# SWITCH 24/7 Model Formulation

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# Objective Function in detail

$$\min(PPACapacityCosts + PPAEnergyCosts + CongestionCosts + WholesaleStorageArbitrage)$$

$$\sum_{g} BuildGen_g * PPACapacityCost_g$$

$$\sum_{g,t} (PnodePrice_{g,t} - DeliveryNodePrice_t)(RenewableGeneration_{g,t})$$

$$\sum_{g,t} PPAEnergyPrice_g(RenewableGeneration_{g,t} + StorageDischarge_{g,t} - StorageCharge_{g,t})$$

$$= BuildGen_g * CapacityFactor_{g,t}$$

$$\sum_{g,t} PnodePrice_{g,t}(StorageCharge_{g,t} - StorageDischarge_{g,t})$$

# Note on Total Cost of Energy

- Although the objective function minimizes congestion costs (including for generation that exceeds load in a specific hour), the total cost of energy in the summary report does not include this cost term. Instead, it considers DLAP load cost and Pnode revenues, and it also considers the cost of RA

$$\text{Total Cost of Energy} = \begin{array}{r}(Storage)PPACapacityCosts + PPAEnergyCosts + \\ DLAP\ Load\ (Delivered\ Energy)\ Cost + Generator\ Pnode\ Revenue \\ +Storage\ Pnode\ Arbitrage\end{array}$$

# Balancing Constraints

**Load Balance Constraint:**

$$Supply_{z,t} \geq Demand_{z,t}$$

$$RenewableGeneration_{z,t} + GridPower_{z,t} + StorageDischarge_{z,t} \geq Demand_{z,t} + StorageCharge_{z,t} + LoadShift_{z,t}$$

**Volumetric Renewable Target:**

$$\sum_{z,t} RenewableGeneration_{z,t} \geq RenewableTargetPercent * \sum_{z,t} Demand_{z,t}$$

**Time-coincident Renewable Target:**

$$\sum_{t} GridPower_{z,t} \leq (1 - RenewableTargetPercent) * \sum_{t} Demand_{z,t}$$

# Battery Dispatch Constraints

| | | Hybrid (with battery g and paired generator G ) |
|---|---|---|
| Charging | $ChargeStorage_{g,t} \leq BuildGen_g * ChargeToDischargeRatio_g$ | AND $ChargeStorage_{g,t} \leq RenewableGeneration_{G,t}$<br>(hybrid storage can only charge from the paired generator) |
| Discharging | $DischargeStorage_{g,t} \leq BuildGen_g$ | AND $DischargeStorage_{g,t} + RenewableGeneration_{G,t} \leq BuildGen_G$<br>(the combined generation from the hybrid project cannot exceed the nameplate capacity of the paired generator, assuming interconnection is not oversized) |
| State of Charge (MWh, not %) | $SOC_{g,t} = (SOC_{g,t-1} * (1 - LeakageLoss_g)) + (ChargeStorage_{g,t} * \sqrt{RTE_g}) - (DischargeStorage_{g,t} * \frac{1}{\sqrt{RTE_g}})$<br>AND<br>$SOC_{g,t} \leq EnergyCapacity_g$<br>Where RTE is roundtrip efficiency | |
| Cycle Limit | $\sum_t DischargeStorage_{g,t} * \frac{1}{\sqrt{RTE_g}} \leq MaxCycles_g * EnergyCapacity_g$ | |