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FNSNF

Towards Enabling Uninterrupted Long-Term Operation of Solar Energy Harvesting Systems

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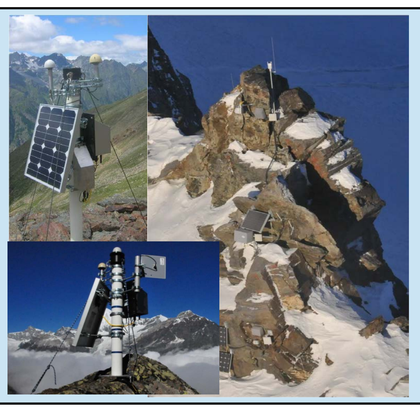
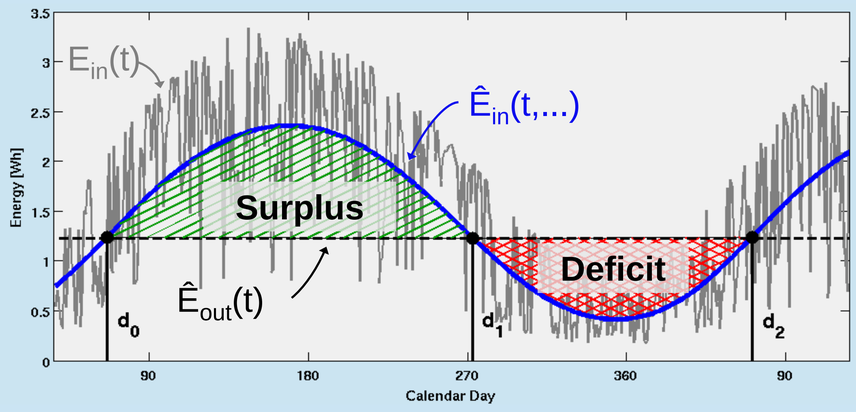
> Motivation

- Wireless Sensor Nodes increasingly leverage solar energy harvesting to mitigate the energy constraints of battery powered systems and so achieve long-term, uninterrupted operation.
- However, systematic design principles for optimized energy harvesting systems are still lacking.
- Variable energy harvesting opportunities and non-intuitive trade-offs between solar panel size and battery capacity complicate the system design.



> Design-Time Power Sub-System Capacity Planning and Dynamic Power Management

Step 1: Provision battery and solar panel to support the expected load indefinitely



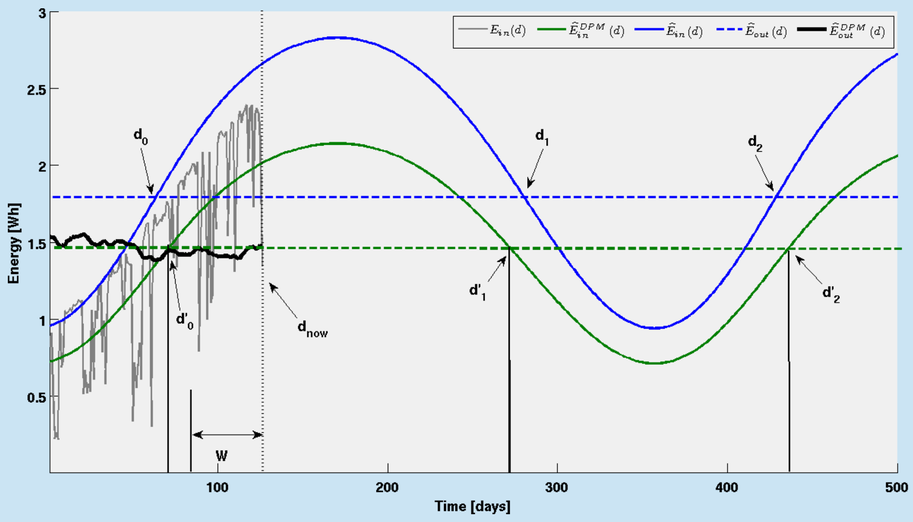
Solar Panel Size

$$\sum_{t=d_0}^{d_1} \hat{E}_{in}(\bullet) \geq B_{\text{nom}} + \sum_{t=d_0}^{d_1} \hat{E}_{out}(t)$$

Battery Capacity

$$B_{\text{nom}} \geq \sum_{t=d_1}^{d_2} \left(\hat{E}_{out}(t) - \hat{E}_{in}(\bullet) \right)$$

Step 2: Dynamically adjust performance level according to energy conditions, such that the load can be supported indefinitely



Runtime constraints

$$B_{\text{nom}} \geq \sum_{t=d_1}^{d_2} \left(\hat{E}_{out}^{DPM}(t) - \alpha \hat{E}_{in}(\bullet) \right)$$

$$\sum_{t=d_0}^{d_1} \alpha \hat{E}_{in}(\bullet) \geq B_{\text{nom}} + \sum_{t=d_0}^{d_1} \hat{E}_{out}^{DPM}(t)$$

Model scaling factor α

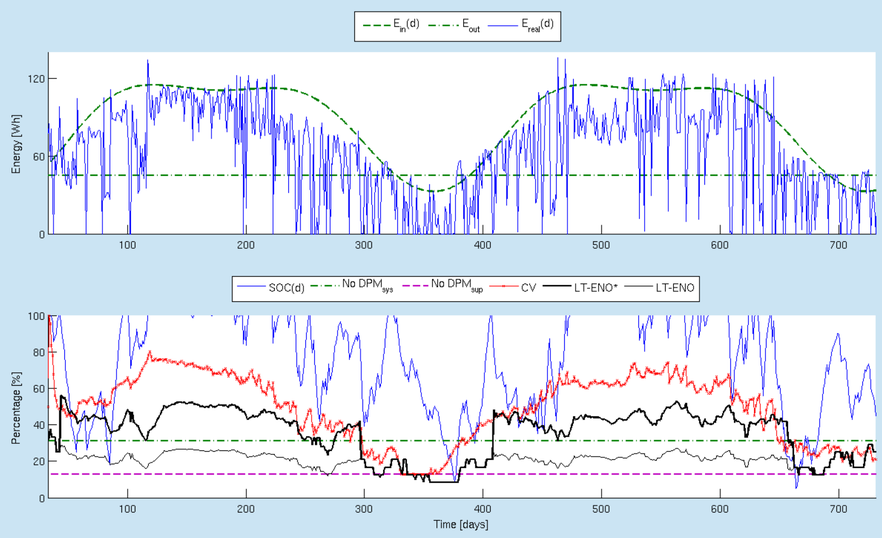
$$\alpha = \frac{\sum_{d-W}^{d} E_{\text{in}}(d)}{\sum_{d-W}^{d} \hat{E}_{\text{in}}(d)}, \quad 0 < W \leq d$$

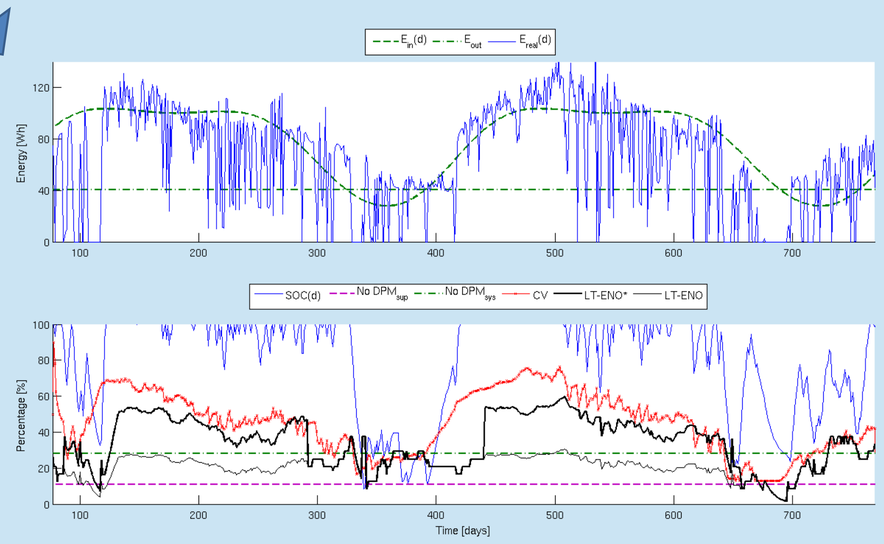
Design-time | Runtime

> Experimental Evaluation

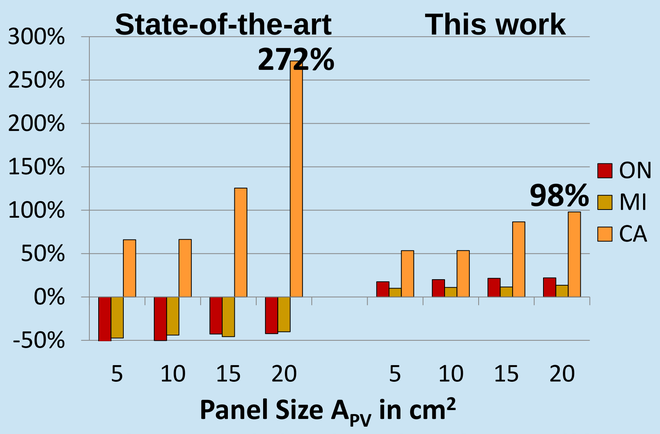
2 locations in Switzerland

2 years of data from





Theoretical Evaluation:



Capacity provisioning for three different locations and 4 harvesting setups. State-of-the-art approach vs. this work.

Benefits of dynamic power Management: Comparison of mean and minimum achievable duty-cycle with and without dynamic power management.