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DECISION MODELS
IE 2086
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ELECTRIC VEHICLE CHARGING POINT SIMULATION

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Electric vehicle charging point simulation

The goal of this project is to build a simulation model to determine the largest expected revenue from an electric vehicle charging station in a one-month time period given the storage capacity, charging grid change costs, demand and supply.

Background

Charging station operators must make a commitment x_t to the market of how much energy they will deliver in period t + 1. Paid at day ahead price P_t^d immediately.

There is a storage device that would be set up by the charging station owner to stock extra power.
If actual main grid power ≥ commitment, excess can be stored. If actual main grid power < commitment, shortfall can be made up from storage or bought from the market (from another grid station) at the spot price P^s_{t+1}

Day ahead price randomly goes up or down by 1: $P^d_{t+1} = P^d_t + \varepsilon_{t+1}$
where ε_{t+1} takes values {-1,+1} each w.p. 1/2.

Spot price is, on average, higher than market price but random: $P^s_{t+1} = P^m_t + \xi_{t+1}$
where $\xi_{t+1} \sim N(3,2^2)$.
Main grid supply $W_t \sim U(5,15)$

The amount in storage at time t is R_t. Minimum is 0, maximum is 50.
If $W_{t+1} > x_t$, add $W_{t+1} - x_t$ to storage.
If $W_{t+1} < x_t$, retrieve as much as possible from storage to satisfy $x_t - W_{t+1}$.
If not enough, pay P^s_{t+1} per unit to buy from other market.

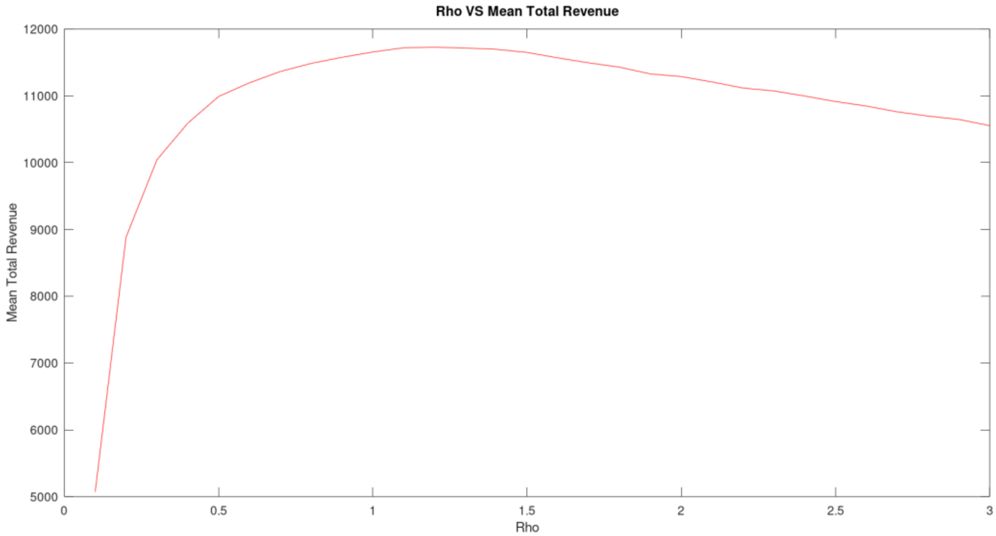
The storage device as a charging efficiency of 0.8 and a discharging efficiency of 0.8. This means that for every 1 unit of energy you try to add to the device, only 0.8 units of energy are actually added. Similarly, for every 1 unit of energy that is stored in the device, after discharging, only 0.8 units are available.

There are 24 time periods.

The highest revenue was found to be 11,727 USD with a Rho value at 1.2. Rho is a sensible parameter that was used to simplify the commitment (x_t) mechanism. A plot for different Rho values versus the mean total revenue has been plotted and the curve tends to fall after the highest revenue point.

The best rho value is **1.2** with mean total revenue of **$ 11727**

Please view the wind octave/MATLAB file for the code.




```
>> max(tr_mean)
ans = 1.1727e+04
>> [val,idx]=max(tr_mean,[],2)
val = 1.1727e+04
idx = 12
>> rho(1,idx)
ans = 1.2000
```

```
N = 5000;
rho = [0.1:0.1:3];
Rmax = 50;
total_revenues = zeros(N,size(rho,2));

for rhoo = 1:size(rho,2)

 for n = 1:N

  R = zeros(24,1);
  x = zeros(24,1);
  P_d = zeros(24,1); P_d(1) = 50;
  P_s = zeros(25,1);
  W   = zeros(25,1);
  revenues = zeros(24,1);
  charge_eff = 0.8;
  discharge_eff = 0.8;

  for t = 1:24
    % Commitment
    x(t) = (R(t)*discharge_eff+10)*rho(1,rhoo);

    % Wind
    W(t+1) = unifrnd(5,15);

    % Spot Price
    P_s(t+1) = P_d(t) + normrnd(3,2);

    % Storage
    excess = (max(W(t+1) - x(t),0));
    shortage = max(x(t) - W(t+1),0);
    if excess > 0
      R(t+1) = min(R(t)+charge_eff*(excess),Rmax);
      revenues(t) = x(t) * P_d(t);
    else
      if shortage < R(t)
        R(t+1) = R(t) - shortage;
        revenues(t) = x(t) * P_d(t);
      else
        R(t+1) = 0;
        revenues(t) = x(t) * P_d(t) - (shortage - R(t)) *
P_s(t+1);
      end
    end


    % Next Price
    if unifrnd(0,1) < 0.5
      change = 1;
    else
      change = -1;
    end
    P_d(t+1) = P_d(t) + change;
  end
  total_revenues(n,rhoo) = sum(revenues);
 end
end

tr_mean = mean(total_revenues)

plot(rho,tr_mean,'r')
xlabel('Rho')
ylabel('Mean Total Revenue')
title('Rho VS Mean Total Revenue')

max(tr_mean)
[val,idx]=max(tr_mean,[],2)
rho(1,idx)
```