Optimal Operation of Islanded AC/DC Hybrid Microgrids: Supplementary Information

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1 Cost Function of DGs

The quadratic cost function of DG_1^{ac} connected at Bus 1 in AC subgrid is:

$$C^{ac}_{DG_1}(P^{ac}_{G_1}) = 140 + 6.3P^{ac}_{G_1} + 0.005(P^{ac}_{G_1})^2 \qquad (\$/\text{h}) \tag{1}$$

The quadratic cost function of DG_3^{ac} connected at Bus 3 in AC subgrid is:

$$C^{ac}_{DG_3}(P^{ac}_{G_3}) = 200 + 10P^{ac}_{G_3} + 0.008(P^{ac}_{G_3})^2 \qquad (\$/\text{h}) \tag{2}$$

The quadratic cost function of DG_3^{dc} connected at Bus 3 in DC subgrid is:

$$C^{dc}_{DG_3}(P^{dc}_{G_3}) = 160 + 7P^{dc}_{G_3} + 0.008(P^{dc}_{G_3})^2 \qquad (\$/\text{h}) \tag{3}$$

The quadratic cost function of DG_6^{dc} connected at Bus 6 in DC subgrid is:

$$C^{dc}_{DG_6}(P^{dc}_{G_6}) = 160 + 5P^{dc}_{G_6} + 0.005(P^{dc}_{G_6})^2 \qquad (\$/\text{h}) \tag{4}$$

2 Parameter Values and Constraint Limits - Optimization

AC and DC Grid no-load voltage is 230V.
AC grid no-load frequency is 50 Hz.

For DG_1^{ac}:

$$-15 \text{ kW} \leq P^{ac}_{G_1} \leq 15 \text{ kW} \tag{5}$$

$$-10 \text{ kVAR} \leq Q^{ac}_{G_1} \leq 10 \text{ kVAR} \tag{6}$$

$$(S^{ac}_{G_1})_{max} = 18.75 \text{ kVA} \tag{7}$$

For DG_3^{ac}:

$$-20 \text{ kW} \leq P^{ac}_{G_3} \leq 20 \text{ kW} \tag{8}$$

$$-15 \text{ kVAR} \leq Q^{ac}_{G_3} \leq 15 \text{ kVAR} \tag{9}$$

$$(S^{ac}_{G_3})_{max} = 25 \text{ kVA} \tag{10}$$

For DG_3^{dc}:

$$-20 \text{ kW} \leq P^{dc}_{G_3} \leq 20 \text{ kW} \tag{11}$$

For DG_6^{dc}:

$$-15 \text{ kW} \leq P^{dc}_{G_6} \leq 15 \text{ kW} \tag{12}$$

For Interlinking Converter:

$$-10 \text{ kW} \leq P_{ic} \leq 10 \text{ kW} \tag{13}$$

For all AC subgrid buses:

$$218.5 \text{ V} \leq |V_i^{ac}| \leq 241.5 \text{ V} \qquad \forall i \in \mathcal{N}_{\text{ac}} \tag{14}$$

$$-\pi \leq \delta_i \leq \pi \qquad \forall i \in \mathcal{N}_{\text{ac}} \tag{15}$$

For all DC subgrid buses:

$$218.5 \text{ V} \leq |V_i^{dc}| \leq 241.5 \text{ V} \qquad \forall i \in \mathcal{N}_{\text{dc}} \tag{16}$$

System frequency:

$$47.5 \text{ Hz} \leq f \leq 52.5 \text{ Hz} \tag{17}$$

Refer next Section for load details.

3 12-bus AC/DC Hybrid Microgrid Details

The details regarding the AC subgrid follows:

Parameters	**Value**
Resistance	0.668 Ω/km
Reactance	0.879 Ω/km
Half Line Charging Susceptance	0.0005 Ω^{-1}/line
Line Lengths	100 m
$K_{P_1}^{ac}$	1.666e-4 (Hz/W)
$K_{P_3}^{ac}$	1.25e-4 (Hz/W)
$K_{Q_1}^{ac}$	1.15e-3 (V/VAR)
$K_{Q_3}^{ac}$	7.66e-4 (V/VAR)
Peak Load (for all loads)	5 kW + j3.75 kVAR

Table 1: 6-bus AC subgrid details.

The details regarding the DC subgrid follows:

Parameters	**Value**
Resistance	2.35 Ω/km
Line Lengths	100 m
$K_{P_3}^{dc}$	1.15e-3 (V/W)
$K_{P_6}^{dc}$	1.53e-4 (Hz/W)
Peak Load (for all loads)	5 kW

Table 2: 6-bus DC subgrid details.

The interlinking converter droop K_P^{ic} is 2e-4 $(1/W)$.

3.1 Load Profile

The loads in the microgrid follow the normalized load profile presented in Figure 1:

3.2 Solar Generation Profile

The solar PV generation profile is presented in Figure 2.
It should be noted that the solar generation in the network was considered at a power factor of 0.8 lagging.

4 Additional Results

Figure 3 presents the frequency of the AC subgrid for the entire year. Figure 4 presents the network losses (AC and DC) obtained via simulation, while Figure 5 presents them for the optimal case for the month of January.

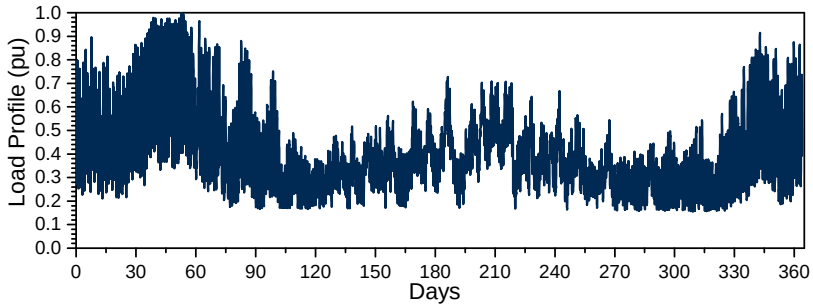

Figure 1: Normalized Load Profile in pu.

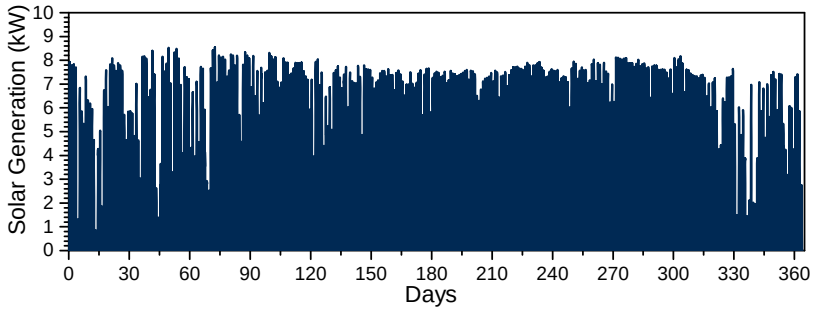

Figure 2: Solar PV Generation Profile in kW.

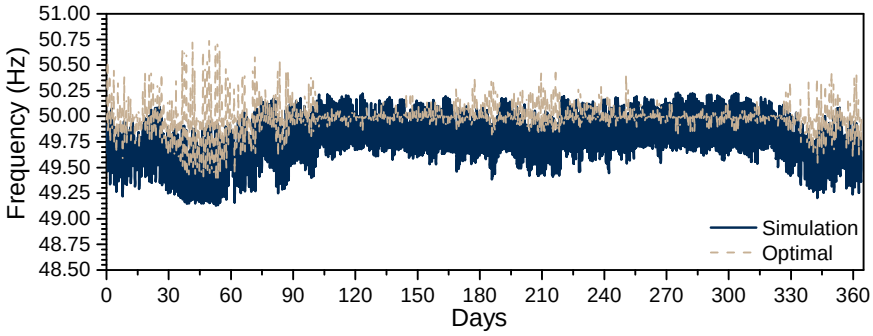

Figure 3: AC subgrid frequency in Hz.

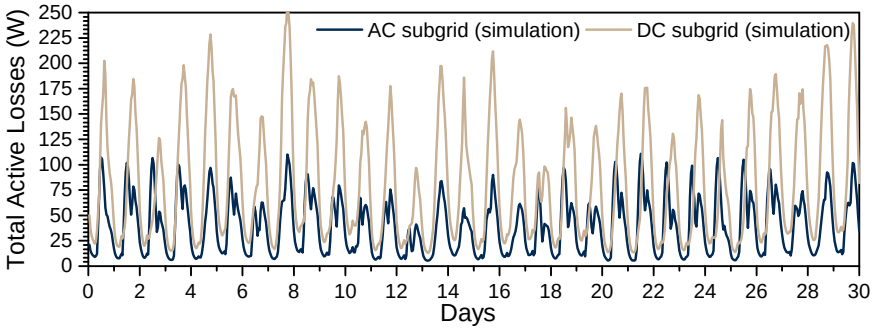

Figure 4: AC and DC subgrid losses in W.

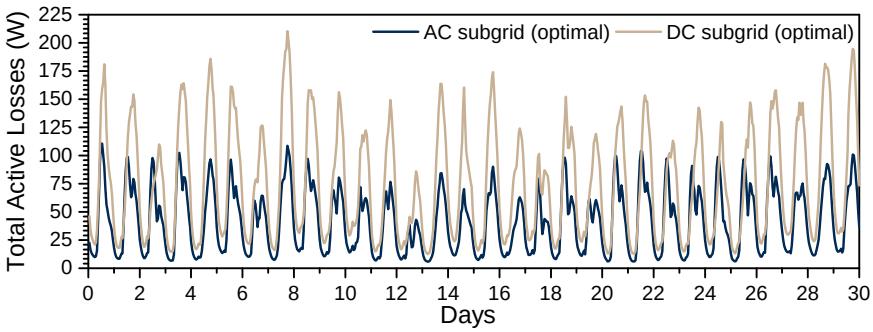

Figure 5: AC and DC subgrid optimal losses W.