

- xxi). *Electricity coupling point flow (import/export) limit (MW) =*
couple_max_limit
- xxii). *Number of non – electric application type (max. 5 type) =*
n_nonelectric_application
- xxiii). *Nonelectric Type specified roduction efficiency = efficiency_{Type}*

Input Sets

- i). *Electricity market committed/must demand (MWh/h) =*
elc_mark_committed_sare_t
- ii). *Electricity market committed/must supply price (US\$/MWh) =*
elc_mark_committed_supply_price_t
- iii). *External electricity market spot price = elc_market_spot_price_t*
- iv). *Wind generation profile (Normalized) = e_wind_genprofile_t*
- v). *Solar generation profile (Normalized) = e_solar_genprofile_t*
- vi). *Non – electric specified Type product value ($\frac{US\$}{unit\ product}$) =*
non_elec_value_{Type,t}

Output Sets:

- i). *SMR_gen_t = SMR generation in instant t*
- ii). *wind_gen_t = Wind generation in instant t*
- iii). *solar_gen_t = Solar generation in instant t*
- iv). *non_elec_consumption_{Type,t} = Non –*
electric Type 1 electricity consumption in instant t
- v). *non_elec_production_{Type,t} = Non –*
electric Type 1 electricity consumption in instant t
- vi). *elc_mark_committed_supply_t =*
Supply to market to meet early committed/must demand (MWh/h)
- vii). *elec_saleto_market_t = Electricity export to electricity market in instant t*
- viii). *elmarket_import_t = Electricity import from market in instant t*

Try Red as decision variables

Abstract Model

Decision Variables:

- i). $SMR_cap = SMR \text{ Installed capacity}$
- ii). $solar_cap = Solar \text{ Installed capacity}$
- iii). $wind_cap = SMR \text{ Installed capacity}$
- iv). $non_elec_cap_{Type} = Non - electric \text{ installed capacity}$
- v). $non_elec_consumption_{Type,t} = Non - electric \text{ Type 1 electricity consumption in instant } t$
- vi). $elec_saleto_market_t = Electricity \text{ export to electricity market in instant } t$
- vii). $elmarket_import_t = Electricity \text{ import from market in instant } t$

Objective Function:

Maximize System Return

$$\begin{aligned}
 &= (\text{Revenue from Electricity Committed Supply} \\
 &+ \text{Revenue from Electricity Sale to Market} \\
 &+ \text{Revenue from Nonelectric Production sale} \\
 &- \text{Expenditure on Imp Elc from market} - \text{SMR CAPEX \&Fixed Cost} \\
 &- \text{SMR Variable Cost} - \text{Nonelectric CAPEX \&Fixed Cost} \\
 &- \text{Nonelectric Variable Cost} - \text{Wind CAPEX \&Fixed Cost} \\
 &- \text{Wind Variable Cost} - \text{Solar CAPEX \&Fixed Cost} \\
 &- \text{Solar Variable Cost})
 \end{aligned}$$

1. Revenue from Committed Supply

Rev_loc_market

$$\begin{aligned}
 &= \sum_{t \text{ in resolution}} (elec_mark_committed_supply_t \\
 &* elc_mark_committed_supply_price_t)
 \end{aligned}$$

2. Revenue from Electricity Sale to Market

$$Rev_loc_market = \sum_{t \text{ in resolution}} (elec_saleto_market_t * elc_market_spot_price_t)$$

3. Revenue from Non-Electric Production

Rev_nonelectric_production

$$= \sum_{Type} \sum_{t \text{ in resolution}} (non_elec_production_{Type,t} * non_elec_value_{Type,t})$$

4. Expenditure on Import from Electricity Market

$$Import_Charges = \sum_{t \text{ in timeresolution}} (elec_import_t * elc_market_spot_price_t)$$

5. SMR CAPEX & Fixed O&M

$$SMR_CAPEX_Fixed_Chares = SMR_capex_fixed_cost$$

6. SMR Fuel and Variable O&M

$$SMR_Variable_andFuel_Chares_t = \sum_{t \text{ in timeresolution}} (SMR_gen_t * SMR_fuel_var_cost)$$

7. Wind CAPEX & Fixed O&M

$$Wind_CAPEX_Fixed_Chares = wind_capex_fixed_cost$$

8. Wind Variable O&M

$$Wind_Variable_andFuel_Chares_t = \sum_{t \text{ in timeresolution}} (wind_gen_t * wind_var_cost)$$

9. Solar CAPEX & Fixed O&M

$$Solar_CAPEX_Fixed_Chares = solar_capex_fixed_cost$$

10. Solar Variable O&M

$$Solar_Variable_andFuel_Chares_t = \sum_{t \text{ in timeresolution}} (solar_gen_t * wind_var_cost)$$

11. Non-Electric CAPEX & Fixed O&M

$$Wind_CAPEX_Fixed_Charges = \sum_{Type} wind_capex_fixed_cost_{Type}$$

12. Non-Electric Variable O&M

$$Non - electric_Variable_Charges$$

$$= \sum_{Type} \sum_{t \text{ in timeresolution}} (non_elec_consumption_{Type,t} * nonelec_var_cost)$$

Subject to:

1. Non-electric Production

$$non_elec_production_{Type,t} = efficiency_{Type} * non_elec_consumption_{Type,t}$$

2. SMR Ramping Down Limit

When $t > 1$:

- if $SMR_{gen_{t-1}} + r_down_limit * SMR_{cap} \leq smr_min_gen_lvl * SMR_{cap}$
 $SMR_{gen_t} \geq smr_min_gen_lvl * SMR_{cap}$
Else
 $SMR_{gen_t} \geq SMR_{gen_{t-1}} + r_{down_limit} * SMR_{cap}$

When $t = 1$:

- if $SMR_{gen_{t-1}} + r_down_limit * SMR_{cap} * t_inst_length \leq smr_min_gen_lvl * SMR_{cap} * t_inst_length$
 $SMR_{gen_t} \geq smr_min_gen_lvl * SMR_{cap} * t_inst_length$
Else
 $SMR_{gen_t} \geq SMR_{gen_{t-1}} + r_down_limit * SMR_{cap} * t_inst_length$

When $t = 1$:

- if $SMR_{gen_{t_resolution}} + r_down_limit * SMR_{cap} * t_inst_length \leq smr_min_gen_lvl * SMR_{cap} * t_inst_length$
 $SMR_{gen_t} \geq smr_min_gen_lvl * SMR_{cap} * t_inst_length$
Else
 $SMR_{gen_t} \geq SMR_{gen_{t_resolution}} + r_down_limit * SMR_{cap} * t_inst_length$

3. SMR Minimum Stable Level or Shutdown

$$smr_min_gen_lvl * SMR_{cap} * t_inst_length \leq SMR_{gen_t} \text{ or } SMR_{gen_t} = 0$$

4. Generation & Consumption Balancing

$$SMR_{gen_t} + wind_{gen_t} + solar_{gen_t} + elec_extmarket_import_t + elec_locmarket_import_t \\ \geq elc_mark_committed_sare_t + elec_saletomarket_t \\ + non_elec_consumption_{Type,t}$$

5. Export/Import Coupling Point Limit

$$elec_saletomarket_t \leq couple_max_limit$$

$$elmarket_import_t \leq couple_max_limit$$

6. SMR Min and Max Capacity Limit

$$smr_min_mw \leq SMR_cap < smr_max_mw$$

7. Wind Min and Max Capacity Limit

$$wind_min_mw \leq wind_cap < wind_max_mw$$

8. Solar Min and Max Capacity Limit

$$solar_min_mw \leq solar_cap < solar_max_mw$$

9. Solar Generation

$$solar_gen_t = solar_cap * e_solar_genprofile_t * t_inst_length$$

10. Wind Generation

$$wind_gen_t = solar_cap * e_wind_genprofile_t * t_inst_length$$

11. Market Must Supply

In case if must supply:

$$elc_mark_committed_supply_t \geq elc_mark_committed_sare_t * t_inst_length$$

$$elc_mark_committed_supply_t \leq elc_mark_committed_sare_t * t_inst_length$$

12. External Market Sale and Import Limit

$$elec_saleto_market_t + elc_mark_committed_supply_t + elmarket_import_t \leq couple_max_limit * t_inst_length$$

13. SMR Capacity to Activity Relation

$$SMR_gen_t \leq SMR_cap * t_inst_length$$