SmartStore

Reducing cost under

Demand based Static Pricing Scheme

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Introduction

- Need for Demand-based Pricing Scheme.
- Types of Demand-based Pricing Scheme.
  - Dynamic Demand-based Pricing Scheme.
  - Static Demand-based Pricing Scheme.
- Potential Drawbacks of Dynamic Pricing.
- Hence, need of Static Pricing.

Introduction

- Peak shaving- A way to reduce electricity cost under Static Pricing Scheme.
- SmartStore – A peak shaving algorithm.
  - Can be used for reducing electricity cost under Static pricing scheme.

SmartStore - Assumptions

- Billing interval divided into slots.
- Unbounded Battery
- No restriction on charge rate and discharge rate.
- Demand prediction available before start of billing interval
- Zero Battery losses.

SmartStore Algorithm

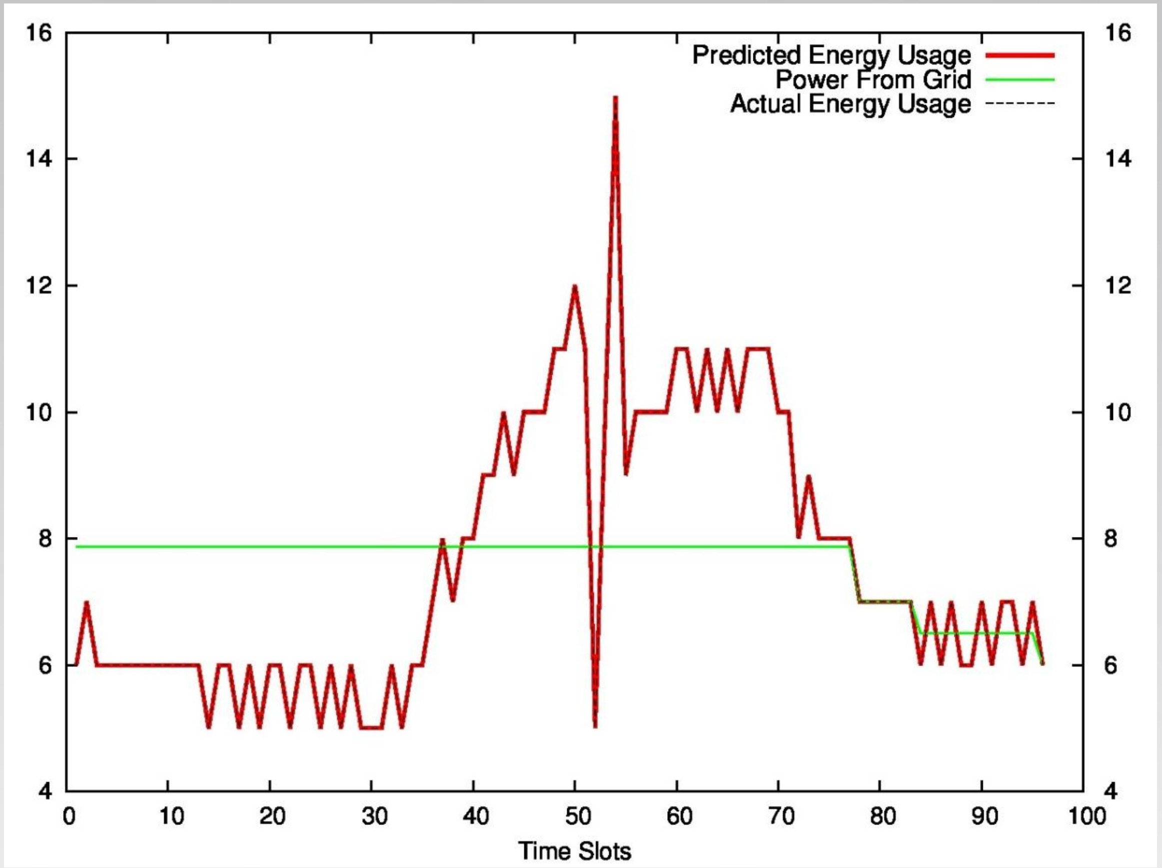
- Mean Demand

$$\mu(j,k) = \frac{1}{k-j+1}\sum_{t=j}^{k} d_t$$

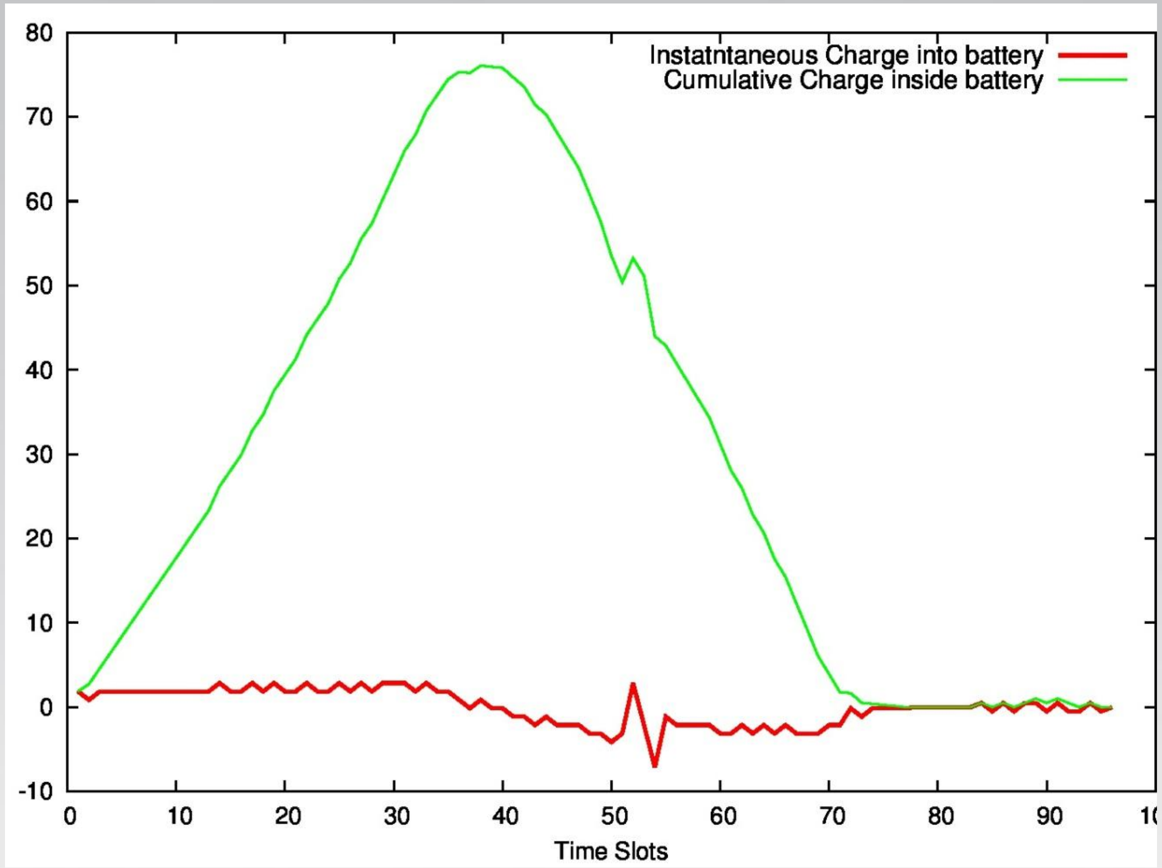
- Maximum Mean Demand in prefix region is selected as threshold for that region.
- The process is followed for all other subsequent subintervals.
- Example

SmartStore Algorithm

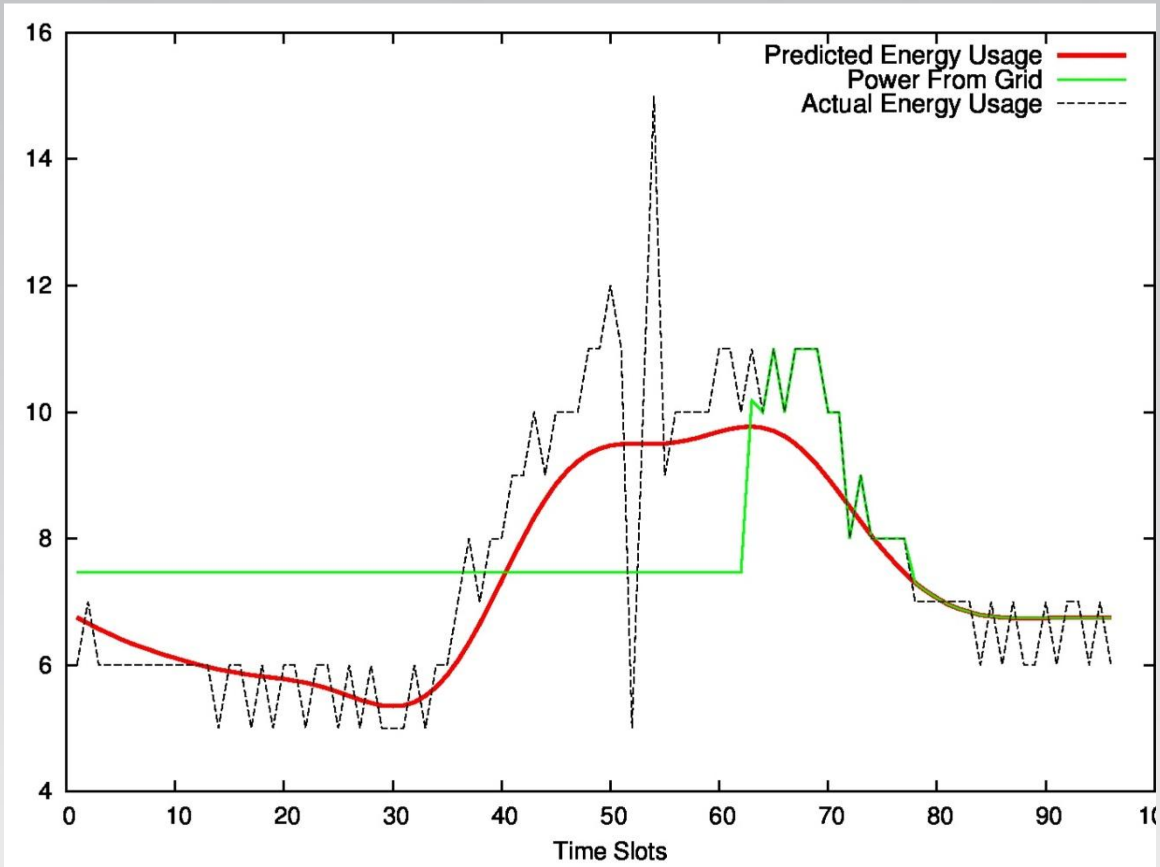
- Threshold calculation is done before start of billing interval.
- At the start of billing interval, threshold is associated with each slot.
- In a slot, energy from grid = threshold for slot.
- If threshold > Actual Demand, store extra energy into battery.
- If threshold < Actual Demand, take extra energy from battery.



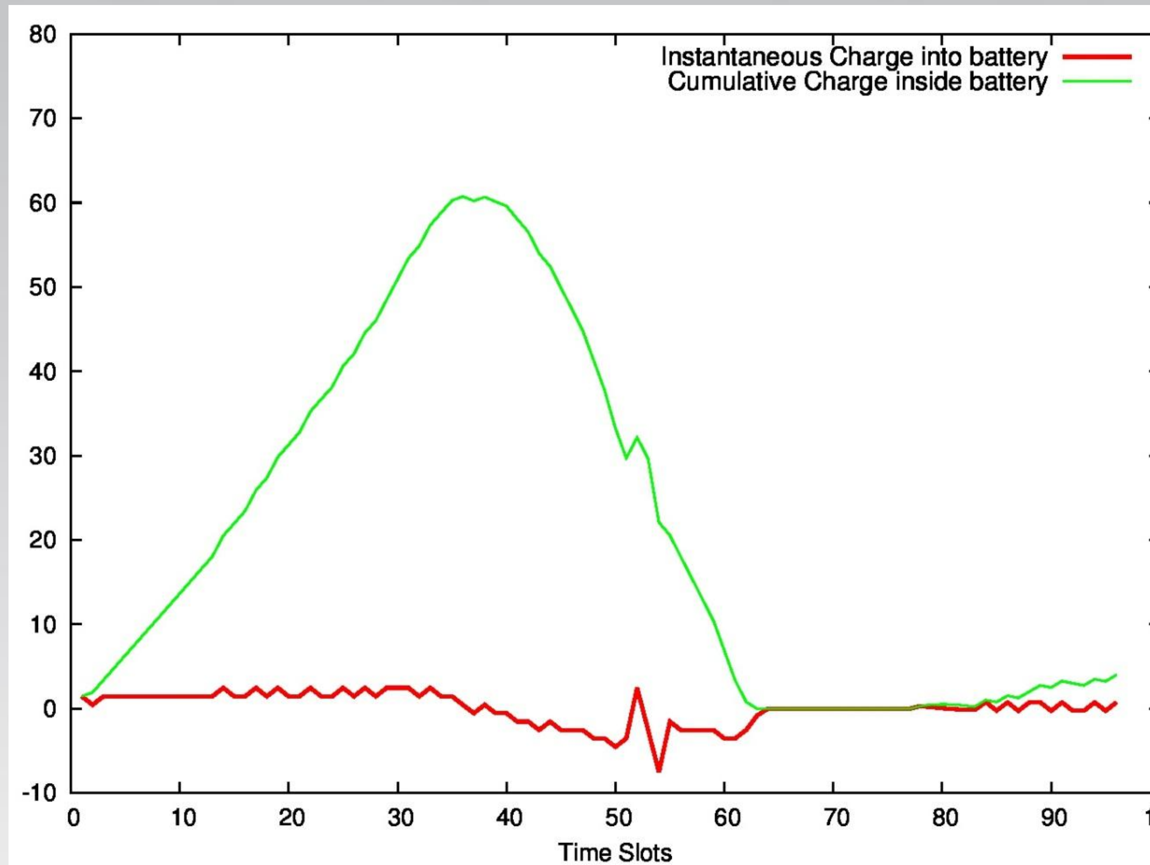
SmartStore Implementation Accurate Prediction



SmartStore Implementation Accuarate Prediction



SmartStore Implementation – Actual Prediction



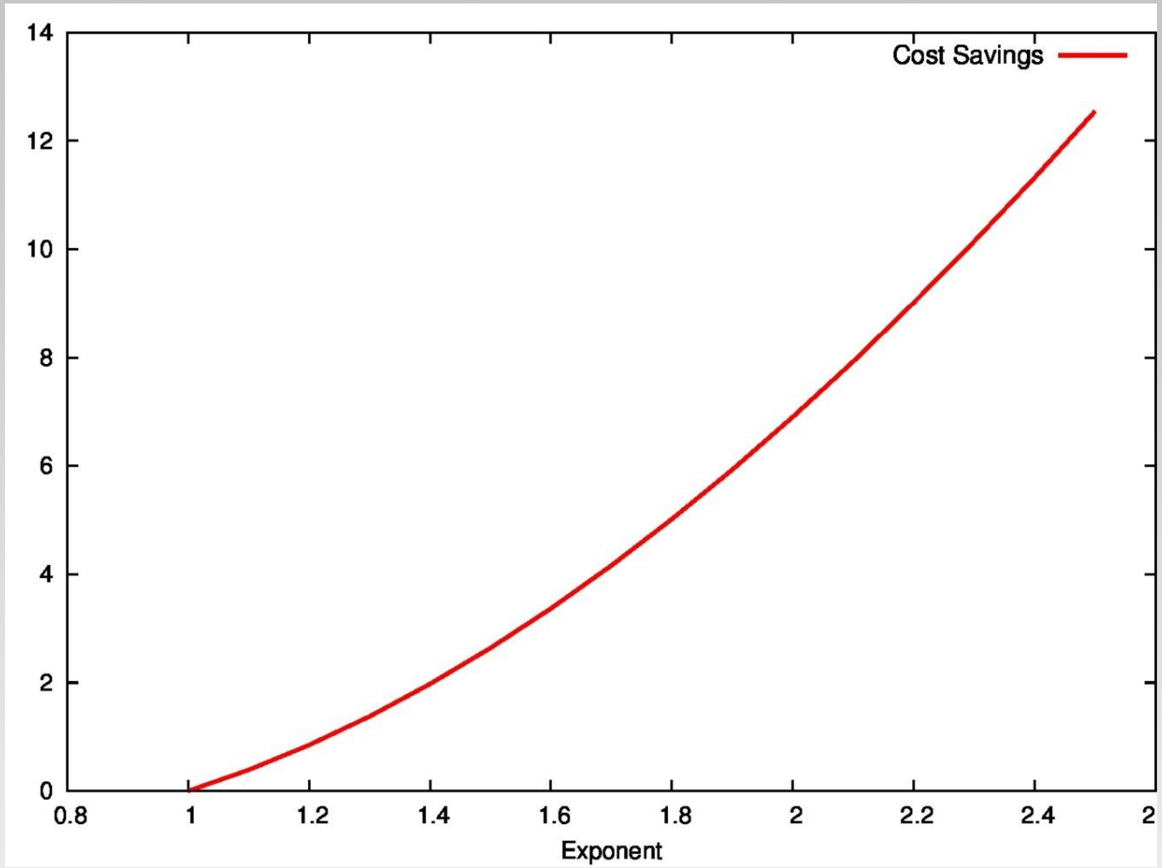
SmartStore Implementation – Actual Prediction

DEMAND BASED STATIC PRICING

Exponential Pricing Scheme

$$E = \sum_{t=1}^{n} d_t^x$$

- n = number of slots
- d_t = demand in slot t
- x = exponent, x > 1



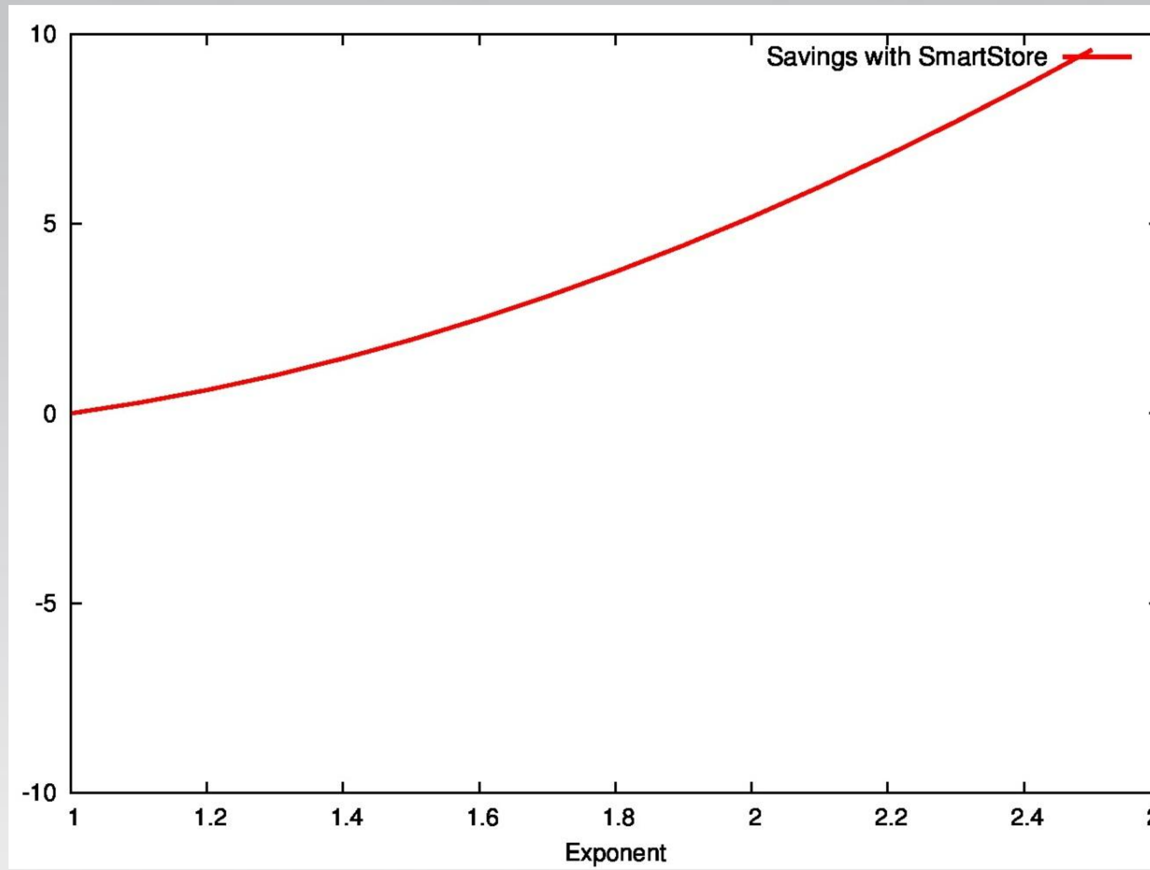
Cost Saving with Varying Exponent Using SmartStore

Slab-based Pricing Scheme

$$E = P * \sum_{t=1}^{n} \sum_{s=1}^{S} F_s * \min(\max(d_t - L_s, 0) U_s)$$

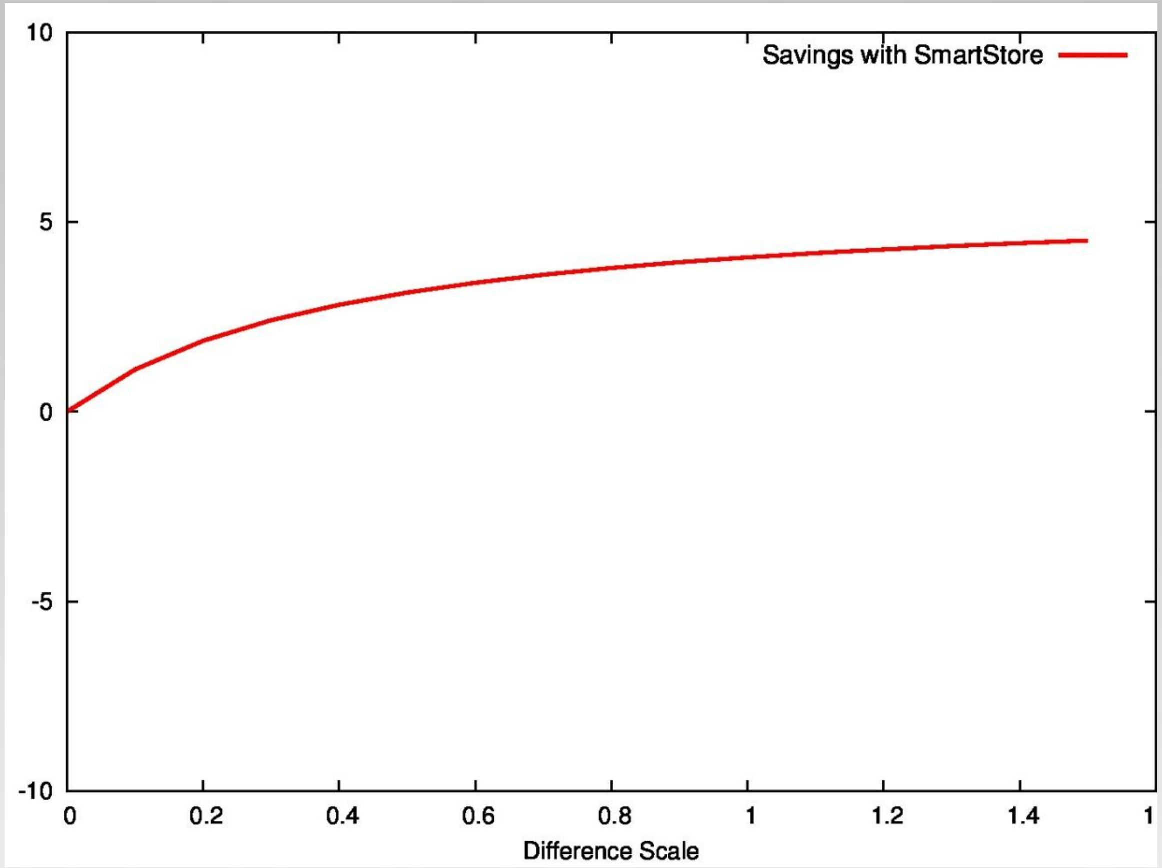
- S = number of slabs.
- U_s = Upper threshold of slab s.
- L_s = Lower threshold of slab s.
- F_s = Unit scale for slab s.
- P = price per unit of electricity.

COST SAVING WITH SMARTSTORE



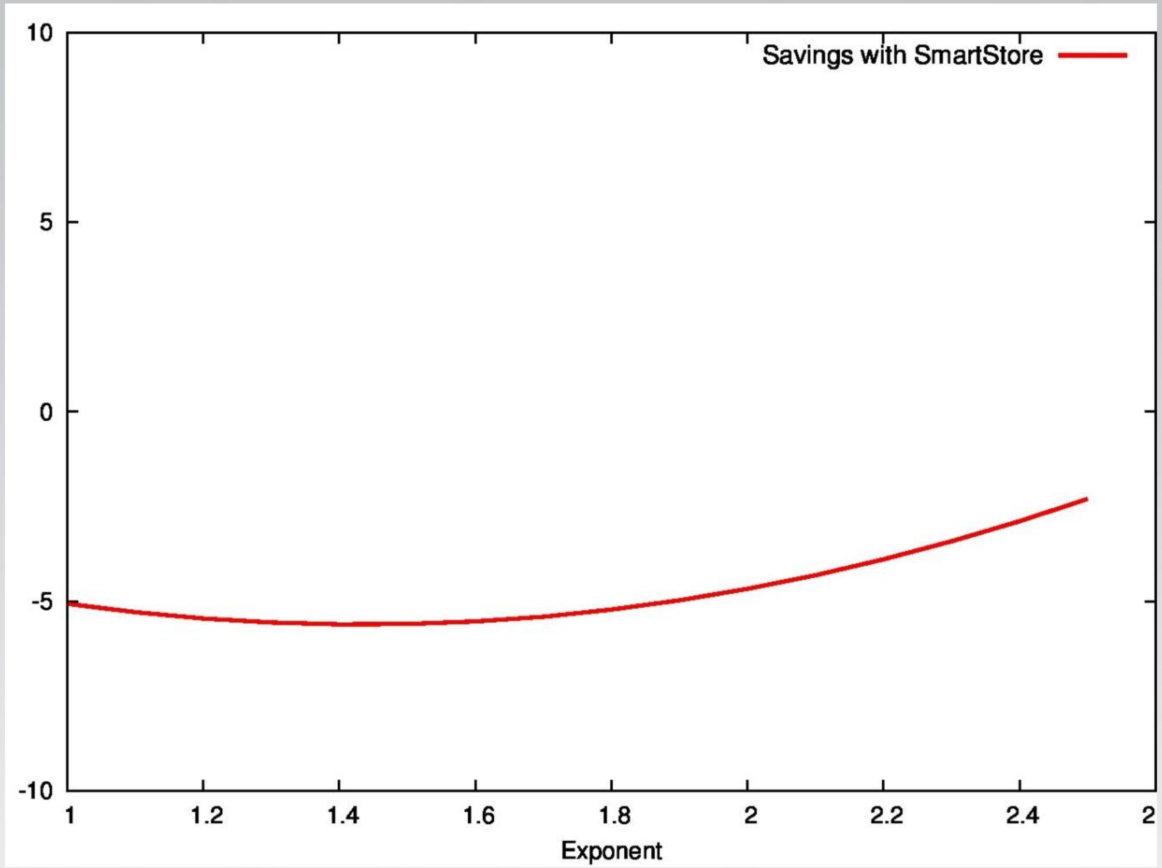
Results with Accurate Prediction

Exponential Pricing, MAPE = 0



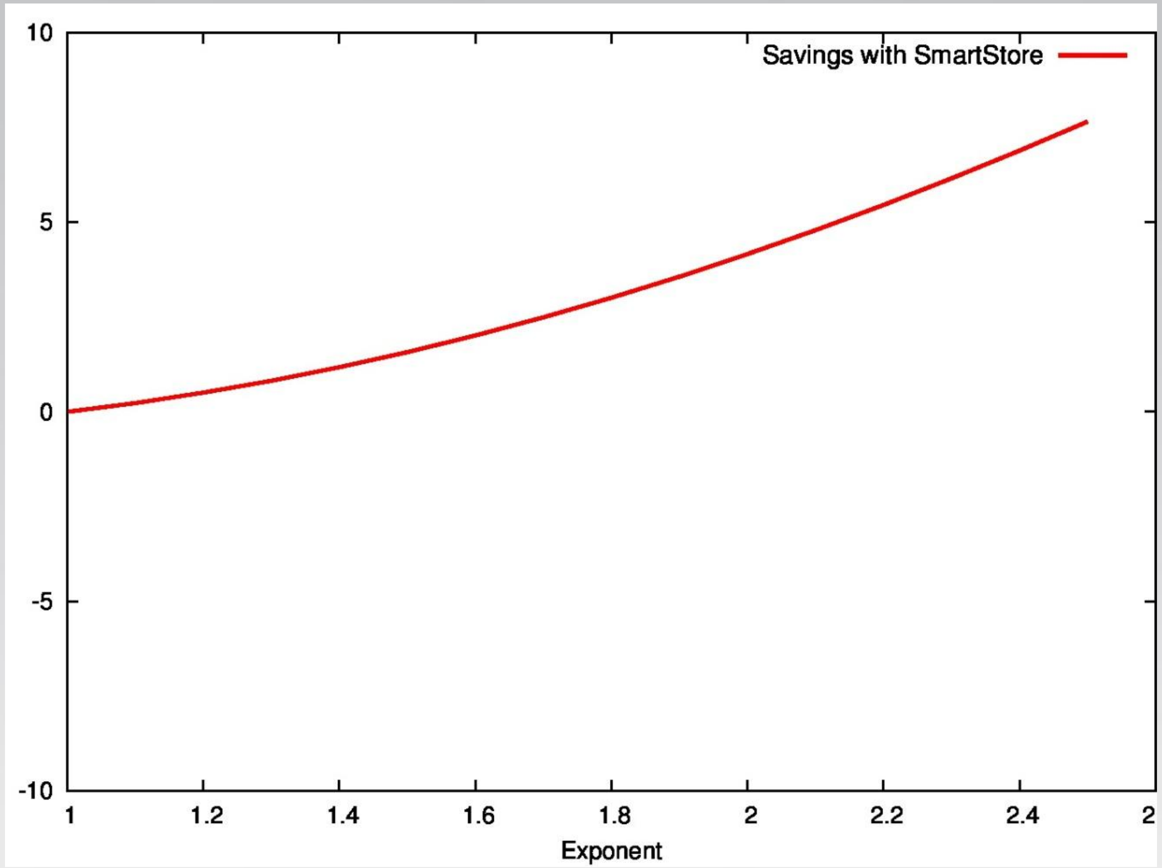
Results with Accurate Prediction

Slab-based Pricing, MAPE = 0



Results with OverPrediction

Exponential Pricing, MAPE = 9.87, MPE = 5.05



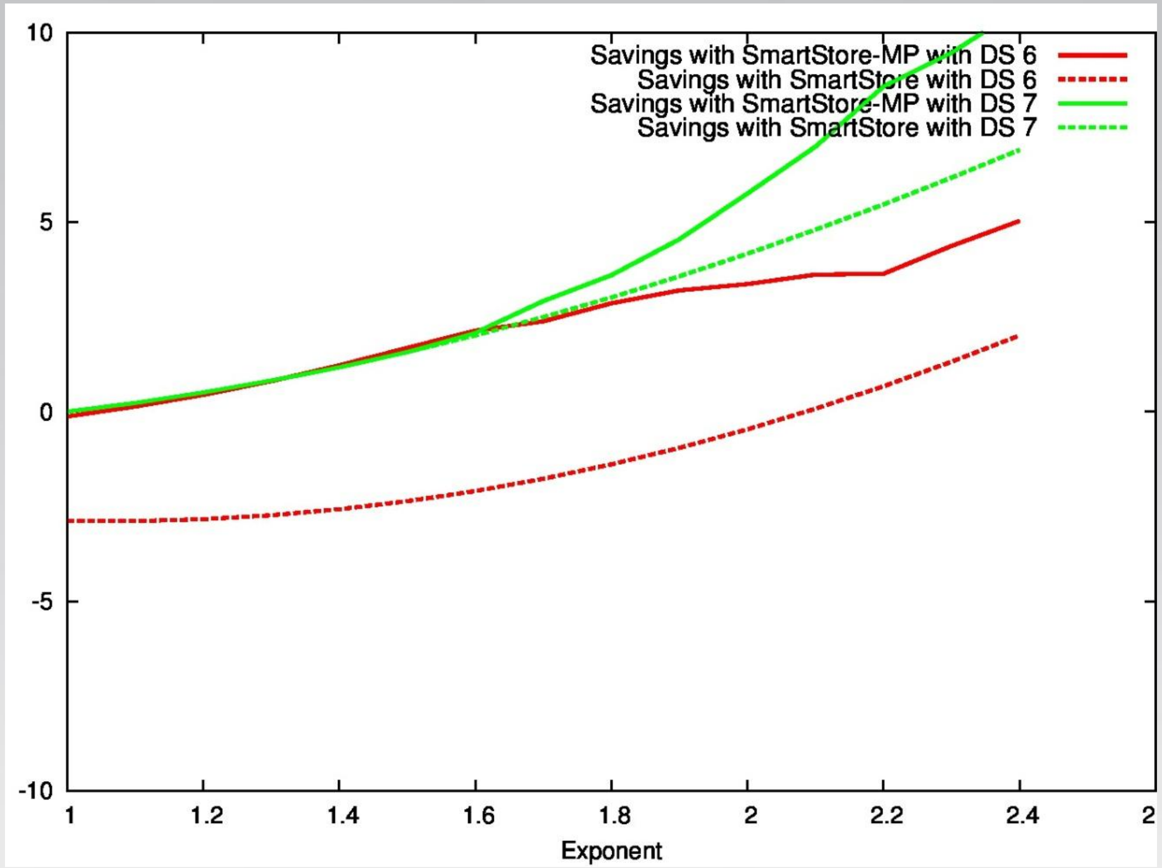
Results with Underprediction

Exponential Pricing, MAPE = 10.01, MPE = -4.92

COMPENSATING FOR MISPREDICTION

Compensating for Misprediction

- Overprediction
  - Using previous day's extra charge in calculation of thresholds
  - Extra energy spread in all the slots of day
- Underprediction
  - Sharing batteries between two buildings
  - The benefit depends on sharing policies
  - Many sharing policies possible.



Cost Saving with SmartStore-MP

DS 6, MAPE= 9.97, MPE = 2.27

DS 7, MAPE = 9.92, MPE = -4.91

OTHER RESULTS

Other Results

- Bounded Battery
  - Cost saving does not improve beyond certain threshold battery size
- Battery Losses
  - Higher cost reduction with higher battery efficiency
  - Need to take extra energy to run SmartStore smoothly

Project Suggestions

- Sharing Batteries with multiple neighbors.
- Effect of sharing batteries with slab based pricing.
- Compensating battery losses.
- Study project on batteries compatible to SmartStore.