PV-BATTERY SYSTEM FOR TRANSMISSION MANAGEMENT

DOE Special Project
2003 State Energy Program (SEP)

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2002

Objectives of the Study

To evaluate the feasibility and potential economic advantages of deferring power transmission system upgrades using PV-battery technologies.

Proposed Analyses

The proposed study will utilize an optimization approach to analyze the economic benefits associated with ancillary services provided by the PV-battery system for

- spot market support,
- peak shaving,
- area frequency,
- voltage regulation,
- VAR compensation services.

Proposed Tasks of the Study

The study will:

1. Evaluate costs associated with upgrading existing power transmission/distribution systems that are near capacity limits.
2. Evaluate the anticipated load growth for the transmission/distribution systems.
3. Evaluate PV-battery devices that will provide for the required periodic peak energy demands.
4. Analyze the potential economic advantage of the deferral of the transmission/distribution systems upgrade against the acquisition and operating costs of the PV-battery system.
5. Analyze economic benefits associated with ancillary services provided by the PV-battery system.

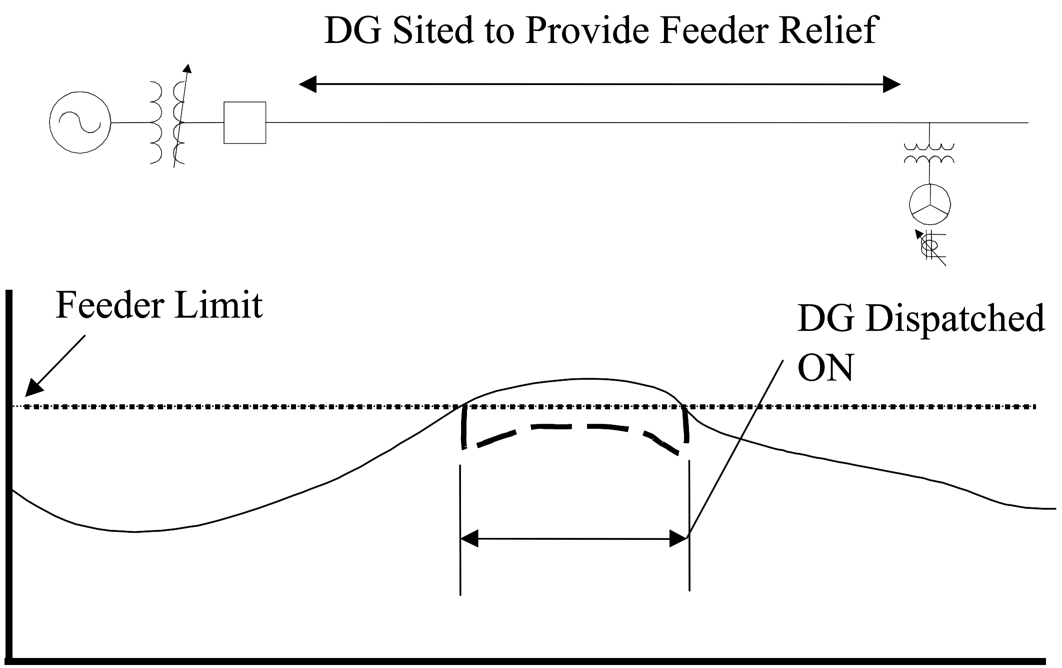
Outcome of the Study

- The outcome of this study will be a detailed technical report and a software product.
- The report will include tables, charts, transmission pricing and PV-battery data, numerical analyses based on the software product.
- The report will include a set of recommendations that will be applicable to other power systems in the country.

Why DG ?

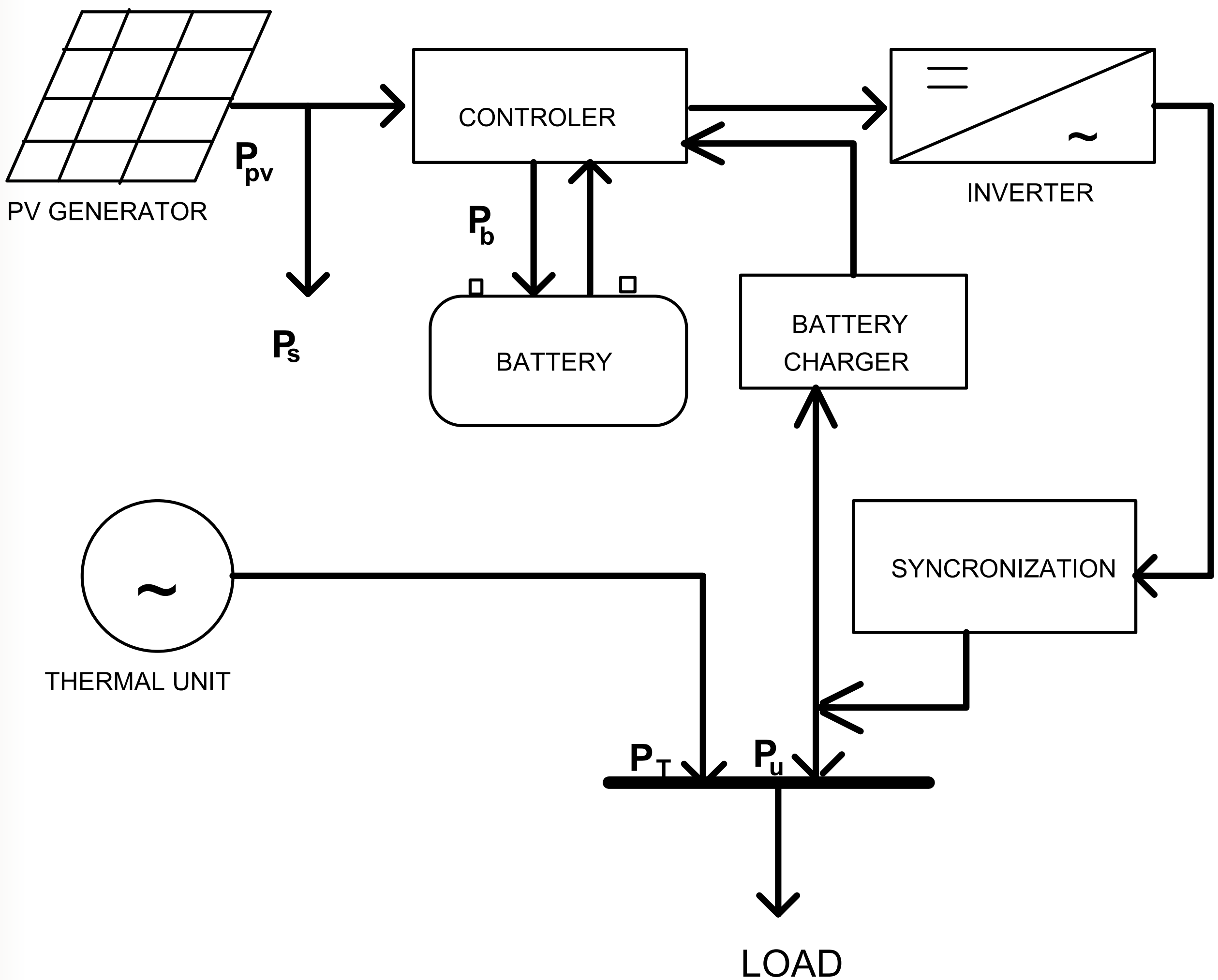
1. DG would not incur transmission and distribution costs, which would greatly reduce its marginal costs, enhance its competition, and reduce severe congestion penalties.
2. DG can be sized appropriately and quickly installed almost anywhere to capture the market value at key locations.
3. DG can operate flexibly to follow hourly fluctuations in energy prices.
4. A DG unit could be connected to consumer’s facility, to the utility’s distribution system, to power transmission grid, or to a combination of these options at the same time.

DG Site



Daily Load Profile

PV-Utility Grid with Battery Storage



Optimization of Scheduling

Objective: To minimize production costing of pv/battery/thermal system over the operational planning period

Subject To:

Thermal unit characteristics

- fuel limits
- generation capacity
- ramping rate limits
- minimum up/down time
- emission limits

Battery characteristics

- efficiency
- capacity
- max/min discharge
- fixed charging

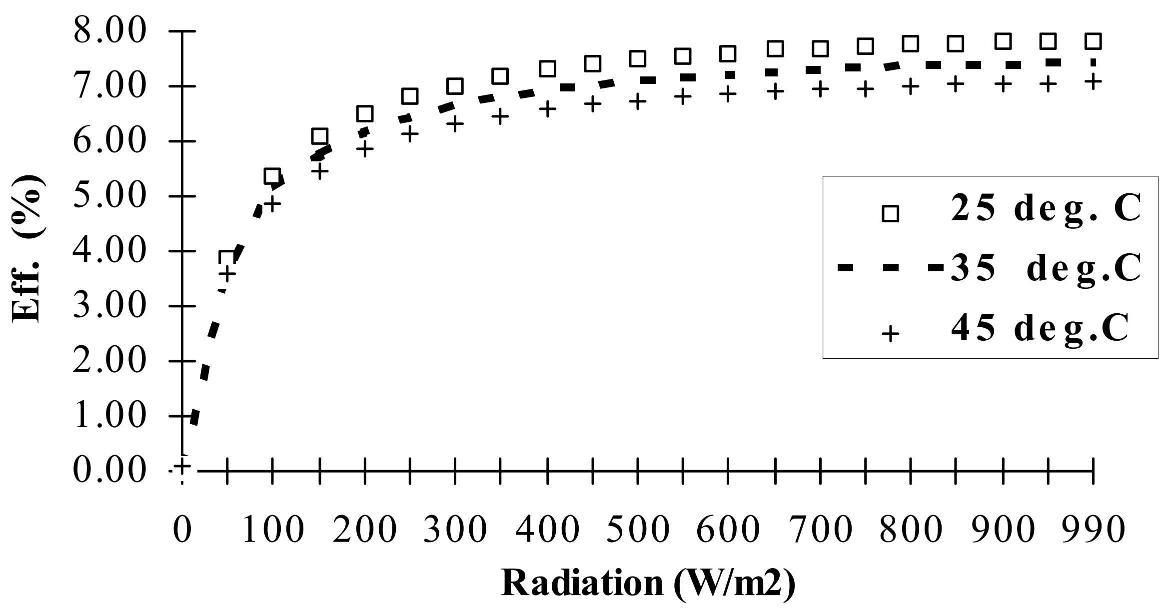
PV plant characteristics

- I/O $P_{out} = \boldsymbol{f}$ (Radiation, Temp.)
- PV penetration limit

System Constraints

- transmission line limits
- spinning reserve req.
- energy balance

PV Generator



$$P_{pv}(t) = \begin{cases} \dfrac{\eta_c}{K_c}(G_t)^2 & 0 < G_t < K_c \\ \eta_c G_t & G_t > K_c \end{cases}$$

Battery

If the system load exceeds the PV output, the difference is drawn from the battery until the battery is fully discharged.

The actual size of battery will depend on the amount of peak shaving desired. Based on the utility's load profile, peak shaving may be constrained by the depth of the battery discharge.

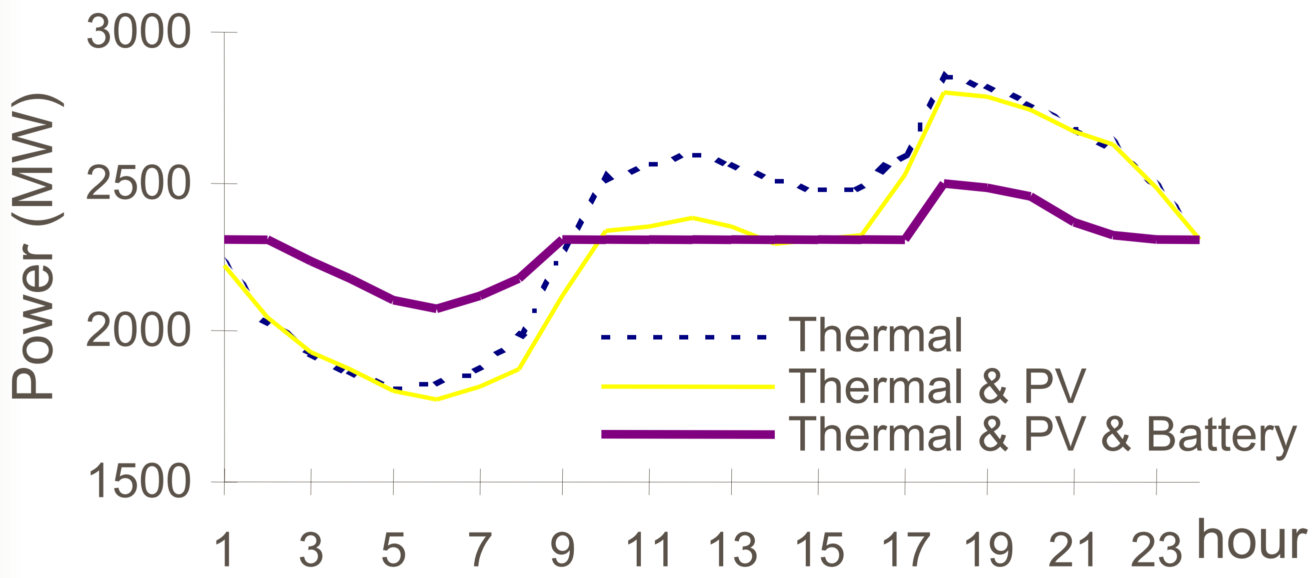
The cost of battery is largely dependent on the MWh size of the battery rather than its MW size. Thus utility planners would opt for a low MWh to MW ratio for the battery. That means a small period of discharge.

Example of a Case Study

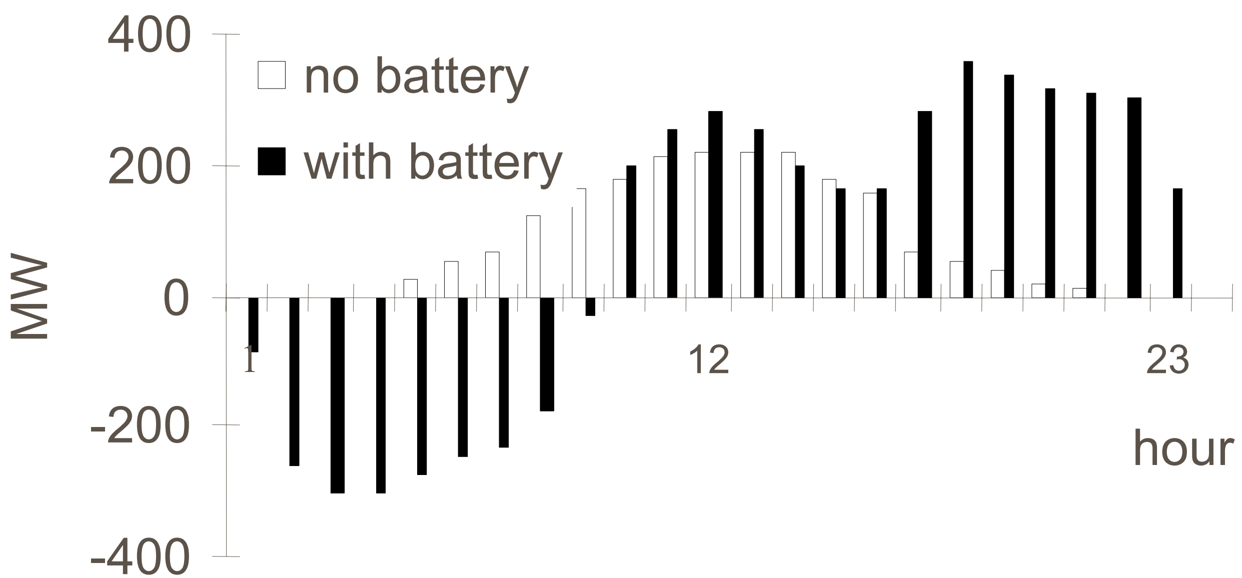
- 24 buses system
- 26 thermal units
- 260 MWp PV
- 3500 MWh Battery

No.	Case	Cost ($/day)	Battery Consumption
1.	Thermal only	749,541	-
2.	Thermal&Battery	742,931	388 MWh/day
3.	Thermal&PV	709,808	-
4	Thermal&PV&Battery	696,124	344 MWh/day

Example of a Case Study



Example of a Case Study



Observations

- It is anticipated that the pv/battery/thermal provides a greater flexibility to schedule thermal units and:
  - avoid commitment of expensive thermal units during peak load hours, which in turn can save fuel costs.
  - avoid base generation to be shut down at low load hours.
  - avoid frequent start up and shut down of thermal units, which in turn may reduce the start up and maintenance costs.
- The proposed method can be applied to other renewable energy sources with an intermittent nature

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