TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

A Novel Control Approach for Microgrids Islanded Operation - Load Step Pre-announcement and Bang-Bang Control

14. Symposium Energieinnovation 2016

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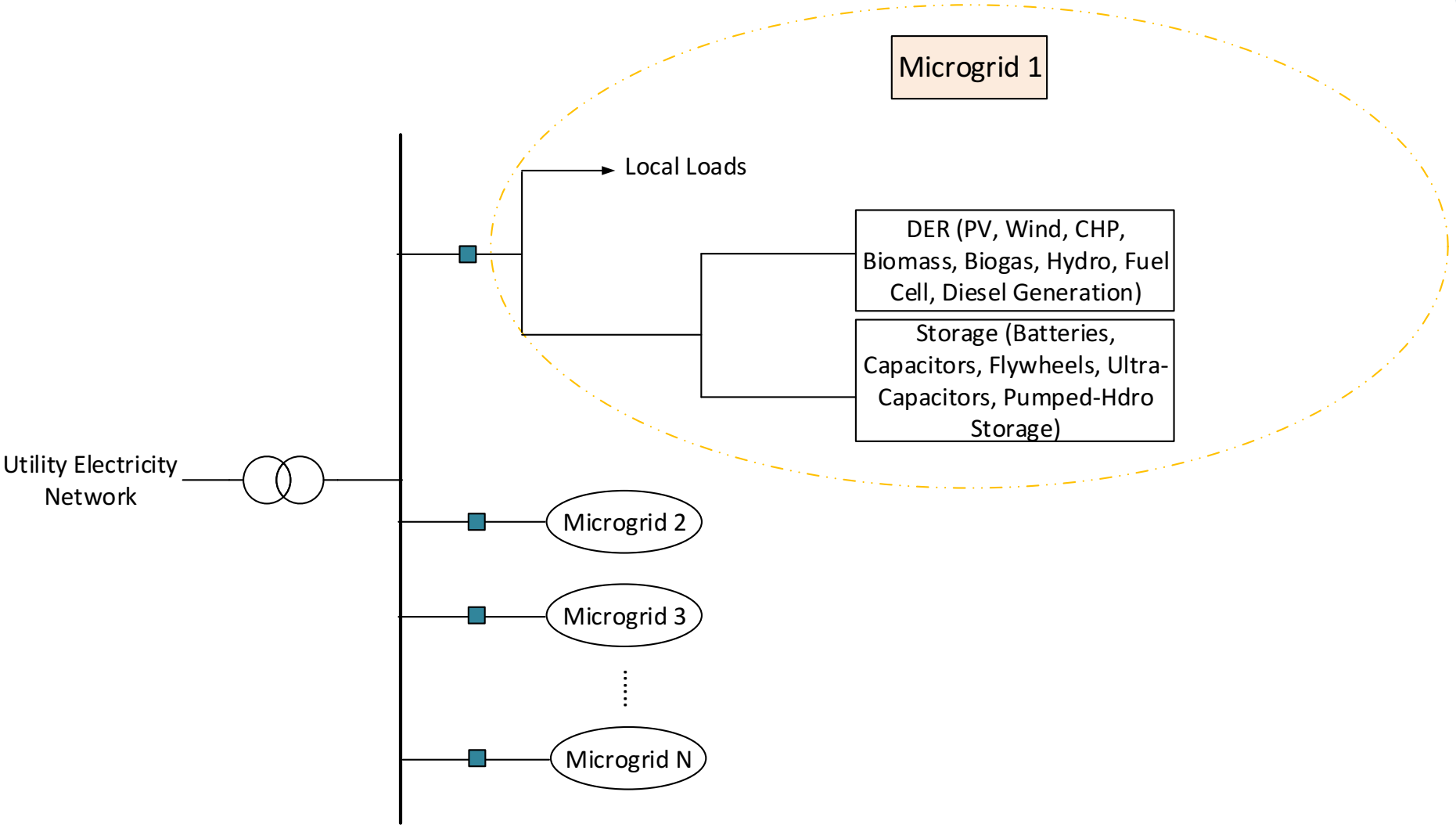
Introduction



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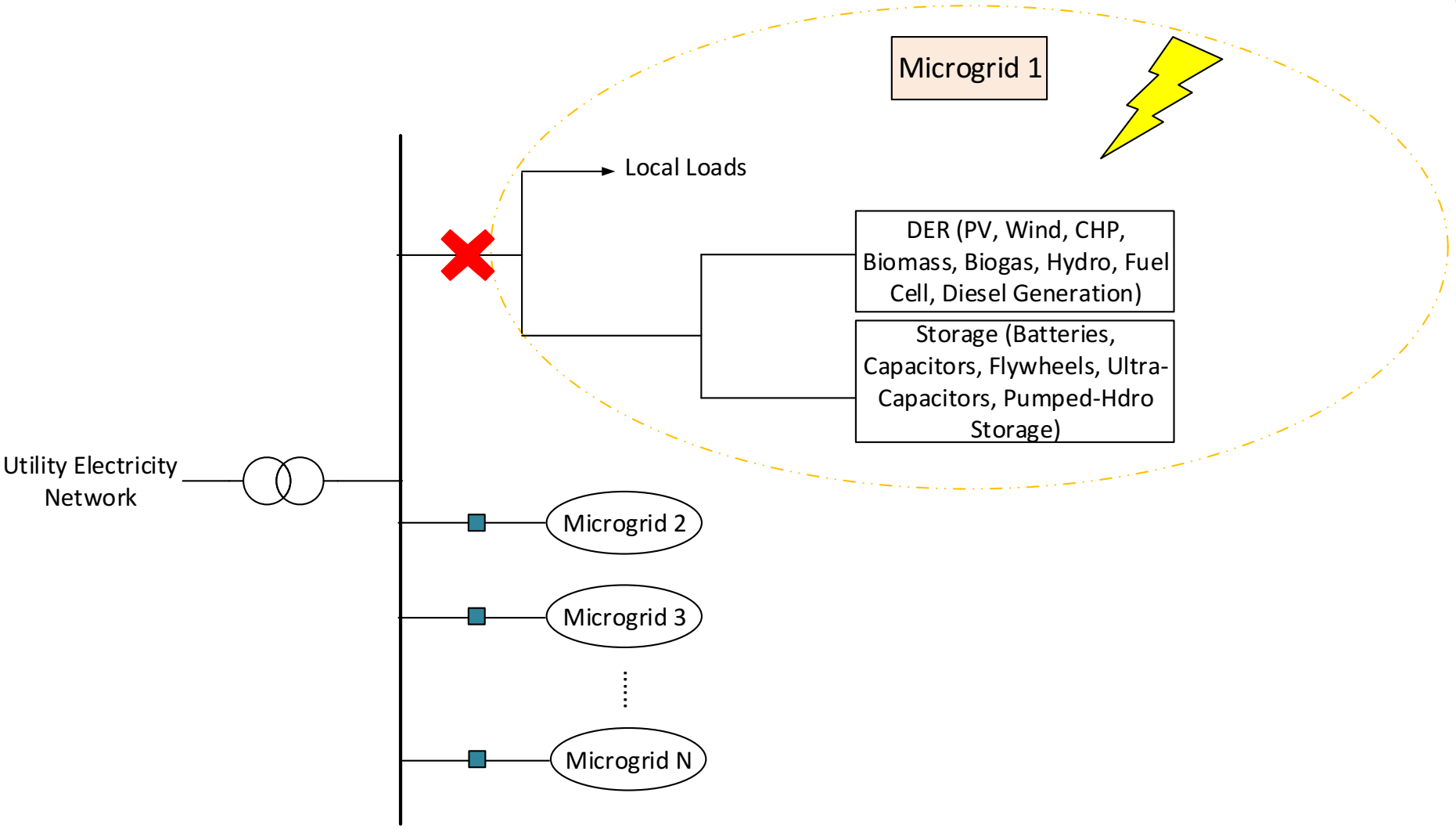

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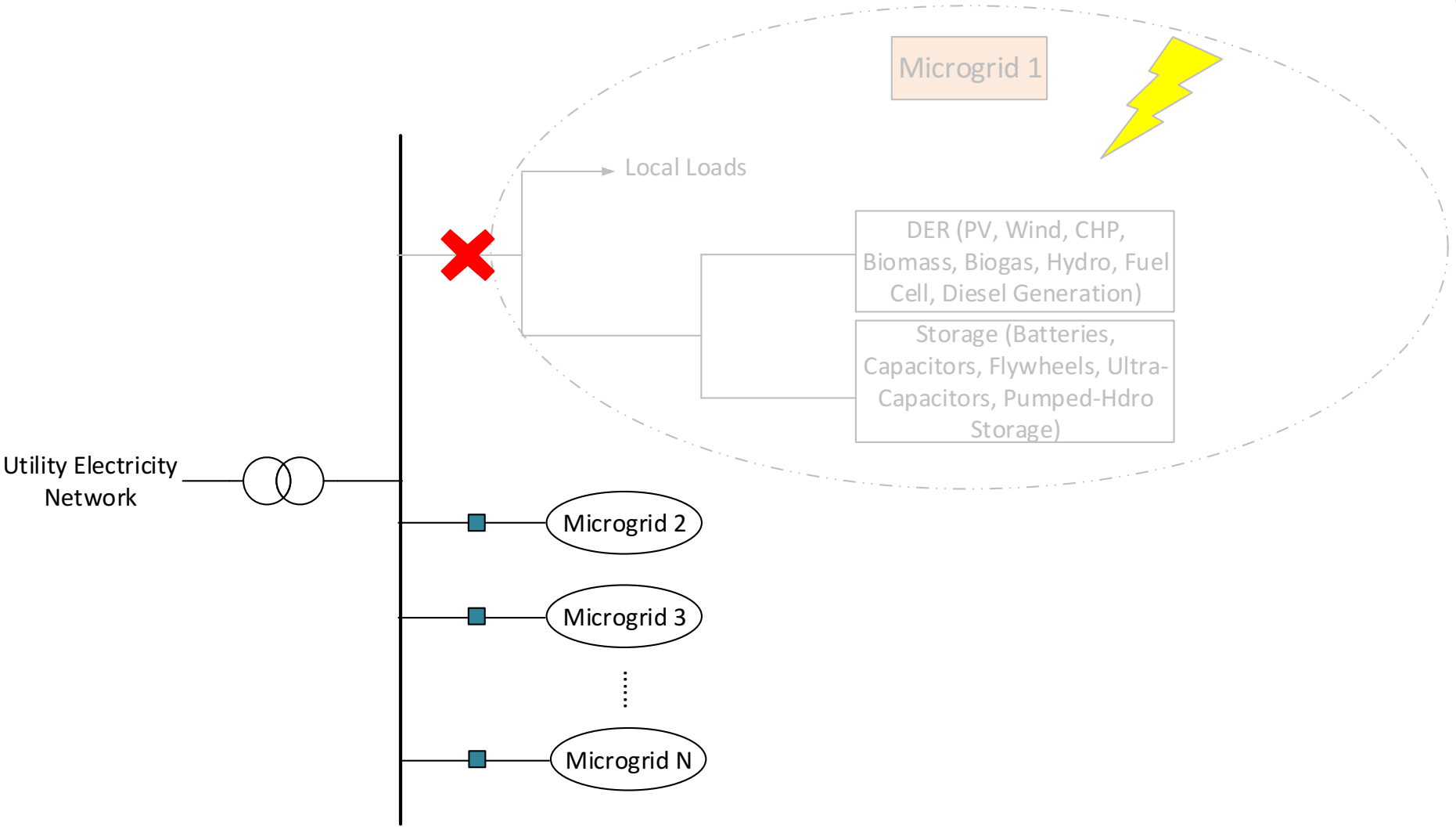

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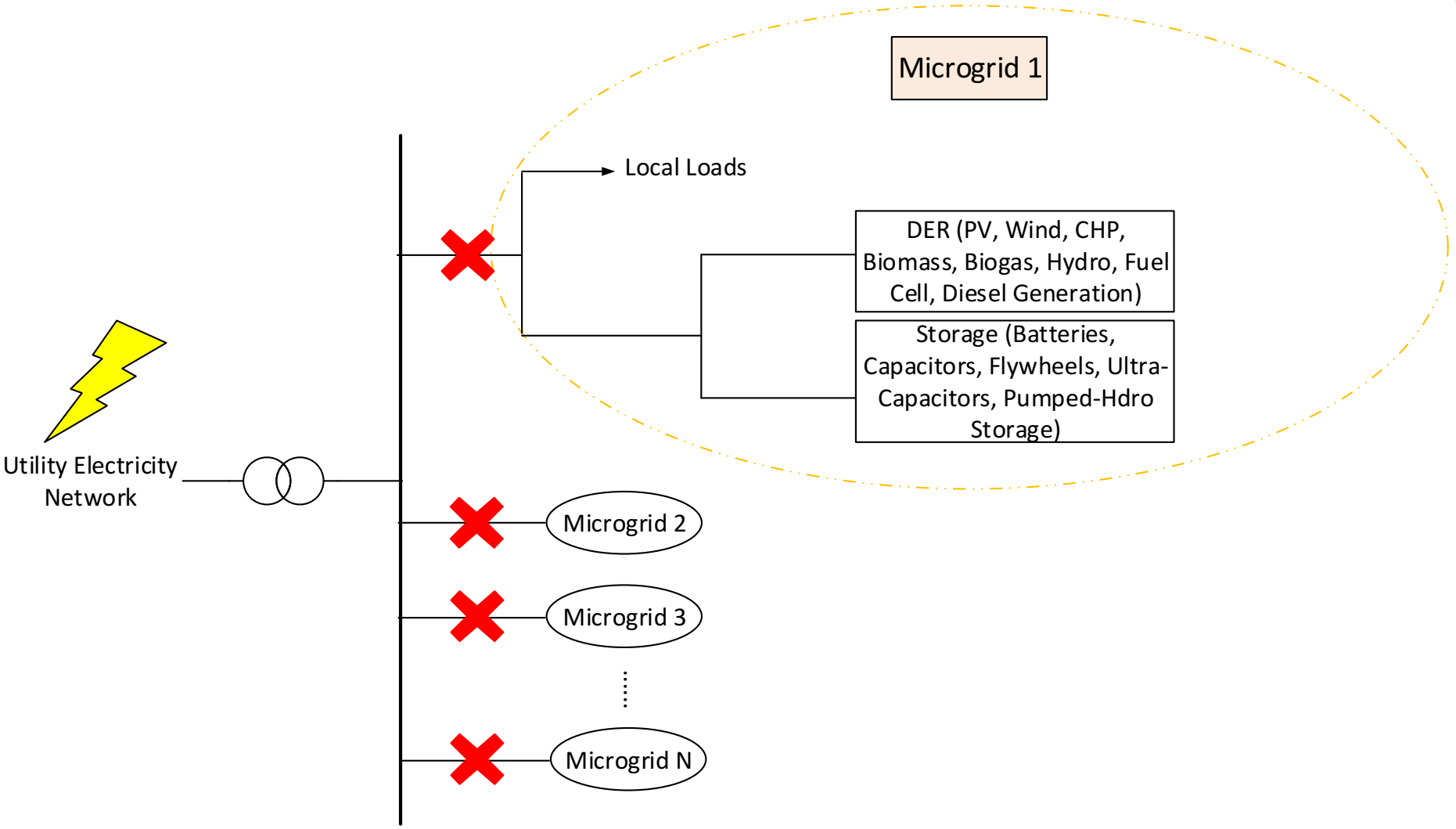

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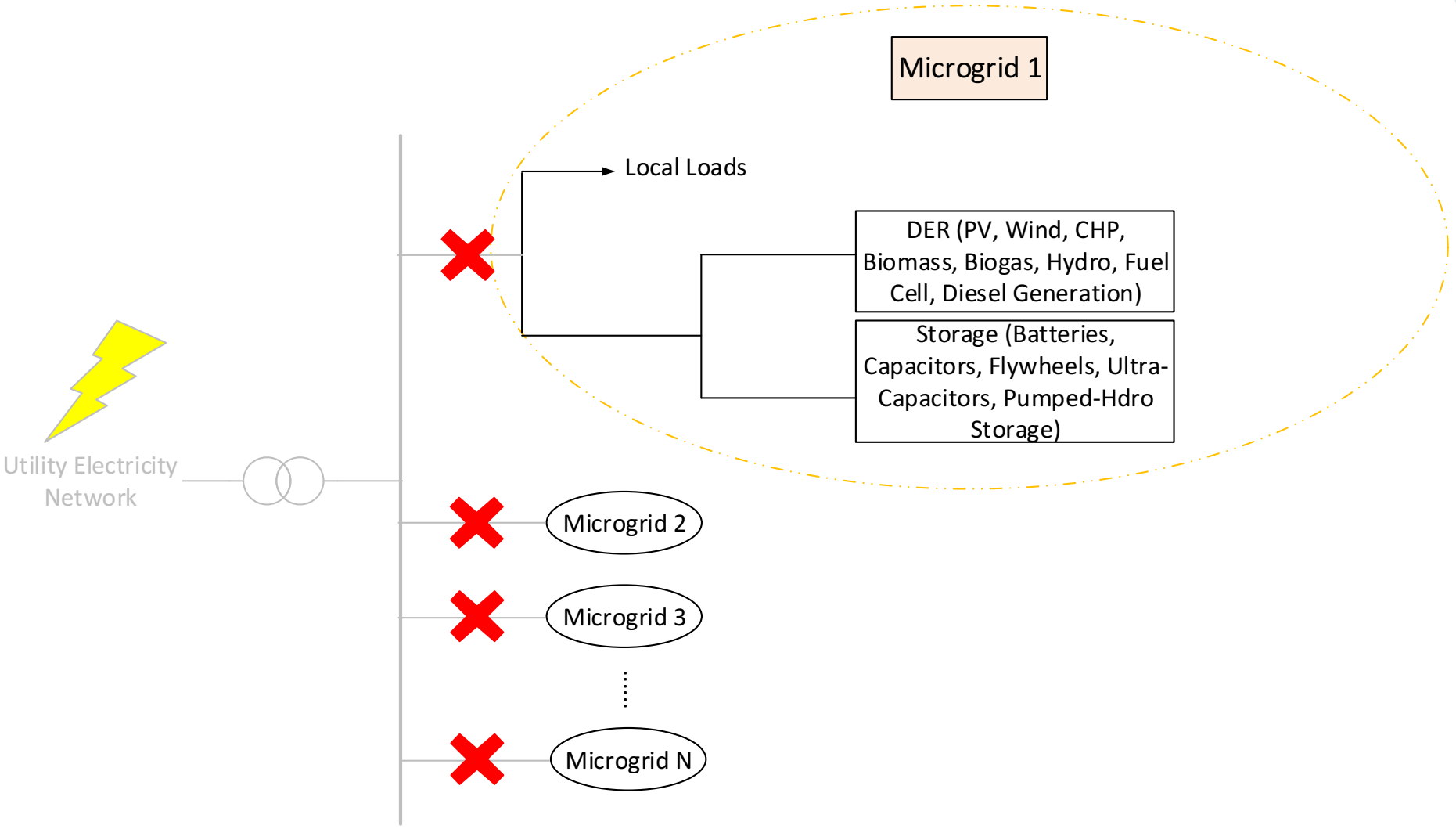
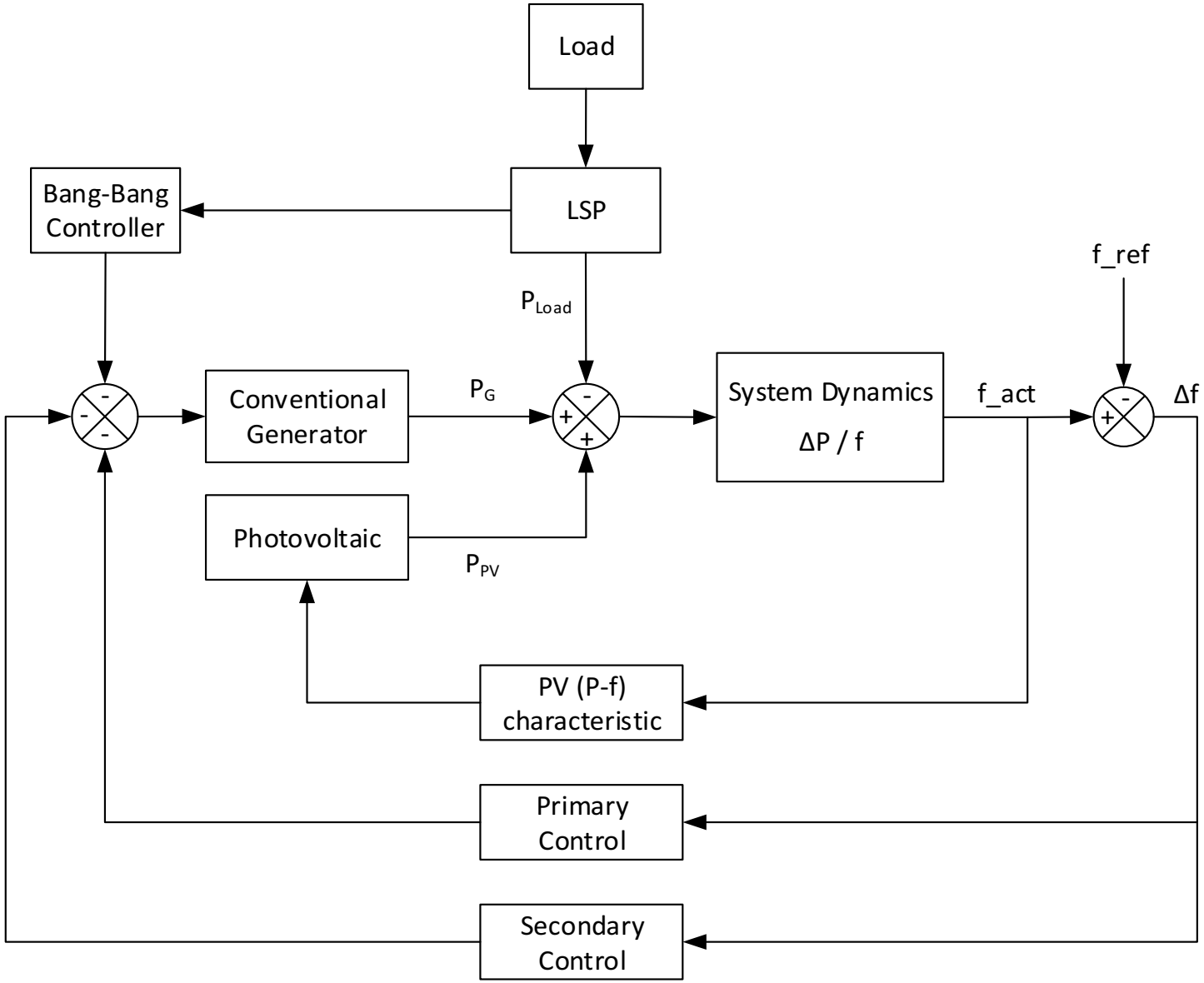
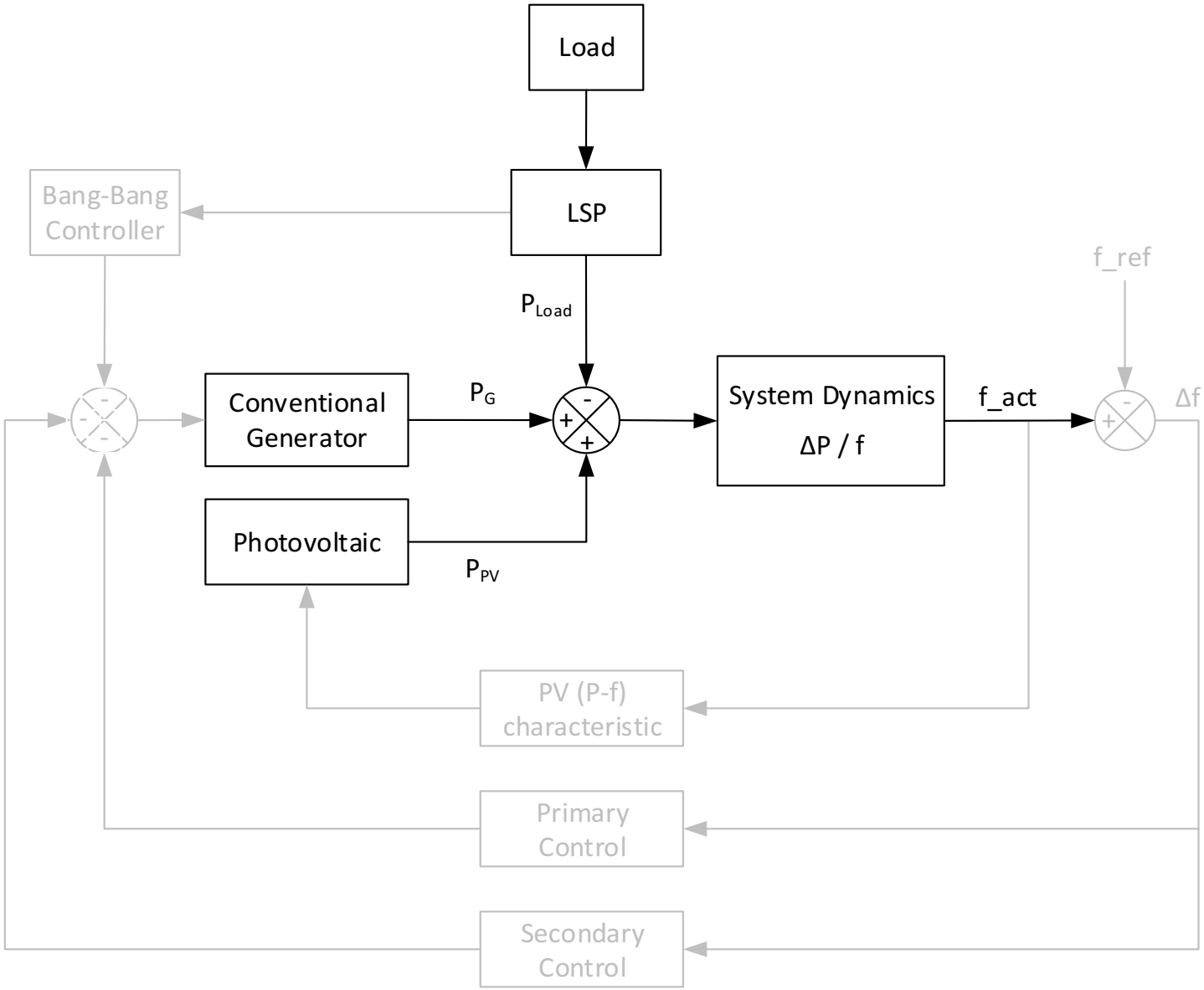


The Schematic Block Diagram of the Islanded Microgrid



Schematic Block Diagram of an Islanded Microgrid



Mathematical Model

- $\sum P_{Generator} - \sum P_{Load} = J * \omega * \frac{d\omega}{dt}$
- $T_A = J * \frac{\omega_n^2}{P_n}$
- $\omega = 2 * \pi * f$

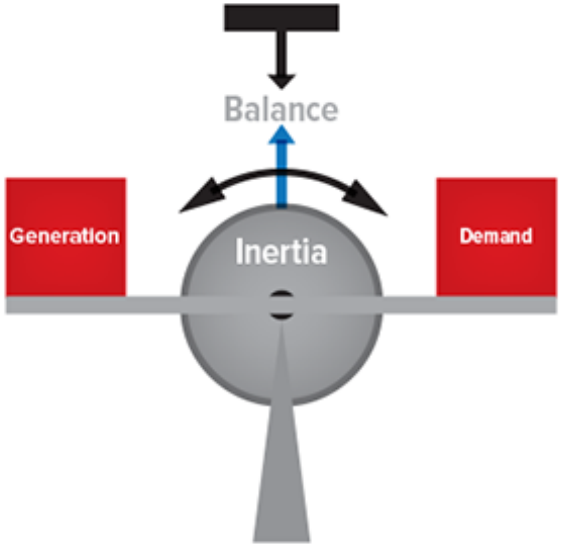
$P_{Generator}$: Generated power

P_{Load}: Load

J: Moment of Inertia

T_A: System starting time constant

f: Frequency

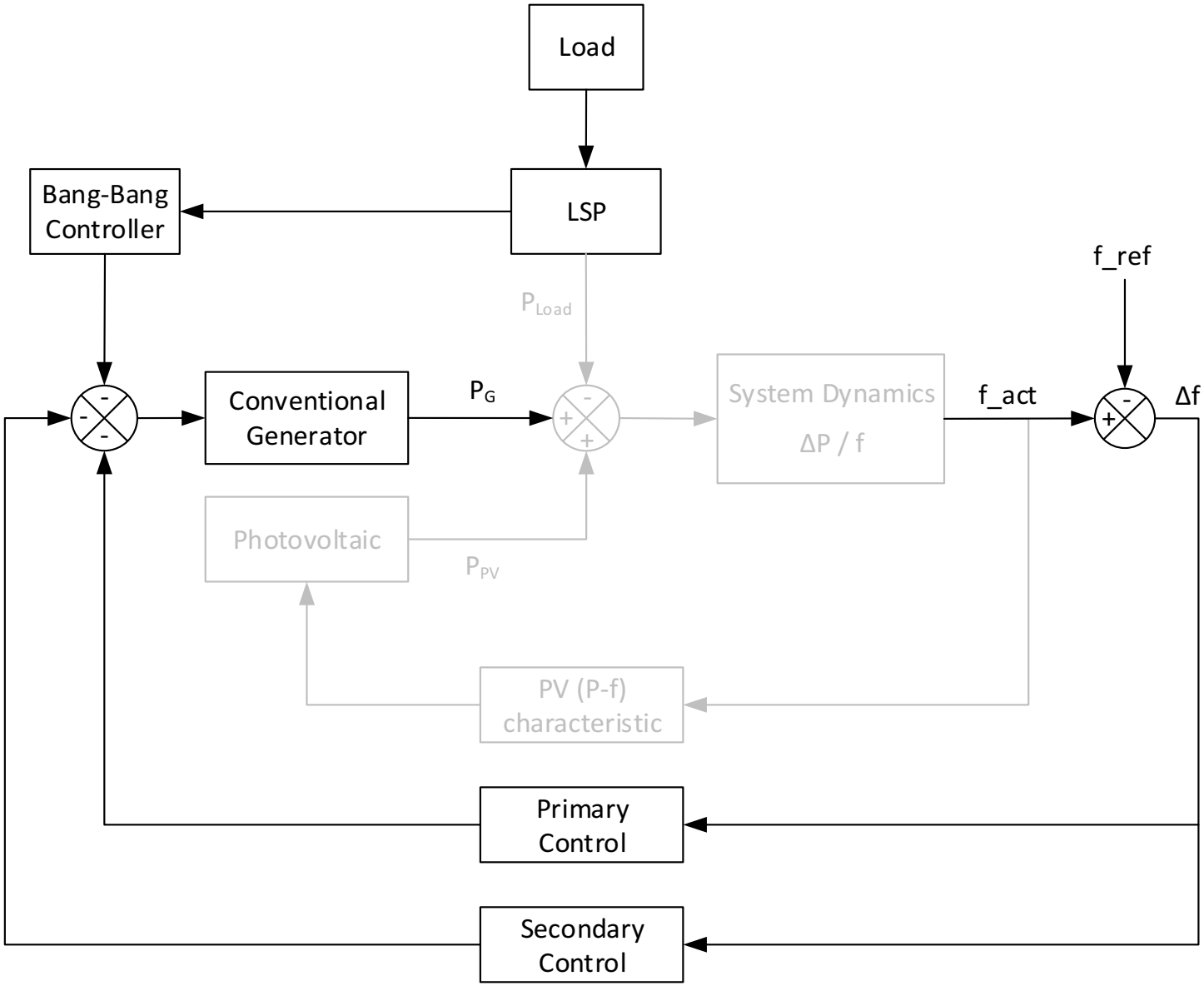


Source: http://www.smartpowergeneration.com/the-book-power-supply-challenges/chapter-2-balancing-the-electricity-supply-in-case-of-calamities

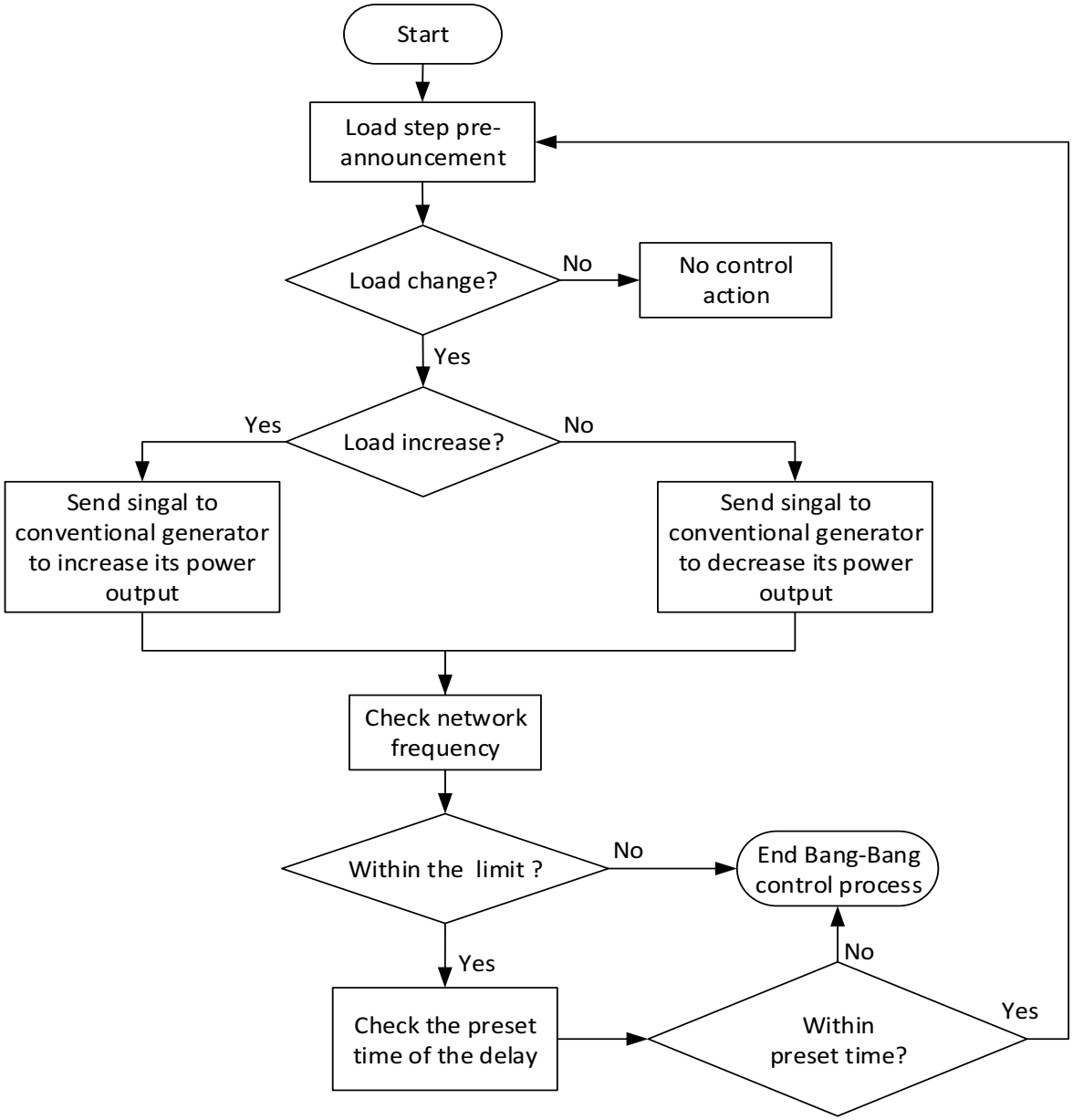
➢ Therefore, system mathematical equation:

$$\frac{df}{dt} = \frac{\sum P_{Generator} - \sum P_{Load}}{P_n} * \frac{f_n^2}{f_{act} * T_A}$$

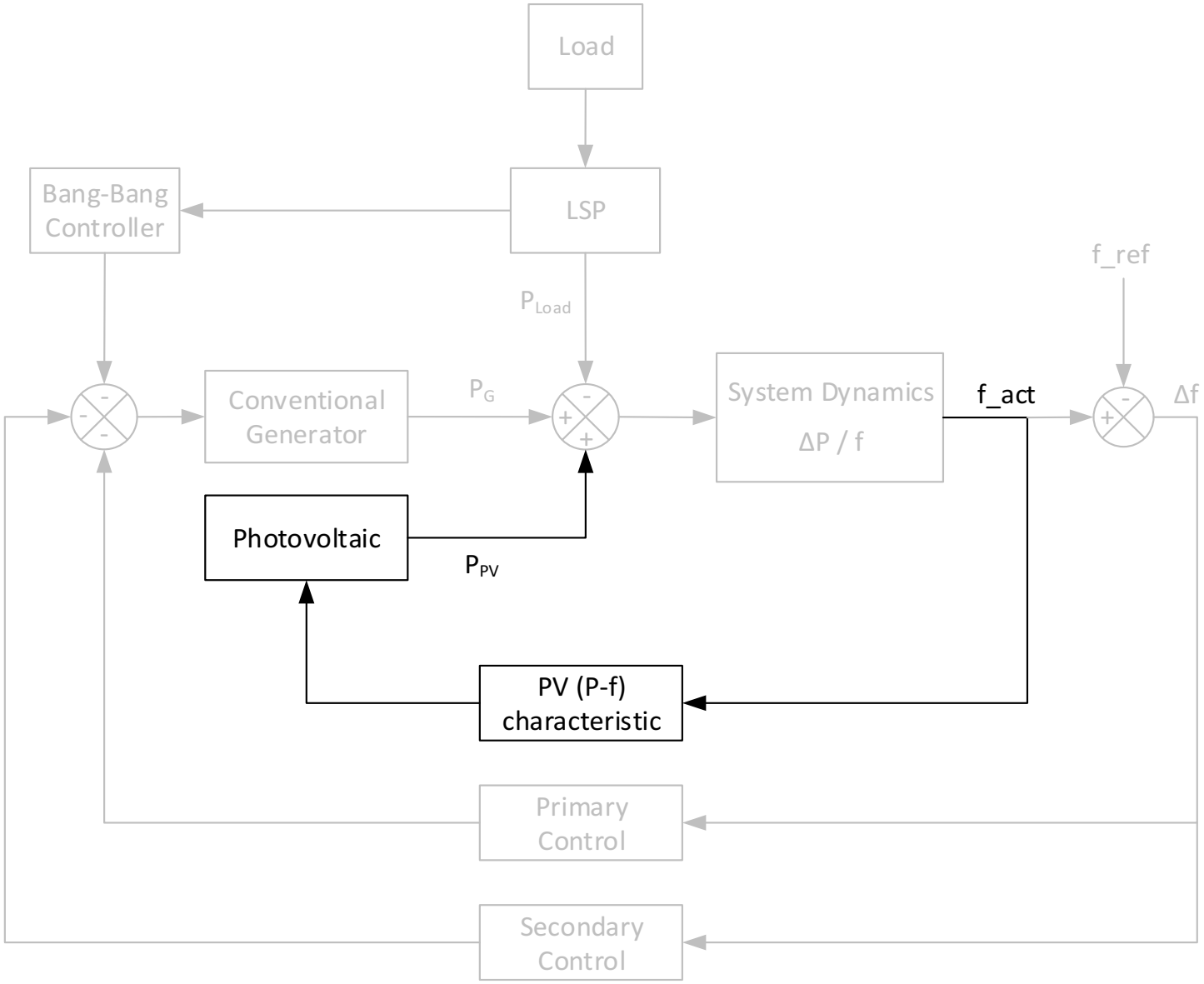
The Schematic Block Diagram of the Conventional Generator



Bang-Bang Controller

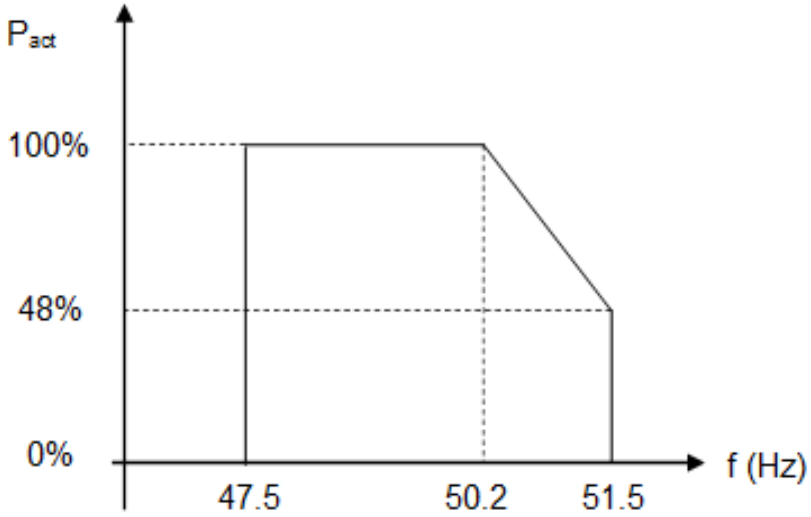


The Schematic Block Diagram of the Photovoltaic System



Photovoltaic Generator

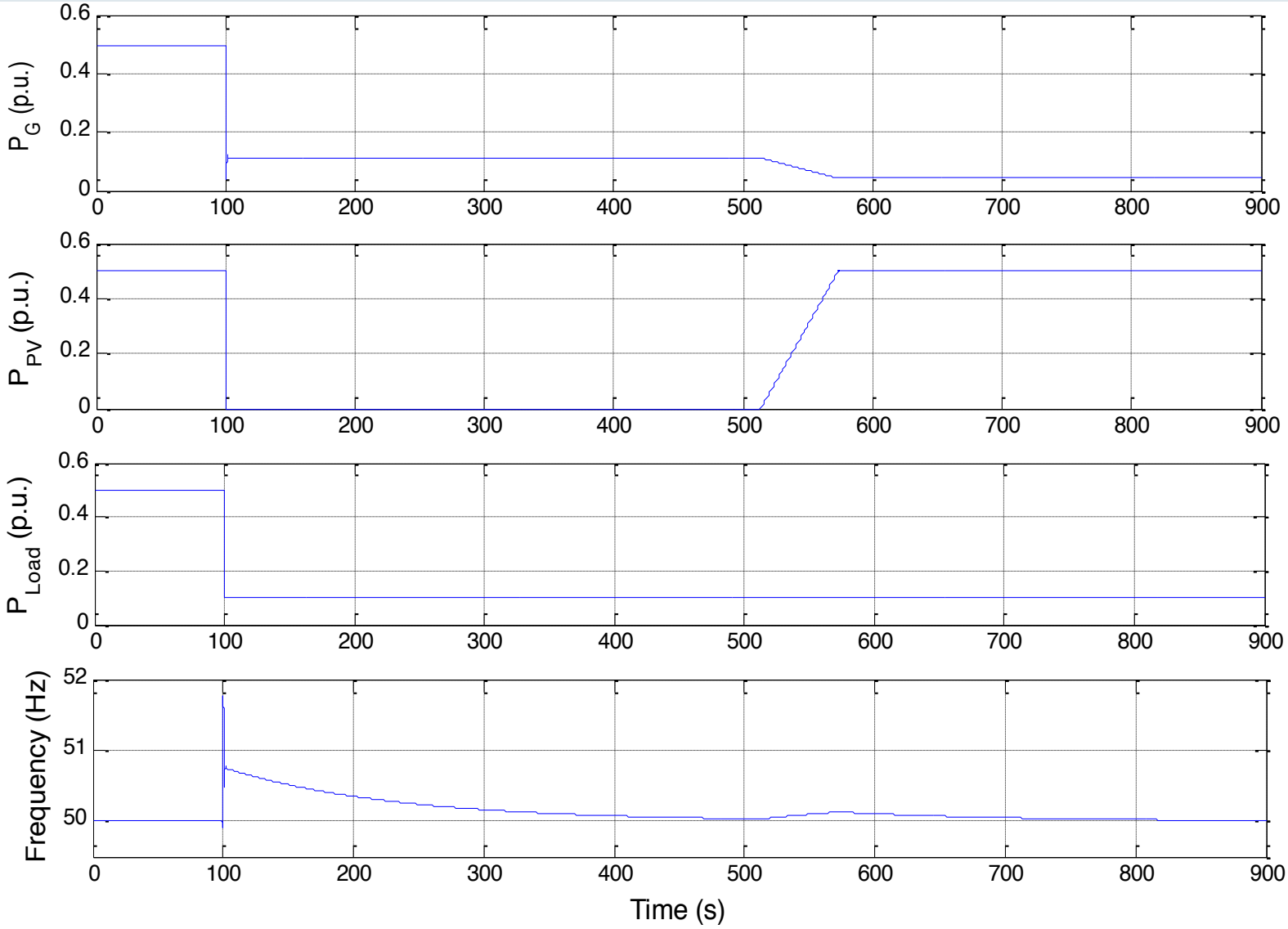
- $$P_{PV} = \begin{cases} 100\% * P_{act}, & 47.5\ Hz \leq f \leq 50.2\ Hz \\ P_{act} * \left(1 - \frac{40\%}{Hz} * \Delta f\right), & 50.2\ Hz < f \leq 51.5\ Hz \\ 0, & f < 47.5\ Hz\ or\ f > 51.5\ Hz \end{cases}$$
- $\Delta f = f - 50.2\ Hz$



PV characteristic curve
[Source: VDE-AR-N 4105]

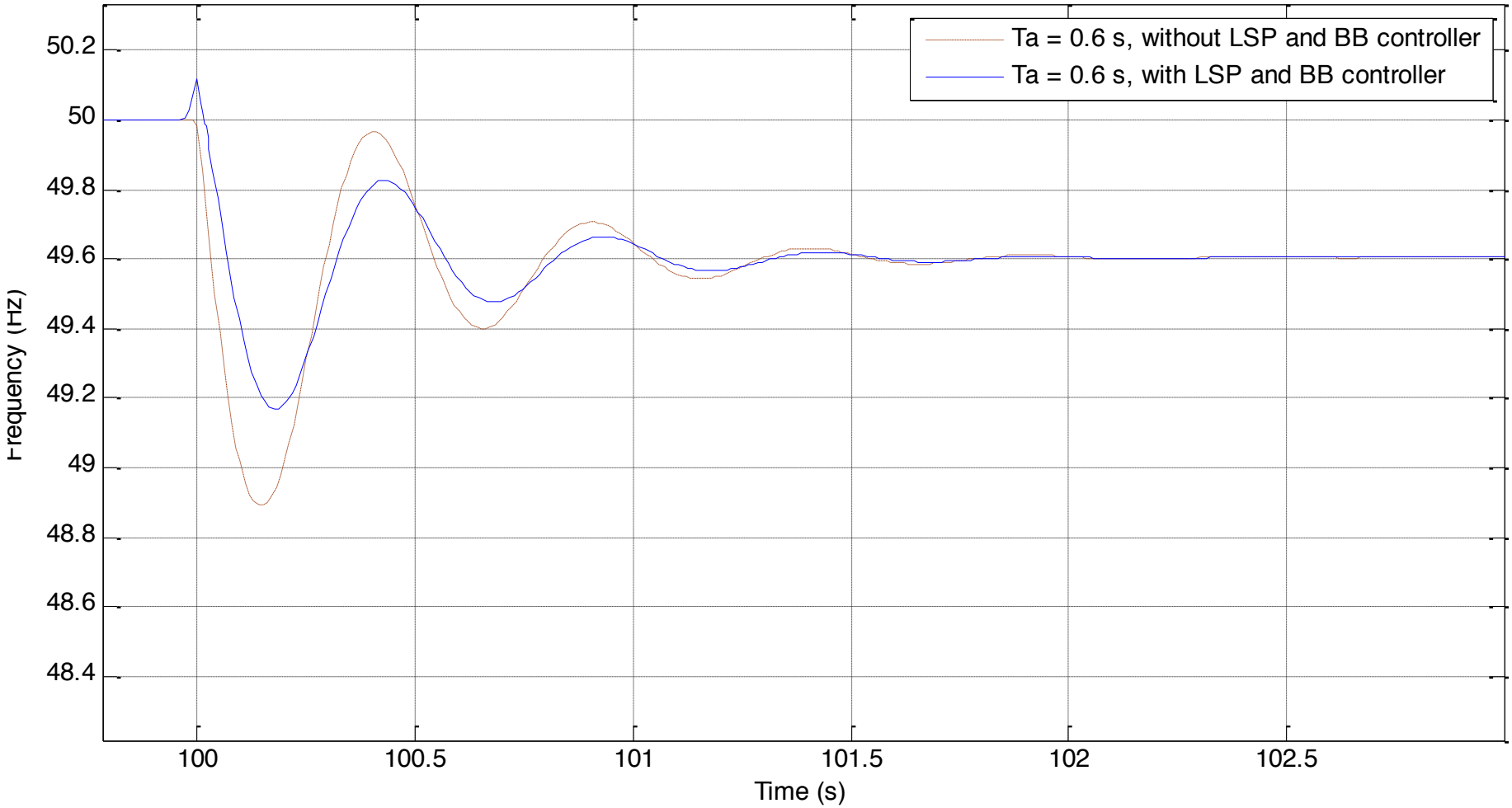
- Reconnection frequency:
  47.5 Hz ≤ f ≤ 50.05 Hz
- Not exceed 10% of the maximum active power of photovoltaics per minute after the reconnection

Dynamic Simulation Results



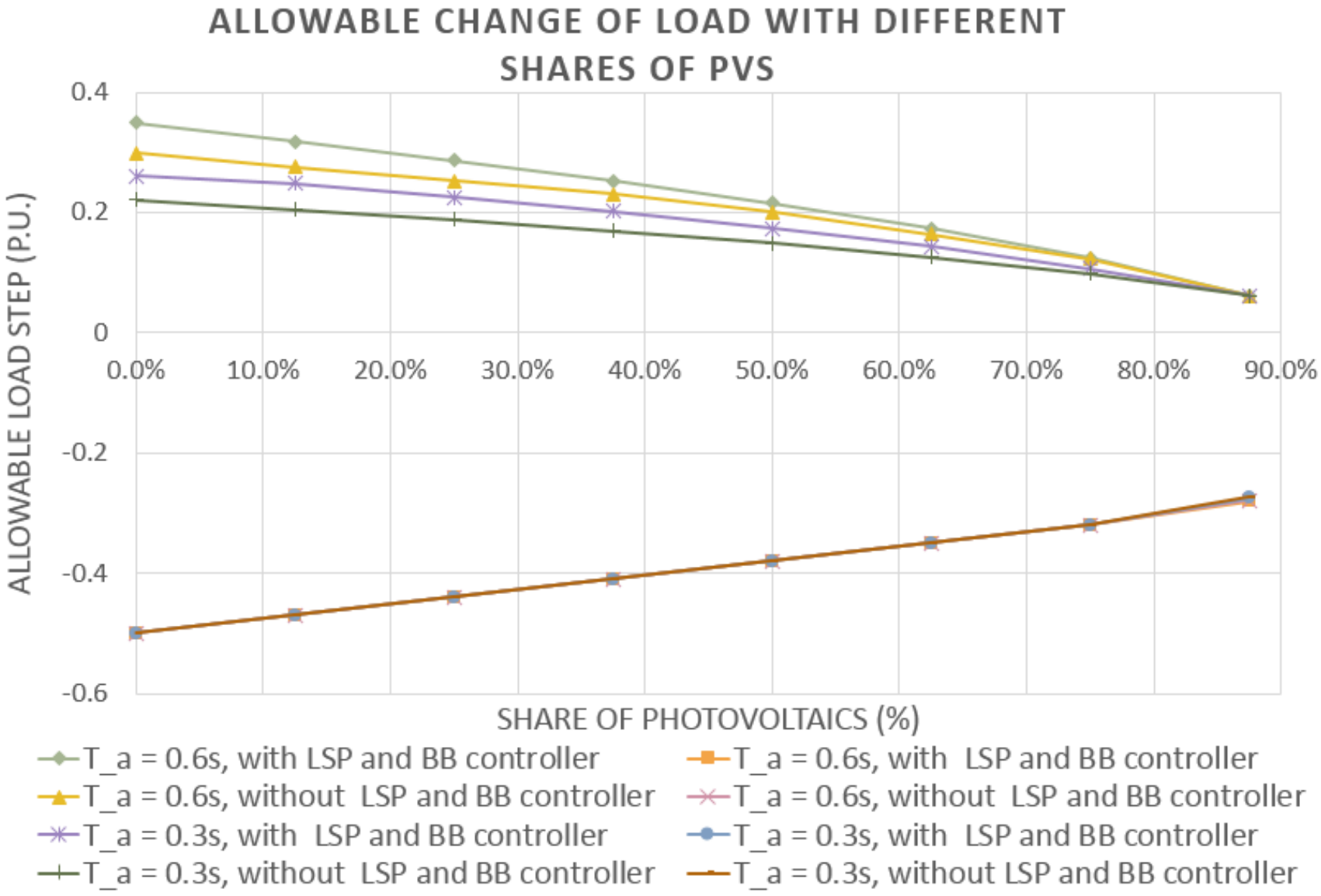
- Load step: 0.5 p.u. to 0.1 p.u.; T_A = 0.6 s ; 12.5% share of PV

Results Comparison



- Load step: 0.5 p.u. to 0.65 p.u.; T_A = 0.6 s ; 25% share of PV

Maximum Possible Load Change



Conclusions

1. The load can only change less in the MG with a higher share of PVs
2. The maximum possible load decrease step is greater than the maximum load increase step
3. LSP and the BB controller can improve the maximum load increase step
4. LSP and the BB controller have no influence on a large load decrease step

Outlook

- The preset time should be further optimized
- Load step pre-announcement can be developed to be more intelligent
- Other control methods for decreasing a large amount of load or a big load loss in MGs should be considered

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