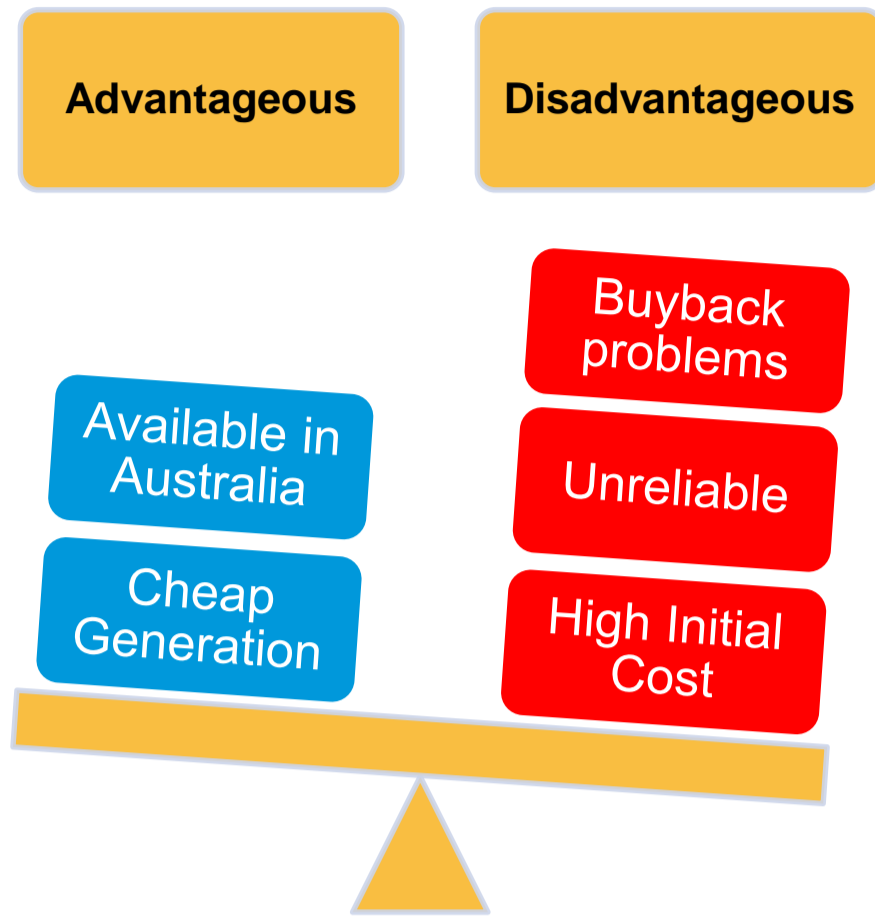


## 1. Introduction

### 1.1. Photovoltaic (PV) Energy



### 1.2. Battery Storage Systems

**Store:** To use at peak time

- Free solar radiation
- Cheap off-peak (from the grid)

**Beware of:** Battery Limitations

- Round trip efficiency
- Limited life

## 2. AIMS

- **Optimise battery levels to:**
  - Minimise Cost
  - Shave peak usage
  - Improve battery life
- **Consider:**
  - Unreliable PV generation
    - Not only cloud cover, but haze and fog.
    - Panels may change direction.
    - Panels may get dirty or cleaned.
  - Unforeseeable Consumption
    - Calendar based events, tenants leaving, ...
  - Limited battery storage
  - Variable grid prices
- **Use the Cloud:**
  - Use computationally intensive algorithms
  - Combine with data-mining

## 3. APPROACH

### 3.1. The Model

$$\min \mathbb{E}[\text{cost}] + \lambda \text{Var}[\text{grid usage}] + \gamma \mathbb{E}[\text{Battery charge current}]$$

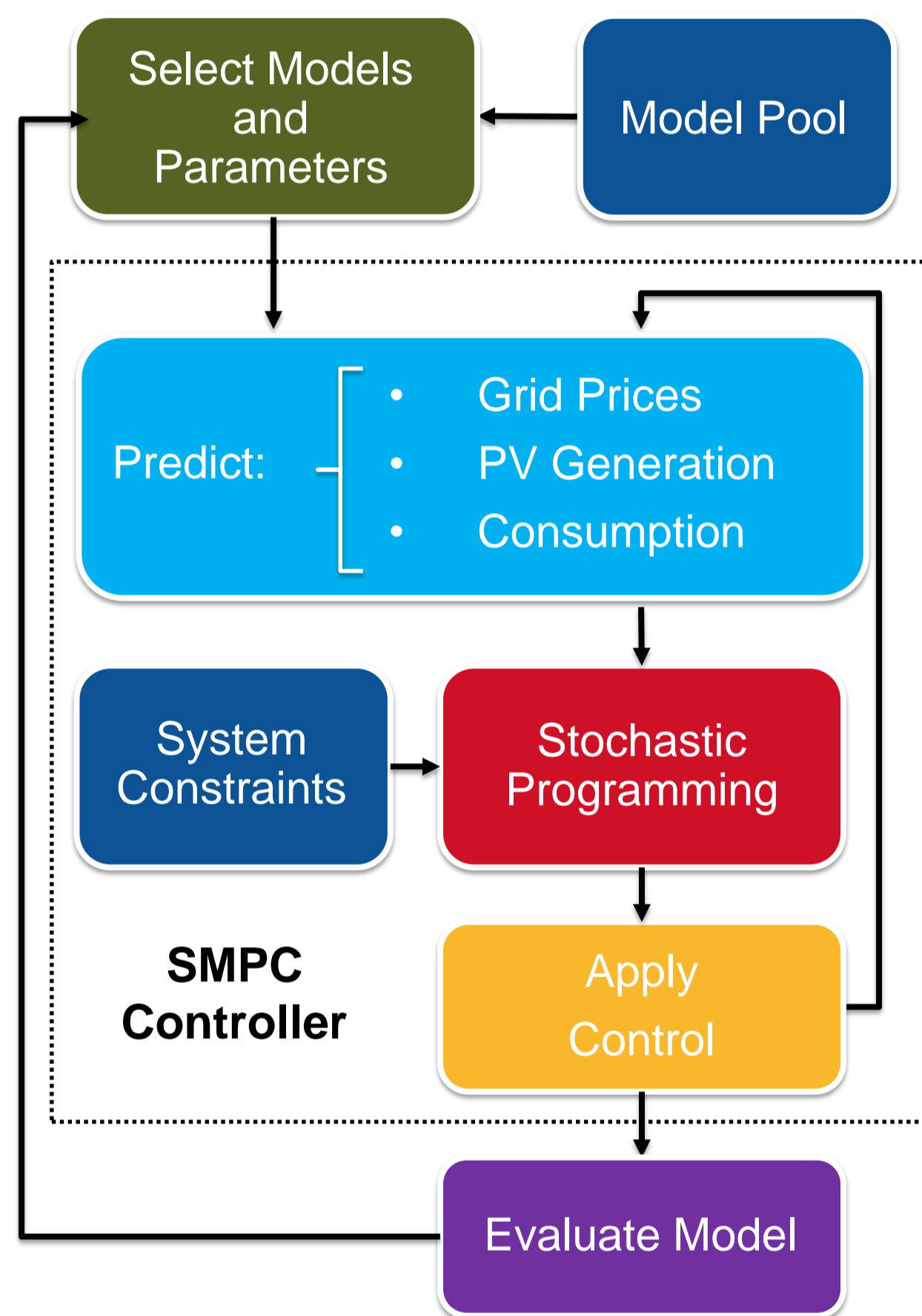
### 3.2. Active Management

- Stochastic Mode Predictive Control (SMPC) is an advanced method of control theory that uses a stochastic model of process to predict its behavior, and employs a finite horizon optimizer to assign process inputs.

### 3.3. Offline Backtesting and Model Selection

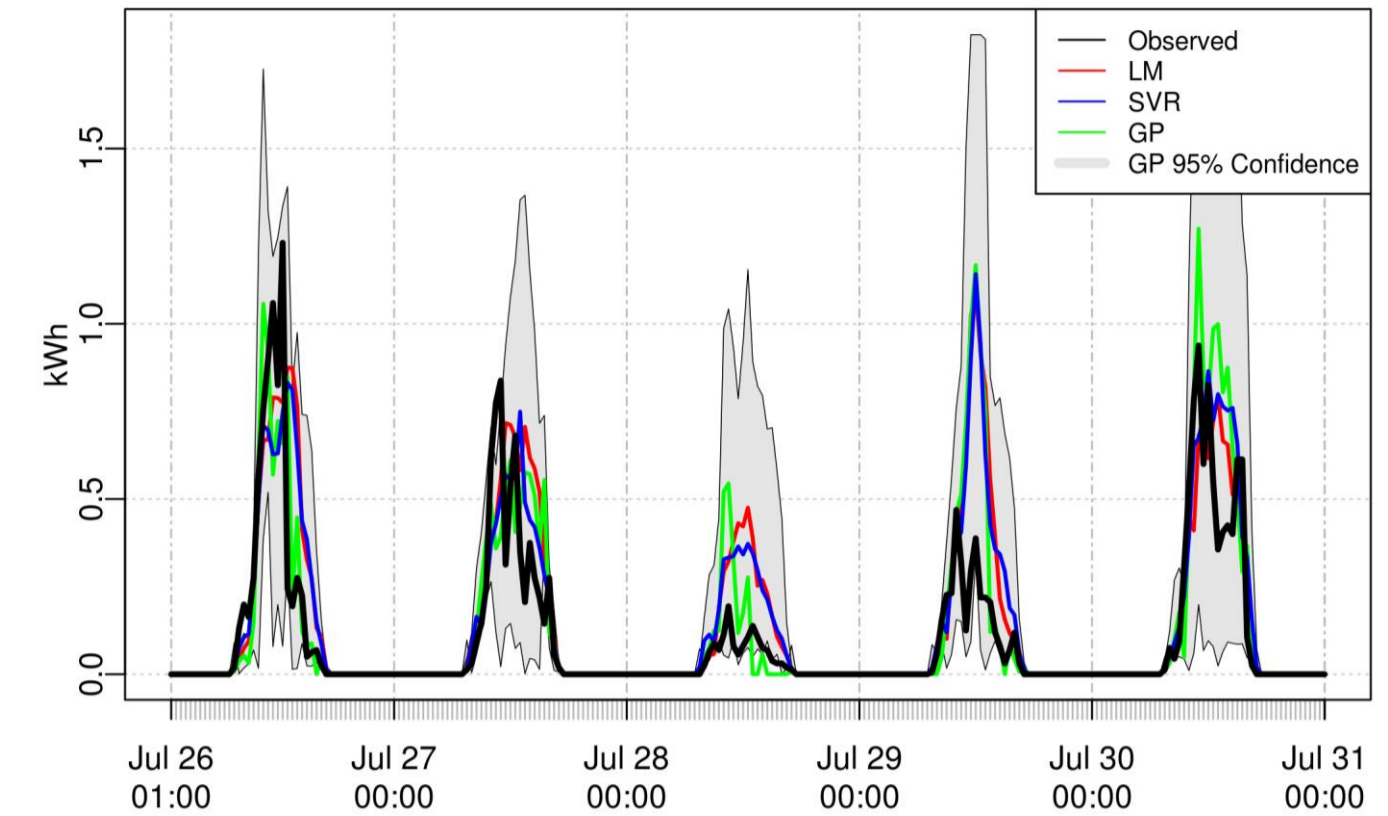
- Use Evolutionary search to select among:
  - Many Machine Learning (ML) models to choose from, e.g., NNs, SVMs, GPs, ...
  - Many features to use, e.g., cloud cover, historic values, ...
  - Many Parameters to tune, e.g.,  $\lambda$  and  $\gamma$ .

### 3.4. Flowchart

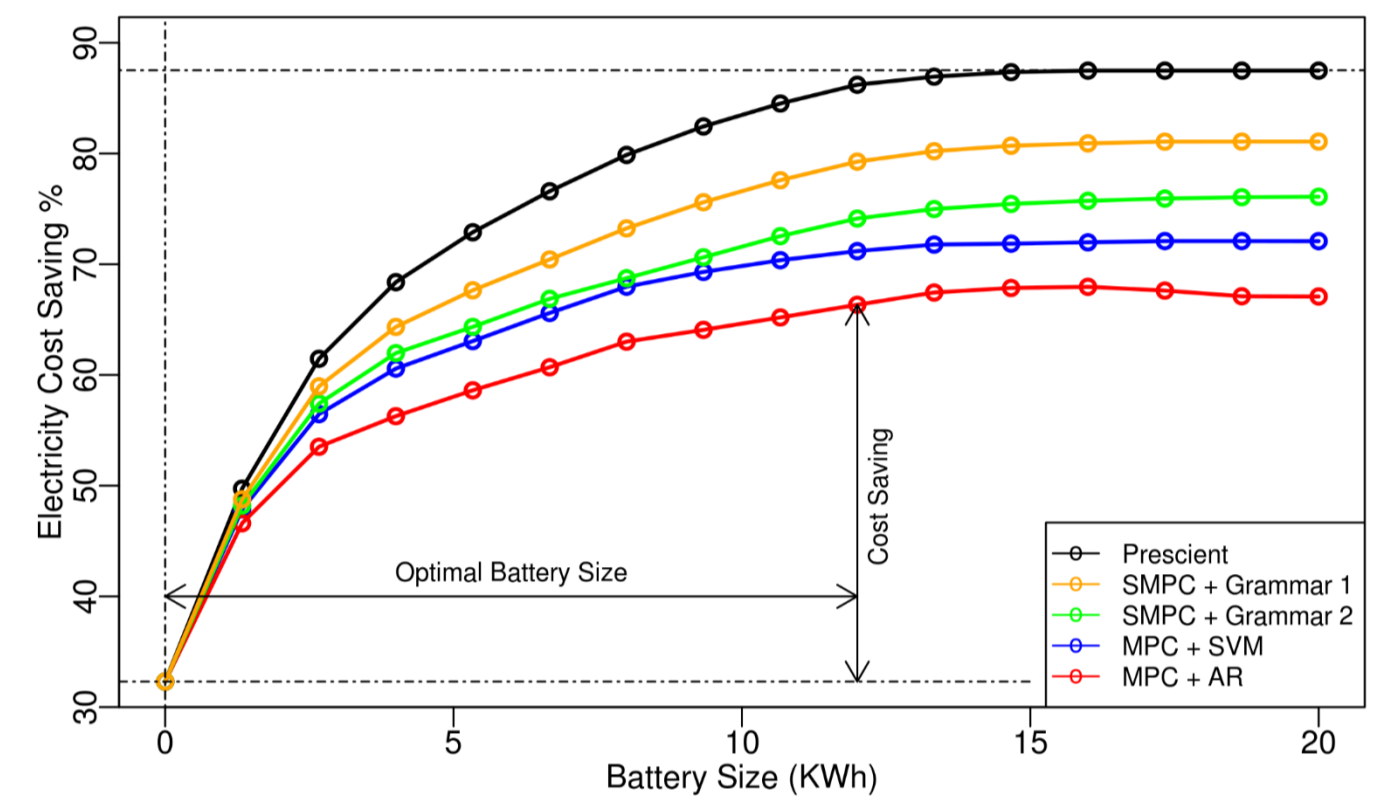


## 4. RESULTS

### 4.1. Predicting Solar Output



### 4.2. Cost optimisation



## 5. CONCLUSIONS

### 5.1. SMPC + ML controller

- Model outperforms common scheduling approaches as:
  1. It uses adaptive modelling to forecast future generation and demand.
  2. It considers unreliable nature of resources through stochastic modeling.

### 5.2. The Cloud-based platform advantages

- User-friendly web-based platform to monitor and configure.
- Low hardware requirement for active control
- Seam-less software upgrades.
- Allows 3<sup>rd</sup> party participation.
- Central collection of data facilitates data-mining or further research.
- Componentised system allows technology reuse in other markets.

## 6. SUMMARY

