Analysis

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2018-05-27

Cost-benefit analysis of charger

It is necessary to analyze how much would it benefit from installation of one charger. The benefit could be estimated by the fuel cost reduction as EV uses electricity. Assumping electricity price and gas price keep changing annually and annual discount factor is 6%, the cost - benefit analyses were constructed based on 4 cases. 1) onwer takes the installation cost of 1 charger and uses it, 2) owner takes the installation cost for the whole chargers (5 renters) and uses one of them, 3) owner doesn't live in the building, but pays the cost of all chargers (6 chargers) and get commission of 20% of the benefit generated from the chargers, and 4) with the case 3, there are additional 6 more EVs are using by sharing the 6 installed chargers. Net present value (NPV) and discounted payback period (DPP) are measured for each scenario.

Benefits

Conventional vehicle

- VMT 10,230 miles
- MPG 33 miles/ gallon
- Gas required 310 gallons
- Gas unit price $2.49/ gallon
- Total cost $772

EV

- Fuel economy 30 kWh/100 mile
- Elec. need per year 3069 kWh
- Elec. unit cost $0.077/ kWh
- Elec. cost $236.3

Annual benefit for one car $535.7

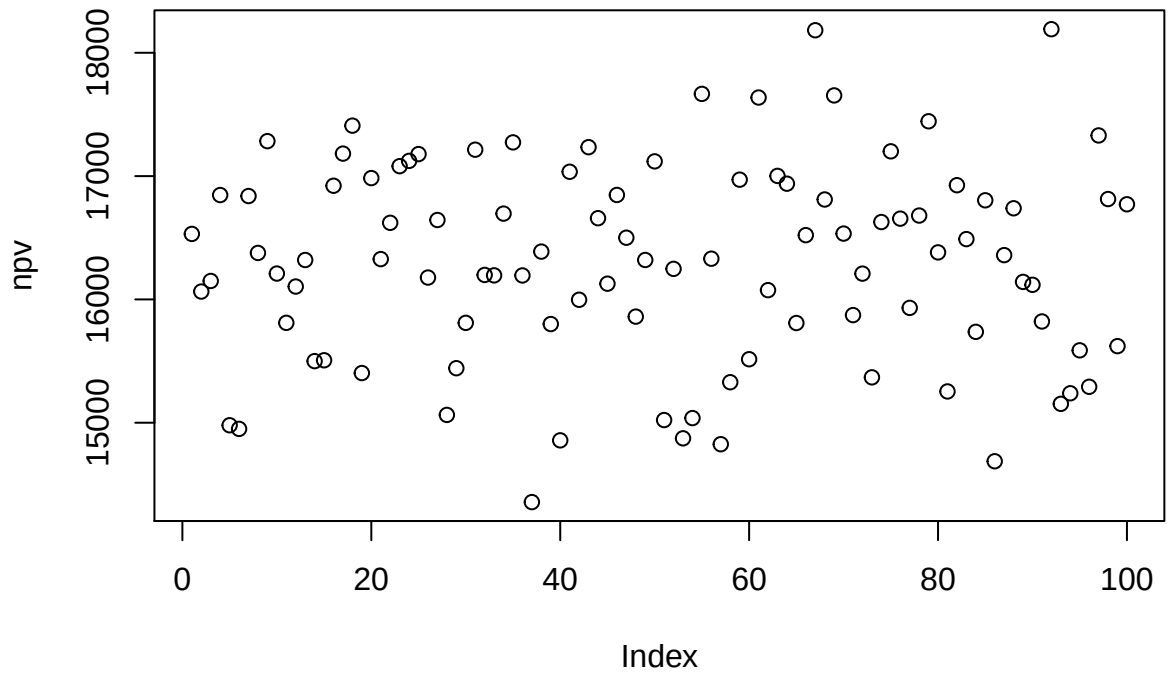
Cost

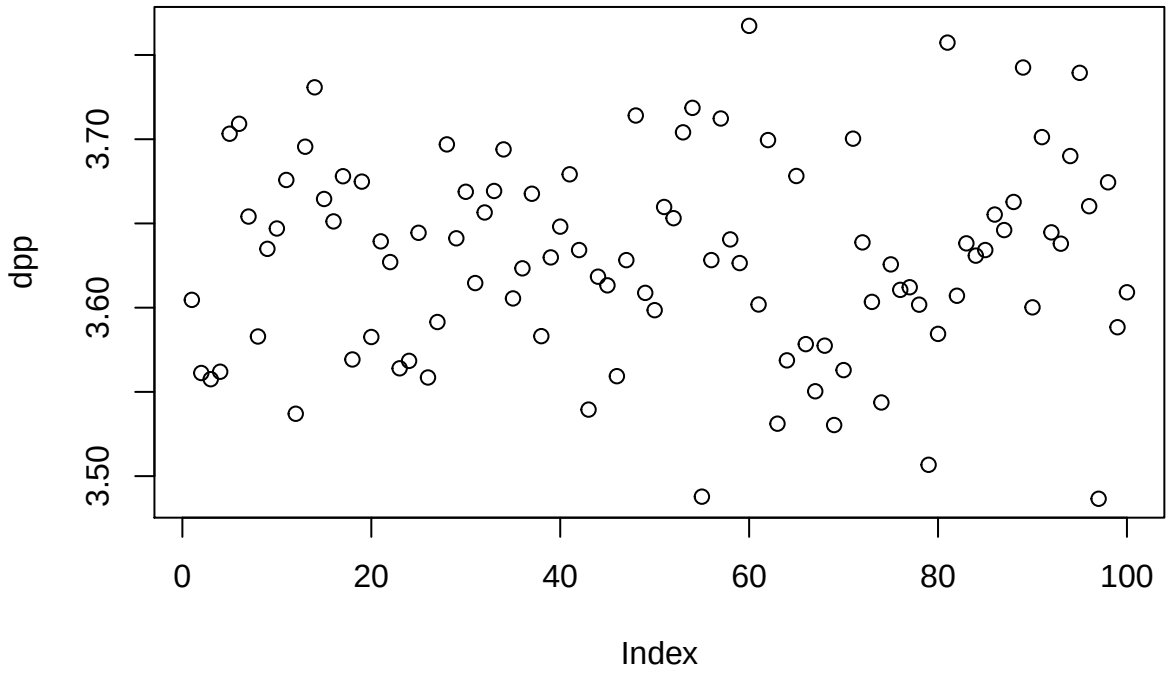
- Installation $2,050 (based on Megan's table)

After 100 times Monte Carlo simulations, it shows that case 1 takes less than 6 years to reach the break-even point, while case 2, over 20 years and case 3, about 18 years. This analysis indicates that government supports are necessary to benefit buiding owners for the same impact as the single family households.

Moreover, MUD charger has potential as one charger could serve muliple EVs. The case 4 shows that it only takes about 10 years to reach the break-even point. Government support could be lessen compared to the case 3.

case1, single owner - single user

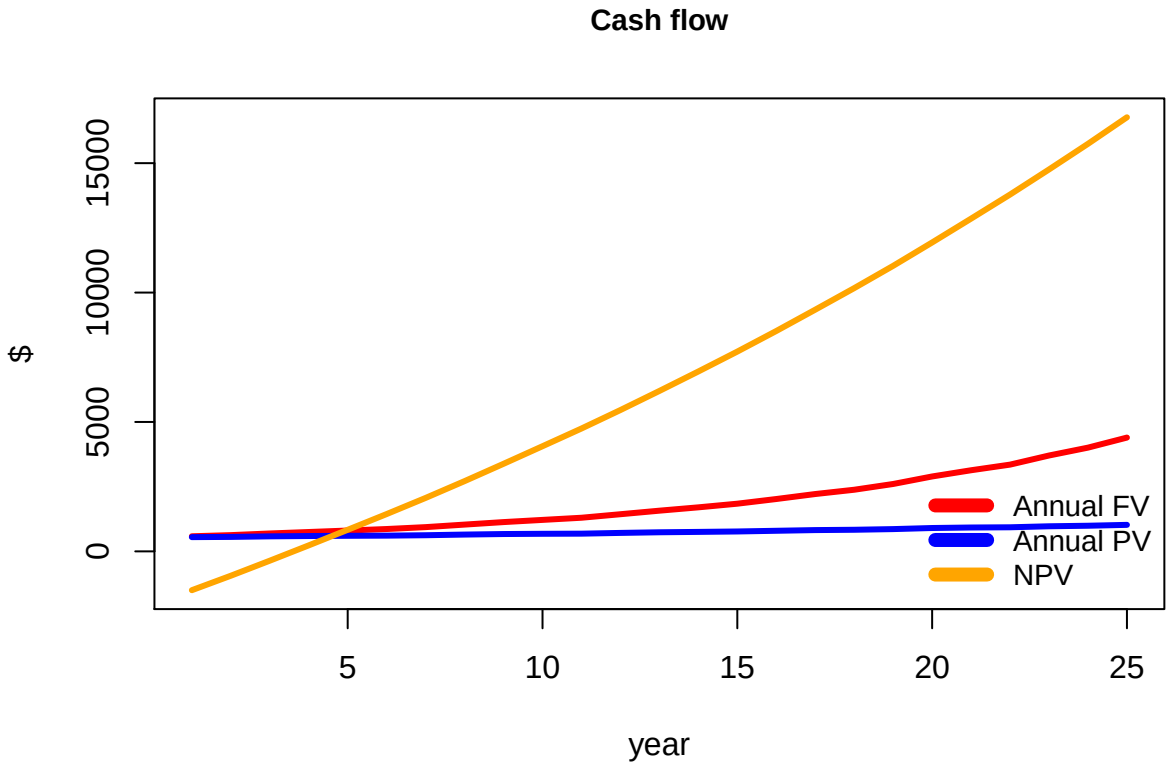


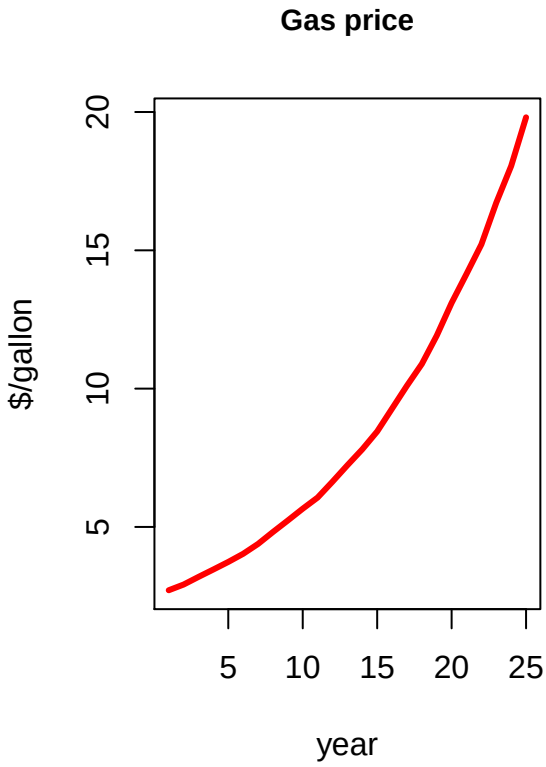


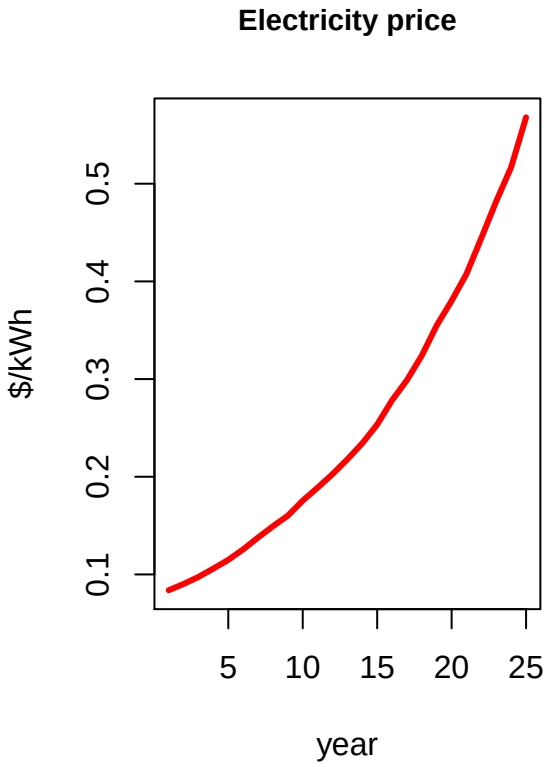
```
##    Gas price($/gallon) Elec.price($/kWh)     FV($)     PV($)     NPV($)
## 1             2.711839        0.08382981  583.3963  550.3738 -1499.6262
## 2             2.917578        0.09027597  627.3922  558.3768  -941.2494
## 3             3.194554        0.09745581  691.2199  580.3615  -360.8878
## 4             3.462760        0.10605504  747.9726  592.4644   231.5766
## 5             3.735158        0.11489643  805.2818  601.7534   833.3299
## 6             4.028906        0.12567203  863.2733  608.5736  1441.9035
## 7             4.385971        0.13775449  936.8826  623.0804  2064.9840
## 8             4.816757        0.14932614 1034.9128  649.3171  2714.3011
## 9             5.234633        0.16019965 1131.0834  669.4865  3383.7876
## 10            5.659656        0.17551300 1215.8439  678.9209  4062.7085
## 11            6.062099        0.18882578 1299.7445  684.6892  4747.3977
## 12            6.636702        0.20270385 1435.2796  713.2900  5460.6877
## 13            7.230607        0.21782274 1572.9903  737.4792  6198.1669
## 14            7.805477        0.23425220 1700.7777  752.2556  6950.4225
## 15            8.450689        0.25343398 1841.9247  768.5708  7718.9934
## 16            9.278662        0.27829200 2022.3070  796.0736  8515.0670
## 17           10.105551        0.29890209 2215.3902  822.7171  9337.7841
## 18           10.891146        0.32417969 2381.3478  834.2904 10172.0745
## 19           11.915161        0.35496699 2604.3063  860.7571 11032.8316
## 20           13.098518        0.38011585 2893.9649  902.3519 11935.1835
## 21           14.146749        0.40773666 3134.1485  921.9267 12857.1102
## 22           15.214673        0.44454671 3352.2347  930.2622 13787.3725
## 23           16.721189        0.48211615 3703.9541  969.6850 14757.0575
## 24           18.048593        0.51693354 4008.5948  990.0369 15747.0944
## 25           19.806647        0.56794756 4397.0295 1024.5018 16771.5963
##    DPP(year)
## 1   0.000000
## 2   0.000000
## 3   0.000000
## 4   3.609130
## 5   4.384836
## 6   6.369317
## 7   8.314153
## 8  10.180240
## 9  12.054303
## 10 13.984068
## 11 15.933654
## 12 17.655635
## 13 19.404531
## 14 21.239442
## 15 23.043308
## 16 24.696331
## 17 26.349933
## 18 28.192486
## 19 29.817590
## 20 31.226750
## 21 32.945914
## 22 34.820953
## 23 36.218403
## 24 37.905563
## 25 39.370489
```

```
## [1] 16301.37
```

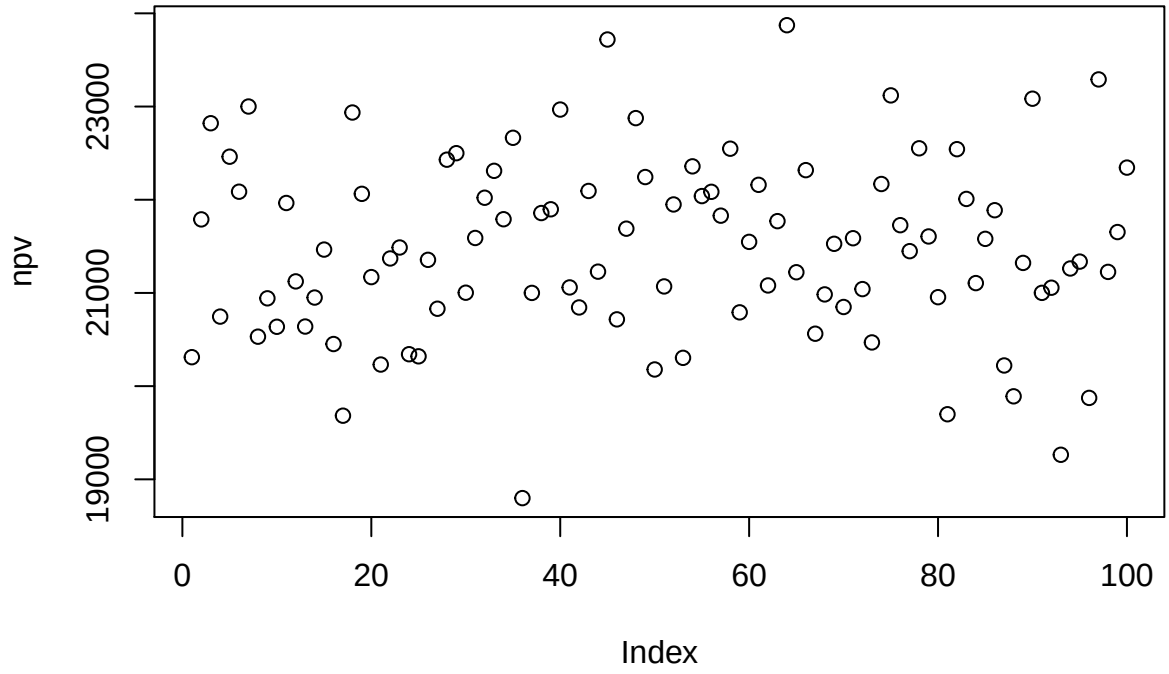
```
## [1] 3.62973
```

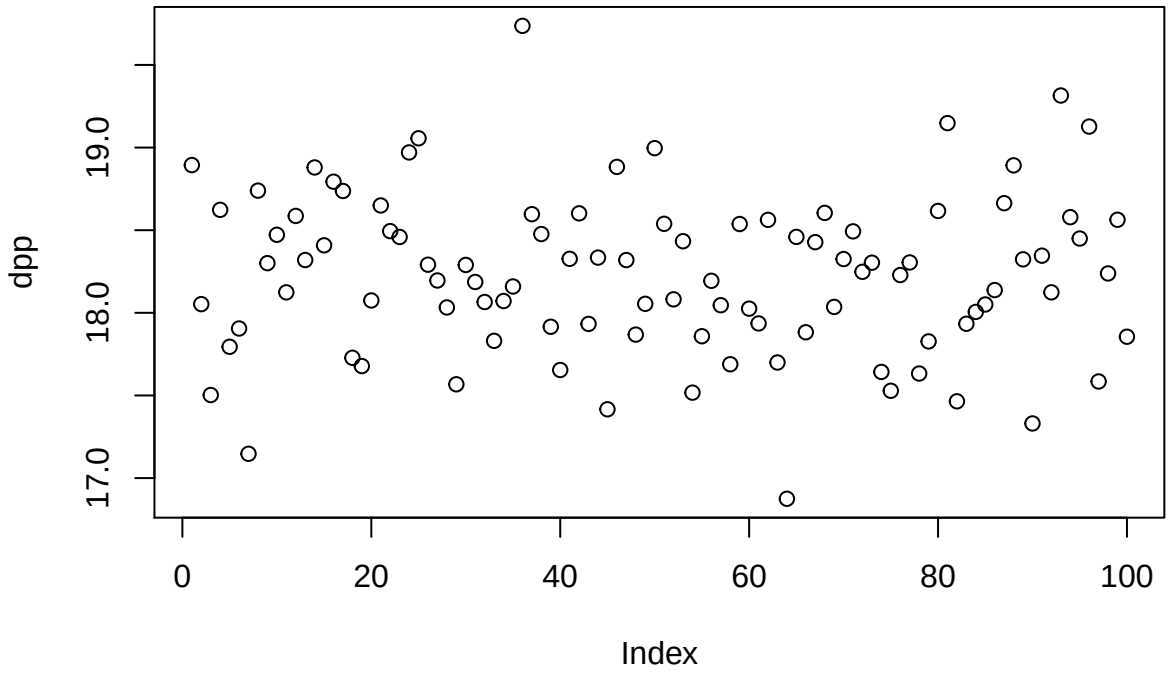

Cash flow
$
0
5000
10000
15000
5
10
15
20
25
year
Annual FV
Annual PV
NPV


Gas price
$/gallon
5
10
15
20
5
10
15
20
25
year


Electricity price
$/kWh
0.1
0.2
0.3
0.4
0.5
5
10
15
20
25
year

case2, one owner - 5 renters



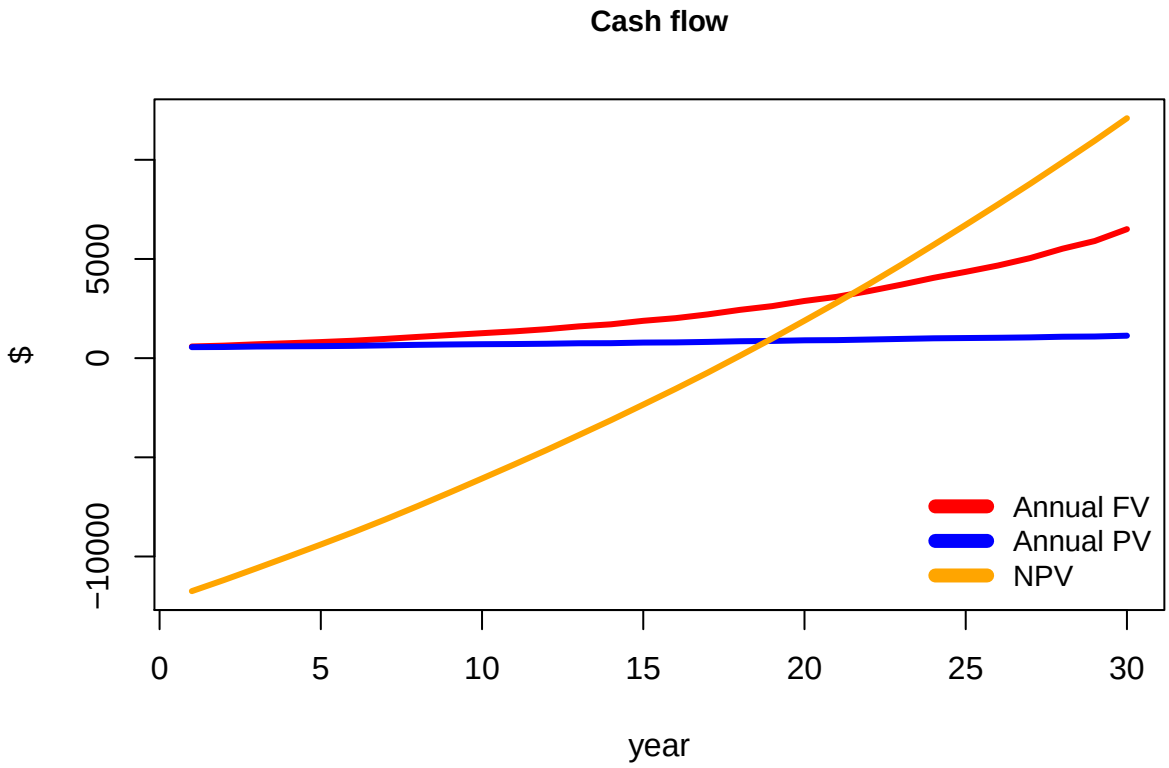


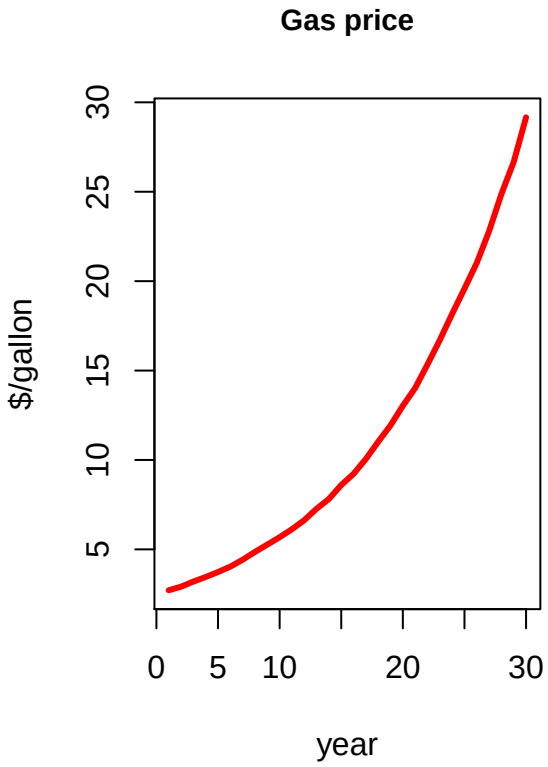
```
##    Gas price($/gallon) Elec.price($/kWh)     FV($)     PV($)      NPV($)
## 1             2.714753        0.08264588  587.9333  554.6540 -11745.3460
## 2             2.912036        0.08845987  631.2479  561.8084 -11183.5376
## 3             3.200131        0.09595252  697.5623  585.6868 -10597.8508
## 4             3.454441        0.10365679  752.7540  596.2516 -10001.5992
## 5             3.733266        0.11306422  810.3183  605.5169  -9396.0823
## 6             4.034814        0.12135590  878.3510  619.2028  -8776.8794
## 7             4.420008        0.13047262  969.7821  644.9605  -8131.9189
## 8             4.858699        0.14217109 1069.8736  671.2520  -7460.6670
## 9             5.269229        0.15287759 1164.2796  689.1353  -6771.5317
## 10            5.680482        0.16366705 1258.6551  702.8265  -6068.7052
## 11            6.128528        0.17927733 1349.6414  710.9743  -5357.7309
## 12            6.632665        0.19441537 1459.4653  725.3095  -4632.4214
## 13            7.272498        0.21294197 1600.9556  750.5904  -3881.8310
## 14            7.819427        0.23415465 1705.4018  754.3009  -3127.5301
## 15            8.598698        0.25519148 1882.4139  785.4655  -2342.0646
## 16            9.225114        0.27530773 2014.8659  793.1445  -1548.9201
## 17           10.055701        0.29679546 2206.4020  819.3792   -729.5409
## 18           11.017426        0.31966245 2434.3582  852.8623    123.3213
## 19           11.933939        0.35084964 2622.7636  866.8575    990.1788
## 20           13.028436        0.37648711 2883.3762  899.0503   1889.2291
## 21           14.022480        0.40916284 3091.2482  909.3073   2798.5365
## 22           15.339718        0.44714164 3383.0350  938.8094   3737.3459
## 23           16.707025        0.48058337 3704.2673  969.7670   4707.1130
## 24           18.171142        0.51658265 4047.6618  999.6856   5706.7986
## 25           19.581000        0.56019833 4350.8613 1013.7447   6720.5433
## 26           21.021309        0.60146820 4670.7000 1026.6667   7747.2100
## 27           22.795844        0.65847045 5045.8658 1046.3509   8793.5609
## 28           24.876602        0.71516691 5516.8994 1079.2718   9872.8327
## 29           26.672032        0.77012103 5904.8286 1089.7759  10962.6086
## 30           29.160227        0.82645079 6503.2928 1132.2892  12094.8978
##    DPP(year)
## 1    0.00000
## 2    0.00000
## 3    0.00000
## 4    0.00000
## 5    0.00000
## 6    0.00000
## 7    0.00000
## 8    0.00000
## 9    0.00000
## 10   0.00000
## 11   0.00000
## 12   0.00000
## 13   0.00000
## 14   0.00000
## 15   0.00000
## 16   0.00000
## 17   0.00000
## 18  17.85540
## 19  18.14226
## 20  20.10136
## 21  22.07766
## 22  23.98094
```

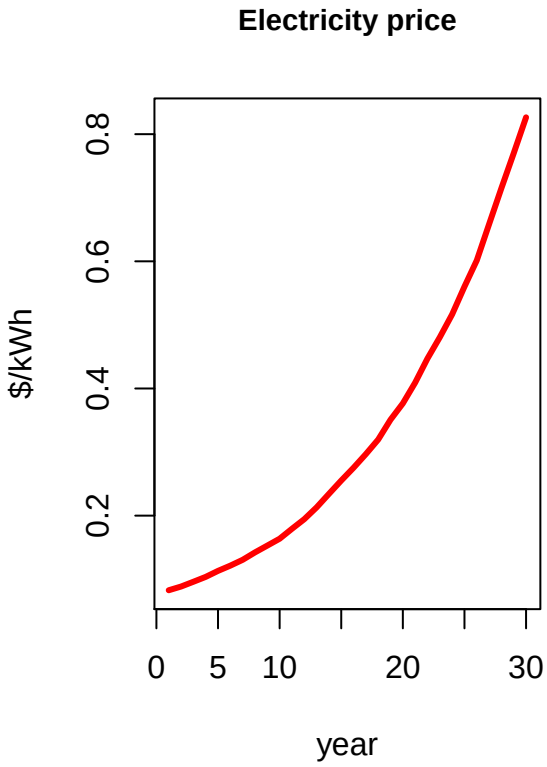
```
## 23  25.85386
## 24  27.70859
## 25  29.62942
## 26  31.54598
## 27  33.40403
## 28  35.14768
## 29  37.05951
## 30  38.68181
```

```
## [1] 21483.77
```

```
## [1] 18.2288
```

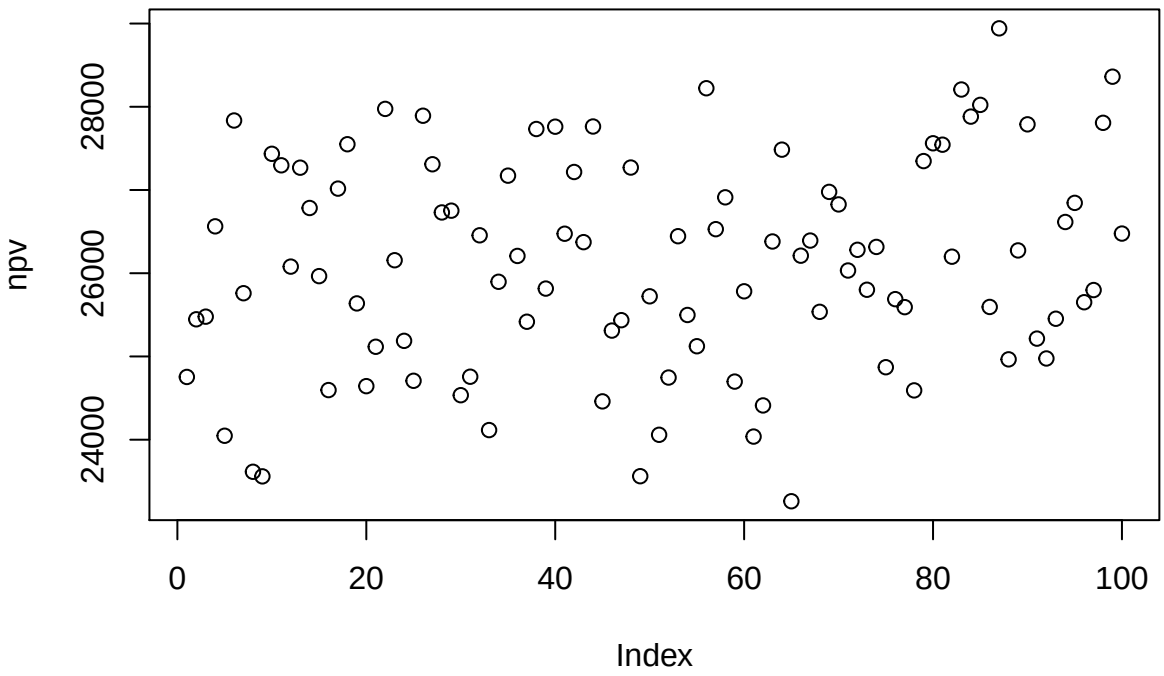


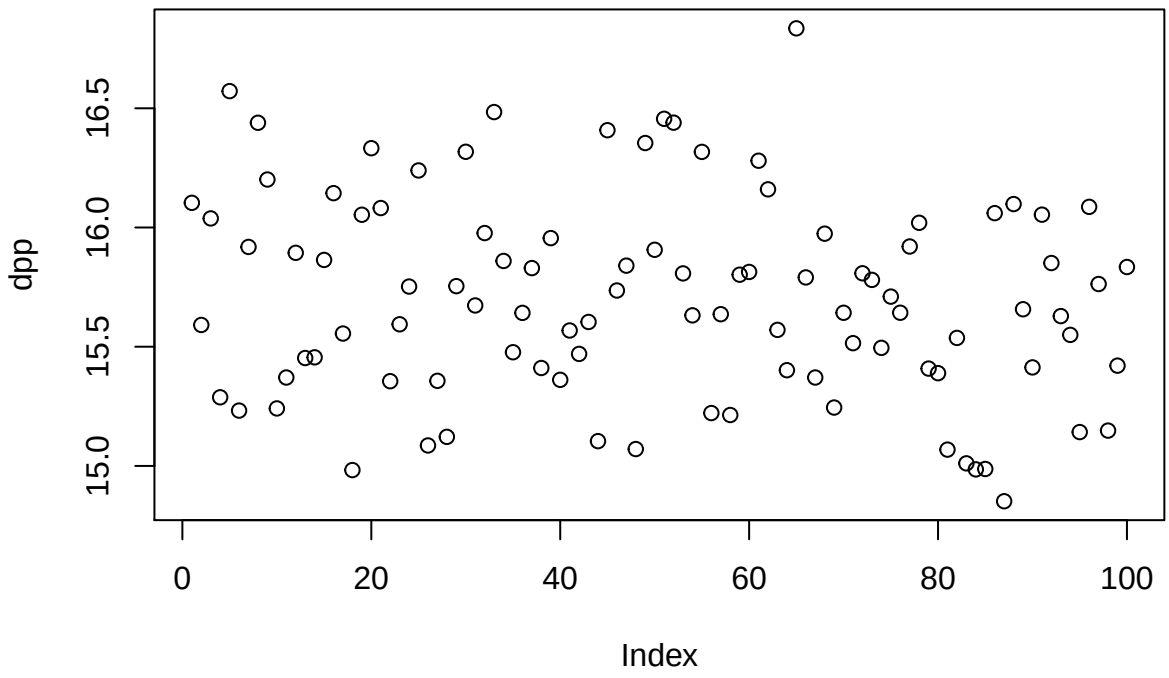




case3, no onwer but only 6 renters living

Here it is assumed that the owner doesn't live in the building while collecting a commission of 20% of profit generated from the charger installation. This commission could be interpreted as the increased rental or tax credits if government supports.


npv
24000
26000
28000
0
20
40
60
80
100
Index

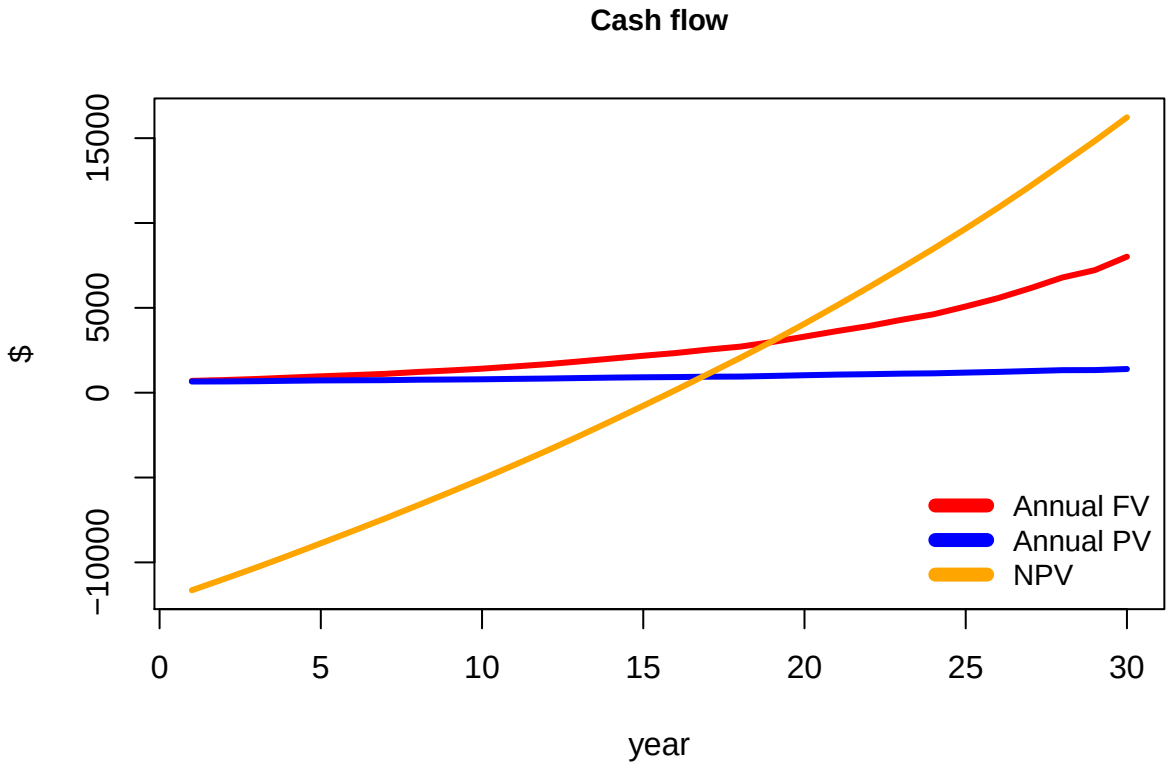


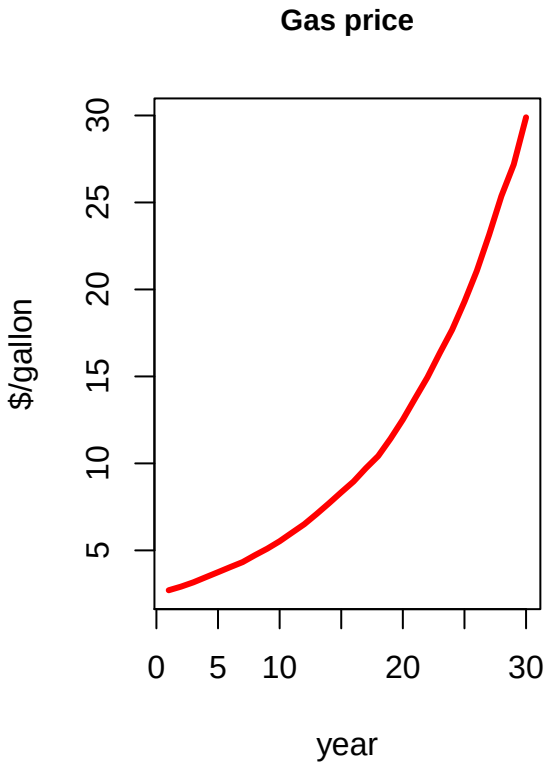

```
##    Gas price($/gallon) Elec.price($/kWh)     FV($)     PV($)      NPV($)
## 1             2.709018        0.08410244  698.0224  658.5117 -11641.4883
## 2             2.917071        0.09235690  745.0183  663.0637 -10978.4247
## 3             3.163141        0.10037289  807.0352  677.6023 -10300.8223
## 4             3.457097        0.10829318  887.2179  702.7597  -9598.0626
## 5             3.745971        0.11591596  966.6059  722.3042  -8875.7585
## 6             4.040000        0.12667526 1036.3604  730.5932  -8145.1653
## 7             4.326731        0.13566067 1109.9329  738.1688  -7406.9965
## 8             4.724344        0.14582227 1220.4216  765.7076  -6641.2889
## 9             5.099193        0.15929268 1310.2568  775.5390  -5865.7500
## 10            5.525241        0.17385983 1415.0988  790.1838  -5075.5662
## 11            6.015907        0.18790662 1545.8951  814.3583  -4261.2079
## 12            6.503746        0.20133495 1677.9170  833.8733  -3427.3346
## 13            7.090782        0.21649347 1840.4687  862.8835  -2564.4511
## 14            7.703910        0.23282559 2008.4045  888.3193  -1676.1318
## 15            8.338115        0.25090876 2177.7319  908.6914   -767.4404
## 16            8.957371        0.27023117 2336.9347  919.9257    152.4853
## 17            9.723385        0.29249980 2539.8810  943.2214   1095.7067
## 18           10.423719        0.31637680 2712.4709  950.2973   2046.0041
## 19           11.421940        0.34254337 2987.4428  987.3887   3033.3928
## 20           12.516311        0.36757403 3302.3660 1029.6933   4063.0861
## 21           13.742430        0.40309796 3627.6549 1067.0943   5130.1804
## 22           14.951041        0.44318625 3929.6209 1090.4898   6220.6702
## 23           16.347499        0.48575568 4292.3285 1123.7198   7344.3901
## 24           17.684537        0.53179321 4620.1596 1141.0803   8485.4704
## 25           19.297695        0.56948707 5081.4354 1183.9675   9669.4379
```

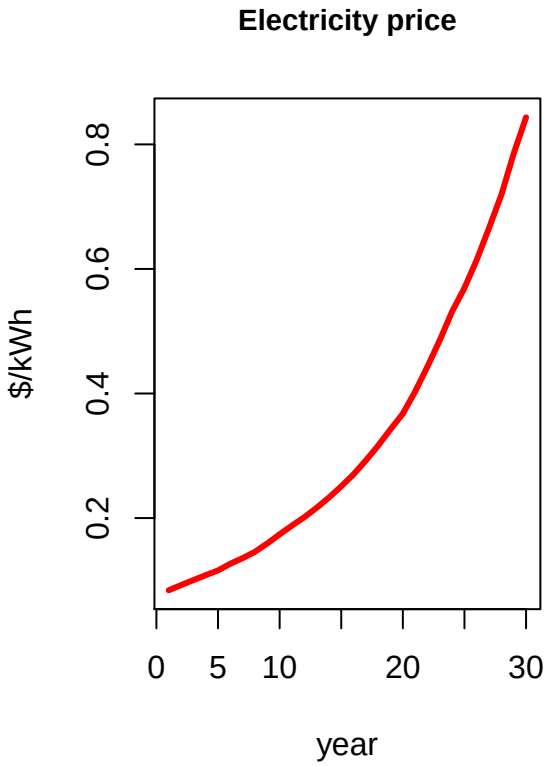
```
## 26           21.064305        0.61471606 5572.0453 1224.7914  10894.2293
## 27           23.137665        0.66598520 6154.5211 1276.2504  12170.4798
## 28           25.372780        0.71932415 6789.5472 1328.2401  13498.7199
## 29           27.182179        0.78542857 7219.1944 1332.3510  14831.0708
## 30           29.892325        0.84338520 8013.9259 1395.3057  16226.3765
##    DPP(year)
## 1    0.00000
## 2    0.00000
## 3    0.00000
## 4    0.00000
## 5    0.00000
## 6    0.00000
## 7    0.00000
## 8    0.00000
## 9    0.00000
## 10   0.00000
## 11   0.00000
## 12   0.00000
## 13   0.00000
## 14   0.00000
## 15   0.00000
## 16  15.83424
## 17  16.16166
## 18  18.15301
## 19  20.07214
## 20  21.94592
## 21  23.80762
## 22  25.70447
## 23  27.53578
## 24  29.43635
## 25  31.16698
## 26  32.89476
## 27  34.53612
## 28  36.16286
## 29  38.13150
## 30  39.62926

## [1] 26108.44

## [1] 15.70562
```

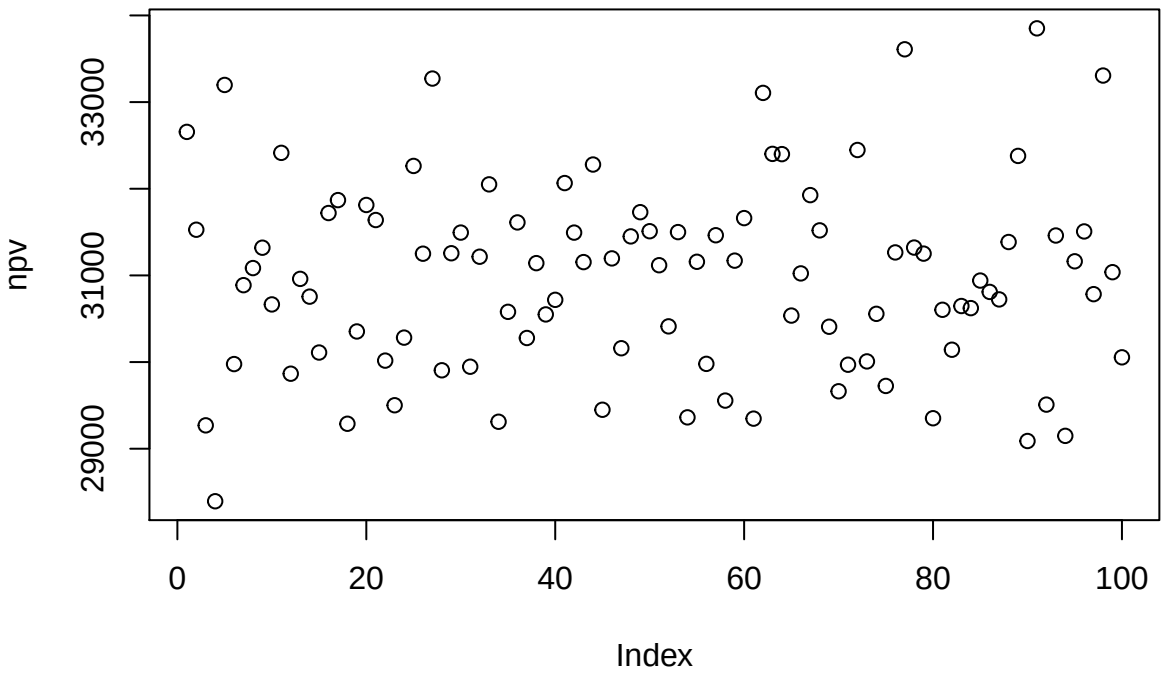

Cash flow
$
15000
5000
0
−10000
0
5
10
15
20
25
30
year
Annual FV
Annual PV
NPV

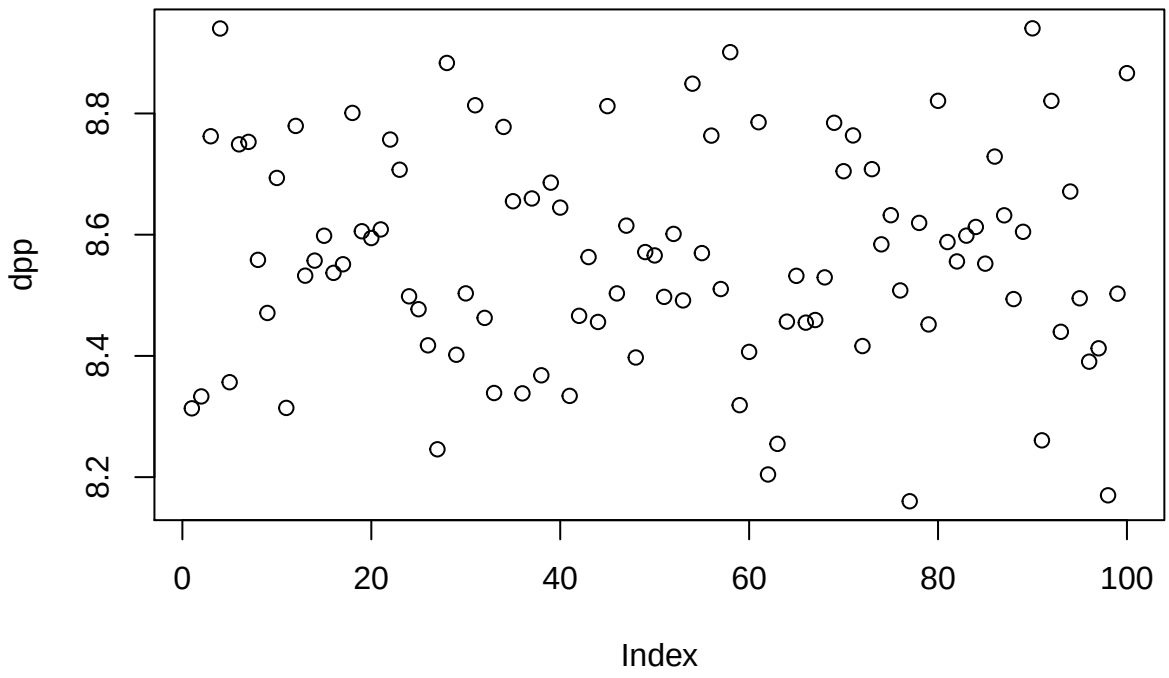




case4, 12 renters (sharing chargers) but rest conditions are the same as case3.

This case, 2 EV owners are using one charger by sharing it given the same utilization rate as the case3.


npv
29000
31000
33000
0
20
40
60
80
100
Index

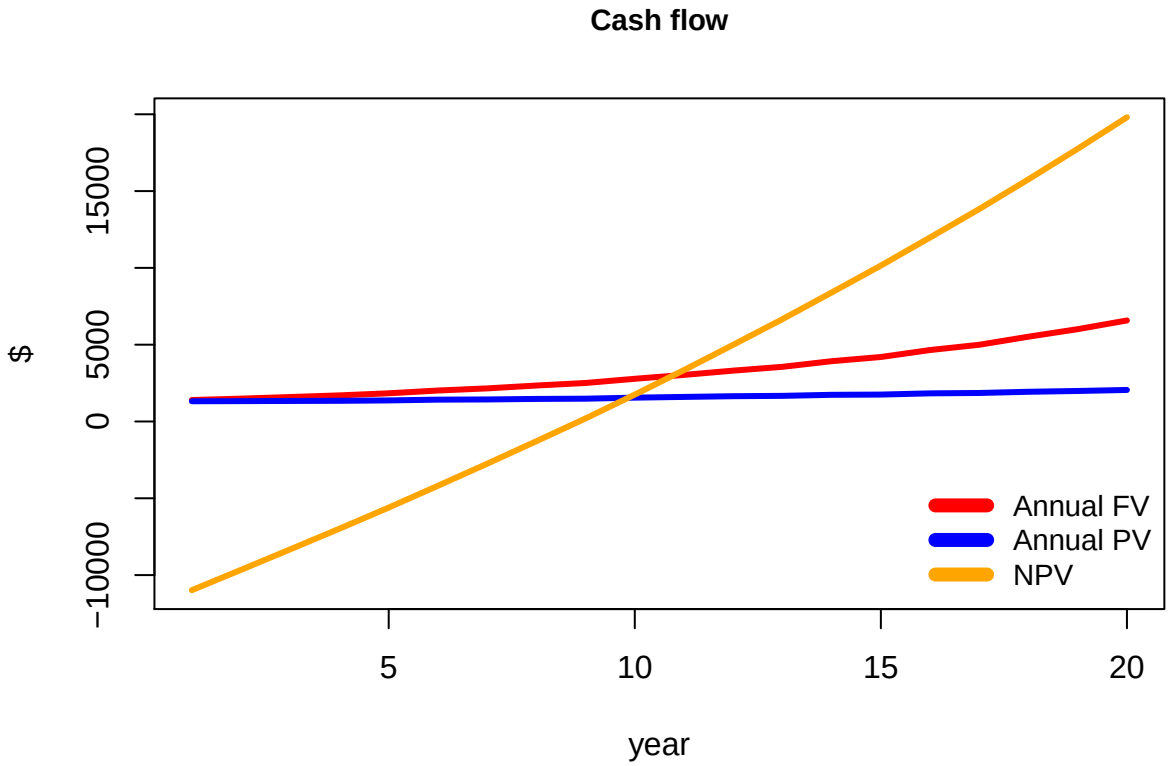


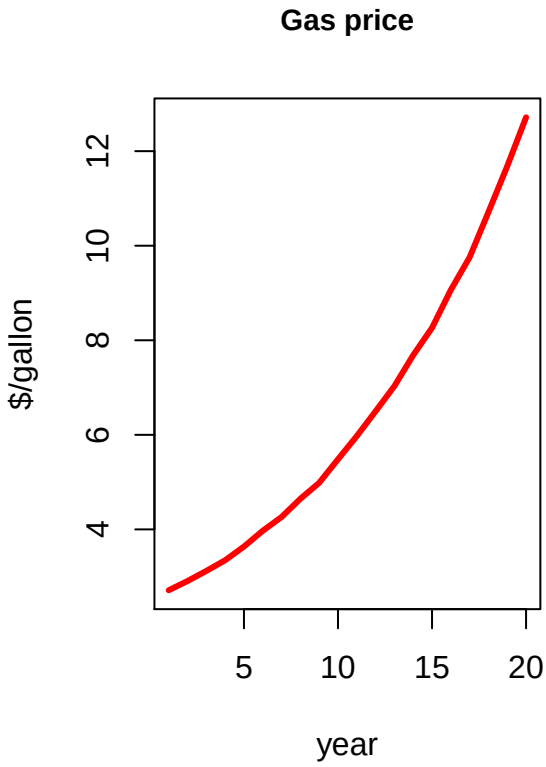

```
##    Gas price($/gallon) Elec.price($/kWh)    FV($)    PV($)      NPV($)
## 1             2.713167        0.08450719 1396.150 1317.123 -10982.8770
## 2             2.907998        0.09178502 1487.499 1323.869  -9659.0082
## 3             3.121849        0.09928033 1591.396 1336.167  -8322.8411
## 4             3.347487        0.10750831 1698.667 1345.504  -6977.3374
## 5             3.636766        0.11824273 1834.825 1371.088  -5606.2493
## 6             3.970537        0.12750103 2014.958 1420.466  -4185.7837
## 7             4.262333        0.13807060 2154.203 1432.668  -2753.1159
## 8             4.647551        0.15177908 2339.834 1468.041  -1285.0751
## 9             4.985329        0.16339481 2505.584 1483.051    197.9762
## 10            5.483027        0.17664030 2778.310 1551.394   1749.3702
## 11            5.974080        0.19164315 3033.149 1597.825   3347.1952
## 12            6.499217        0.20706411 3310.266 1645.101   4992.2960
## 13            7.031583        0.22706399 3559.035 1668.615   6660.9107
## 14            7.685443        0.24339824 3925.196 1736.118   8397.0286
## 15            8.263921        0.26492127 4197.053 1751.284  10148.3122
## 16            9.064769        0.28436752 4649.651 1830.318  11978.6300
## 17            9.756031        0.30731842 4994.902 1854.929  13833.5590
## 18           10.711115        0.33239734 5520.763 1934.165  15767.7242
## 19           11.683067        0.36421288 6009.556 1986.236  17753.9605
## 20           12.714808        0.39143298 6576.679 2050.639  19804.6000
##    DPP(year)
## 1   0.000000
## 2   0.000000
## 3   0.000000
## 4   0.000000
```

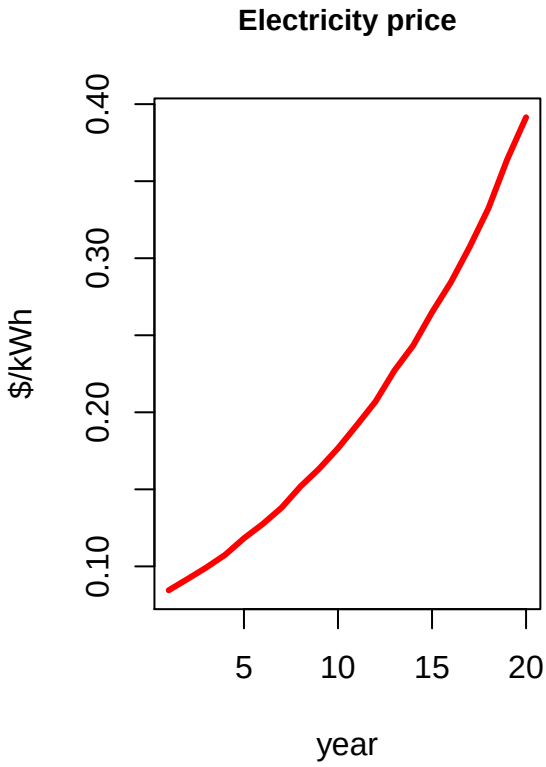
```
## 5   0.000000
## 6   0.000000
## 7   0.000000
## 8   0.000000
## 9   8.866507
## 10  9.127612
## 11 11.094845
## 12 13.034644
## 13 14.991881
## 14 16.836670
## 15 18.794785
## 16 20.544563
## 17 22.457730
## 18 24.152212
## 19 25.938493
## 20 27.657768
```

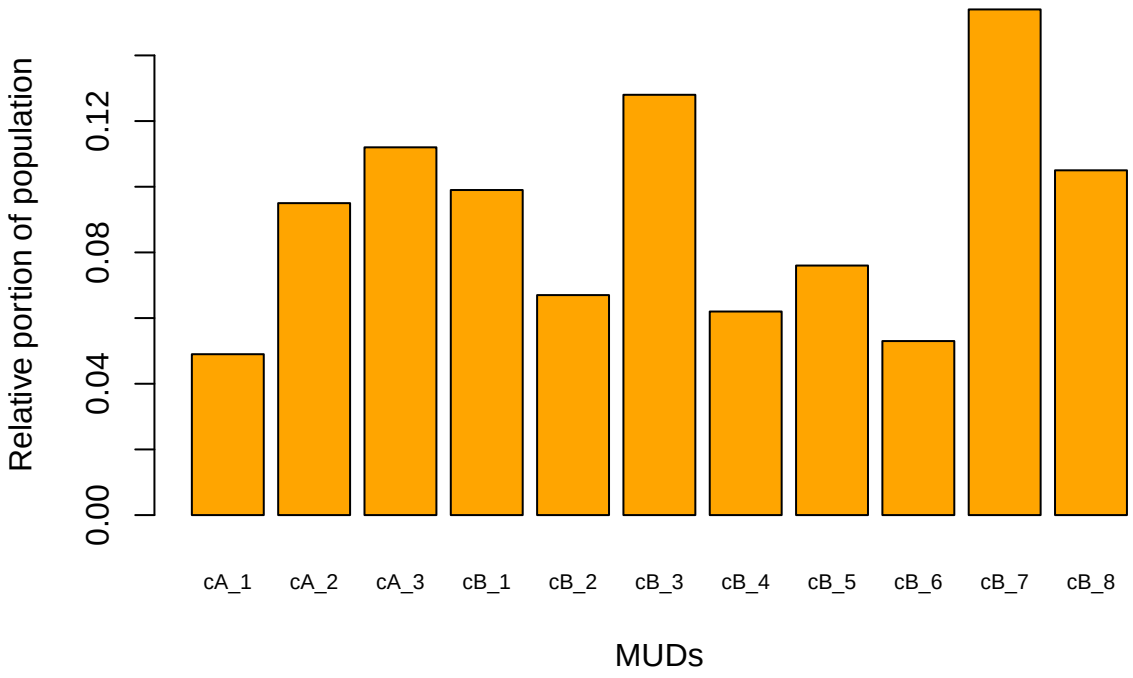
```
## [1] 30972.72
```

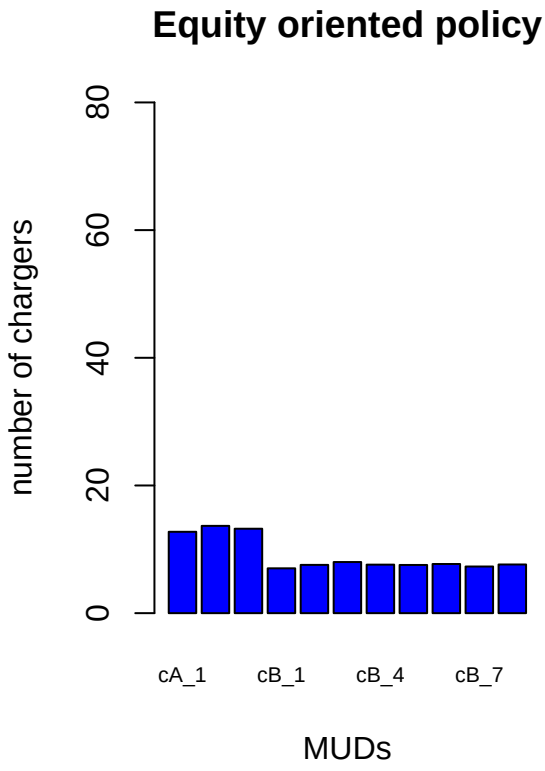
```
## [1] 8.564087
```

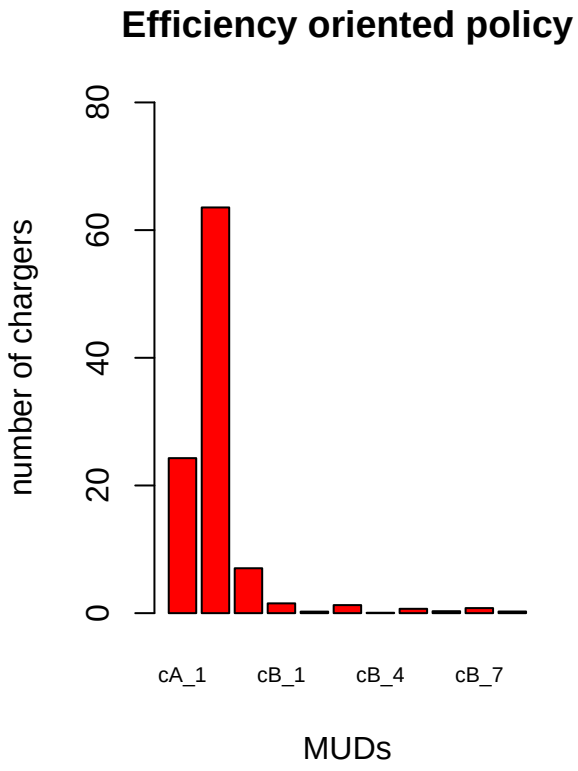



Gas price
$/gallon
4
6
8
10
12
5
10
15
20
year


Electricity price
$/kWh
0.10
0.20
0.30
0.40
5
10
15
20
year


Population proportion in MUD blocks
Relative portion of population
0.00
0.04
0.08
0.12
cA_1
cA_2
cA_3
cB_1
cB_2
cB_3
cB_4
cB_5
cB_6
cB_7
cB_8
MUDs


Equity oriented policy
number of chargers
0
20
40
60
80
cA_1
cB_1
cB_4
cB_7
MUDs


Efficiency oriented policy
number of chargers
0
20
40
60
80
cA_1
cB_1
cB_4
cB_7
MUDs