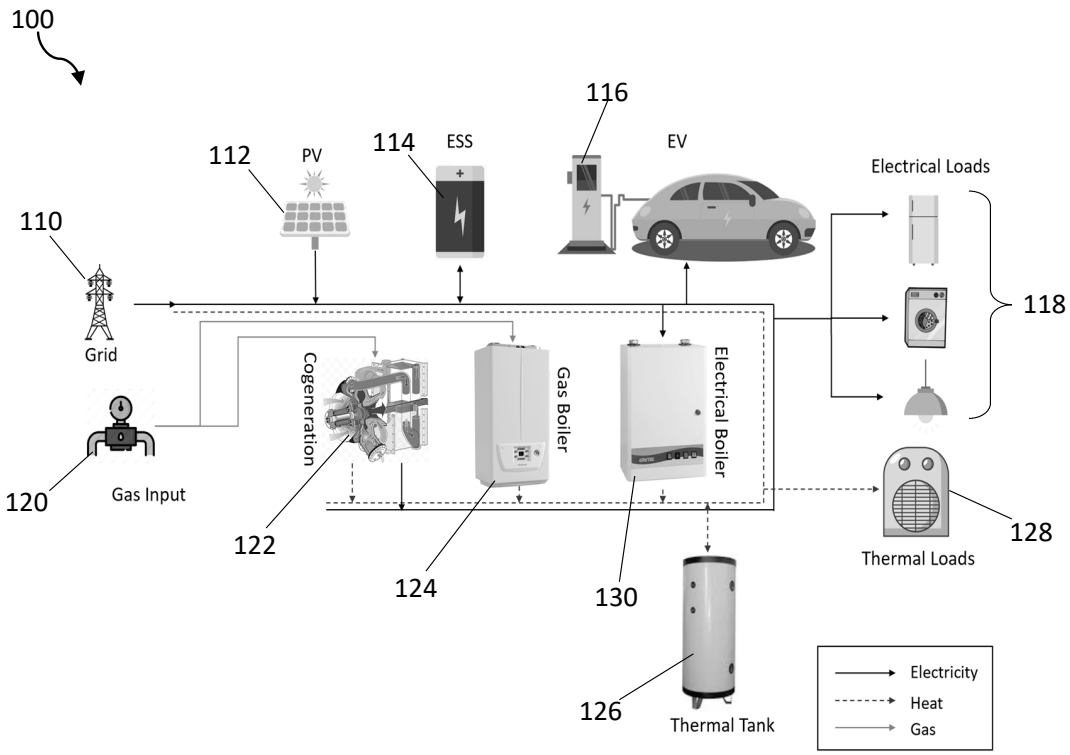

100
116
112
PV
114
ESS
EV
Electrical Loads
110
118
Grid
Cogeneration
Gas Boiler
Electrical Boiler
120
Gas Input
122
124
130
128
Thermal Loads
126
Thermal Tank
Electricity
Heat
Gas

FIG.1

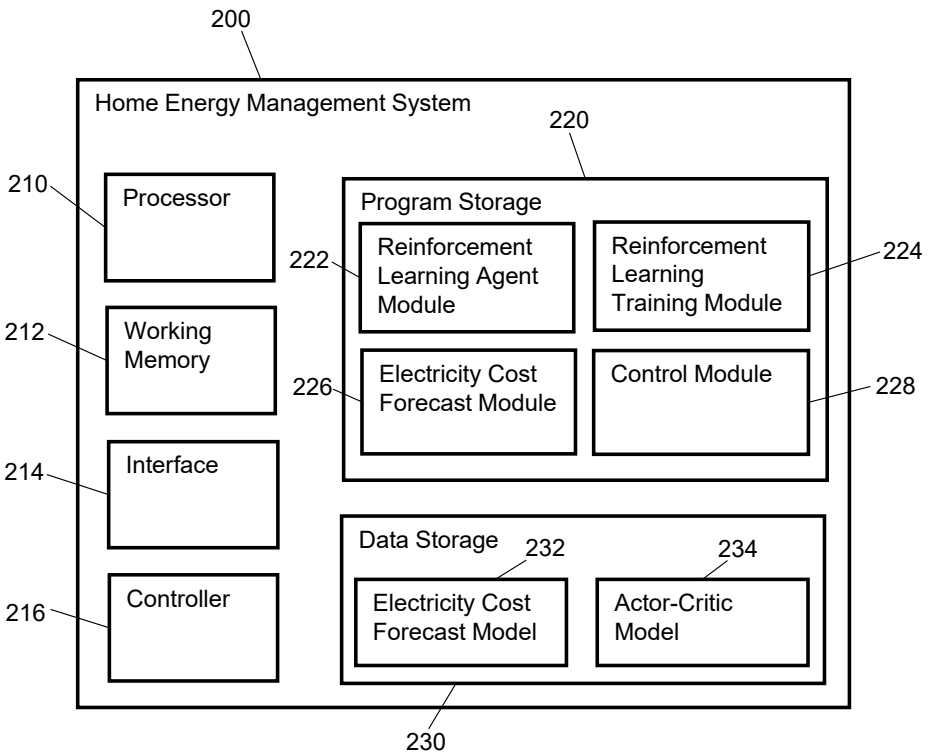

200
Home Energy Management System
220
210
Processor
Program Storage
222
Reinforcement Learning Agent Module
Reinforcement Learning Training Module
224
212
Working Memory
226
Electricity Cost Forecast Module
Control Module
228
214
Interface
Data Storage
232
234
216
Controller
Electricity Cost Forecast Model
Actor-Critic Model
230

FIG.2

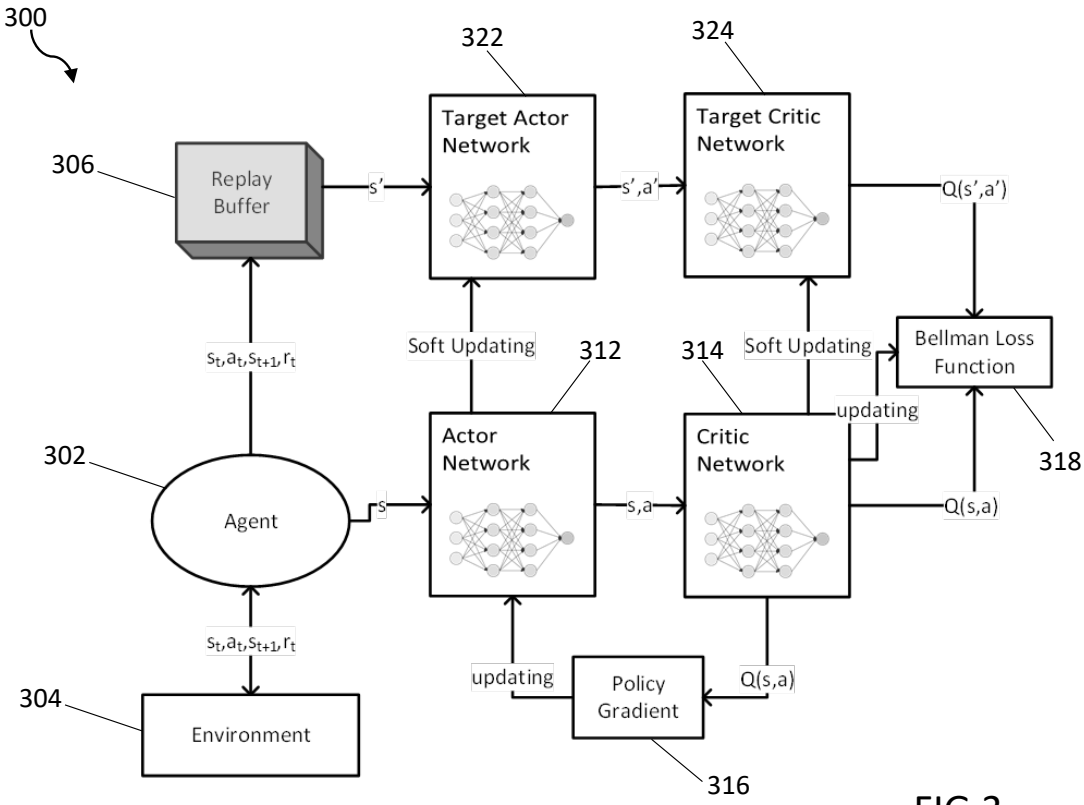

300
322
324
Target Actor Network
Target Critic Network
306
Replay Buffer
s'
s',a'
Q(s',a')
Soft Updating
312
314
Soft Updating
Bellman Loss Function
updating
Actor Network
Critic Network
318
302
Agent
s
s,a
Q(s,a)
304
Environment
updating
Policy Gradient
Q(s,a)
316

FIG.3

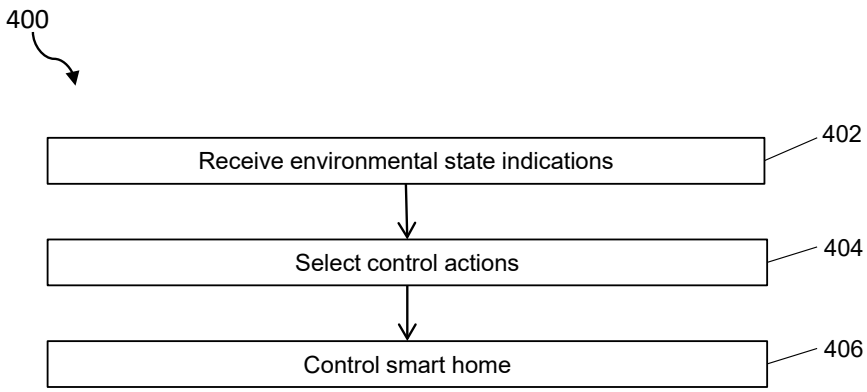

400
Receive environmental state indications
402
Select control actions
404
Control smart home
406

FIG.4

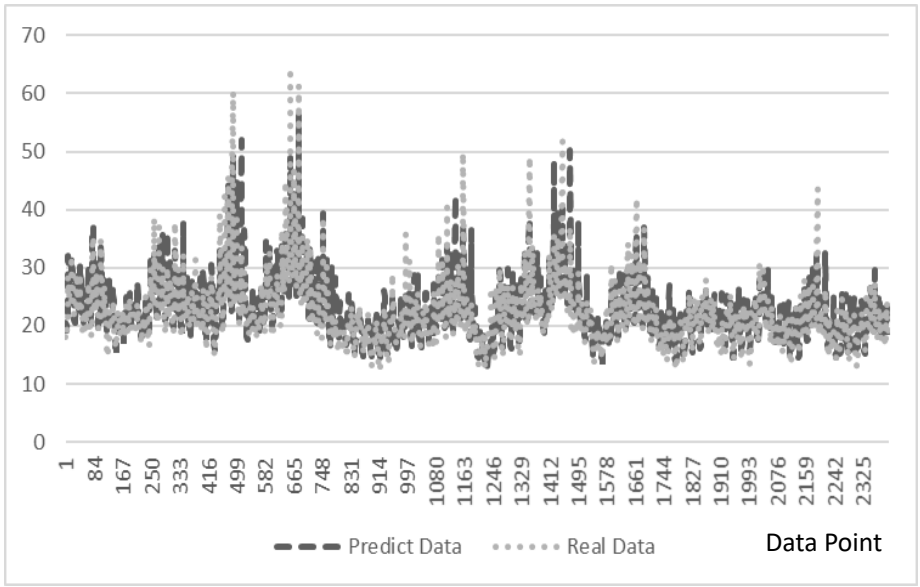

Energy Price (USD)
70
60
50
40
30
20
10
0
1
84
167
250
333
416
499
582
665
748
831
914
997
1080
1163
1246
1329
1412
1495
1578
1661
1744
1827
1910
1993
2076
2159
2242
2325
Predict Data
Real Data
Data Point

FIG.5

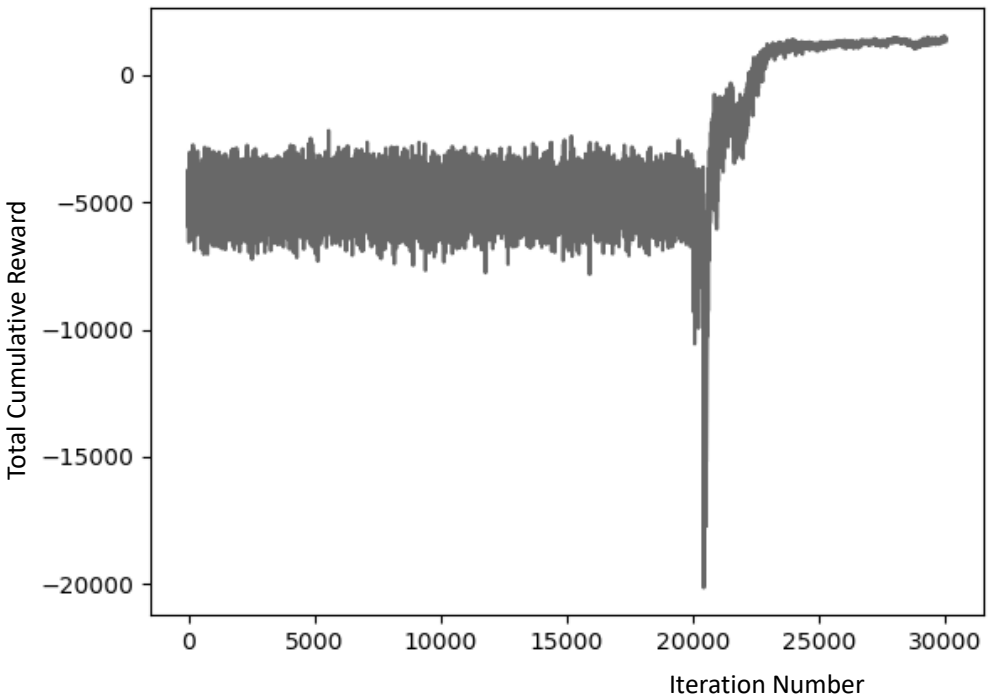

Total Cumulative Reward
0
−5000
−10000
−15000
−20000
0
5000
10000
15000
20000
25000
30000
Iteration Number

FIG.6

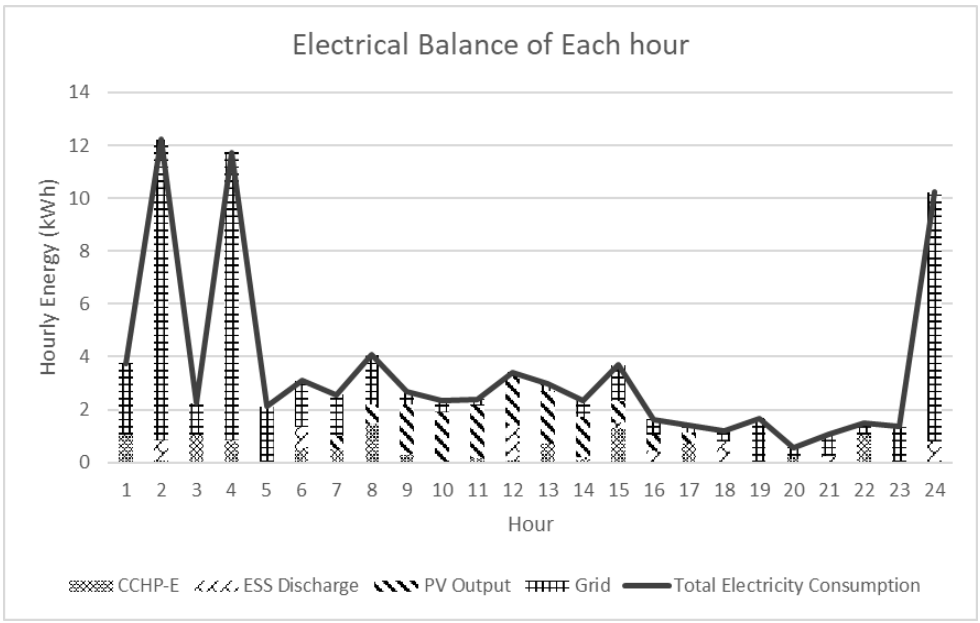

Electrical Balance of Each hour
Hourly Energy (kWh)
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
CCHP-E
ESS Discharge
PV Output
Grid
Total Electricity Consumption

FIG.7

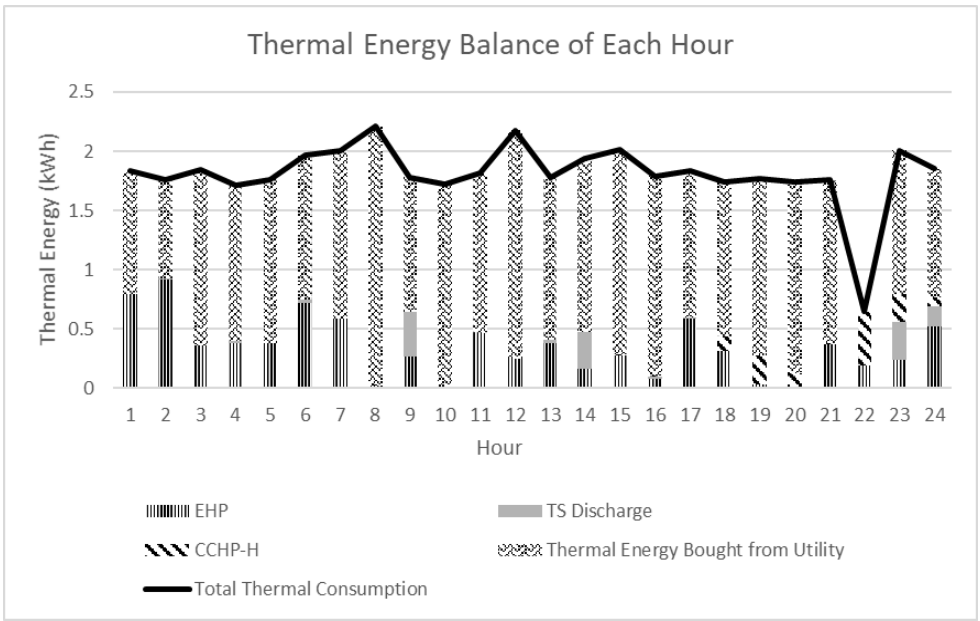

Thermal Energy Balance of Each Hour
Thermal Energy (kWh)
2.5
2
1.5
1
0.5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
EHP
TS Discharge
CCHP-H
Thermal Energy Bought from Utility
Total Thermal Consumption

FIG.8

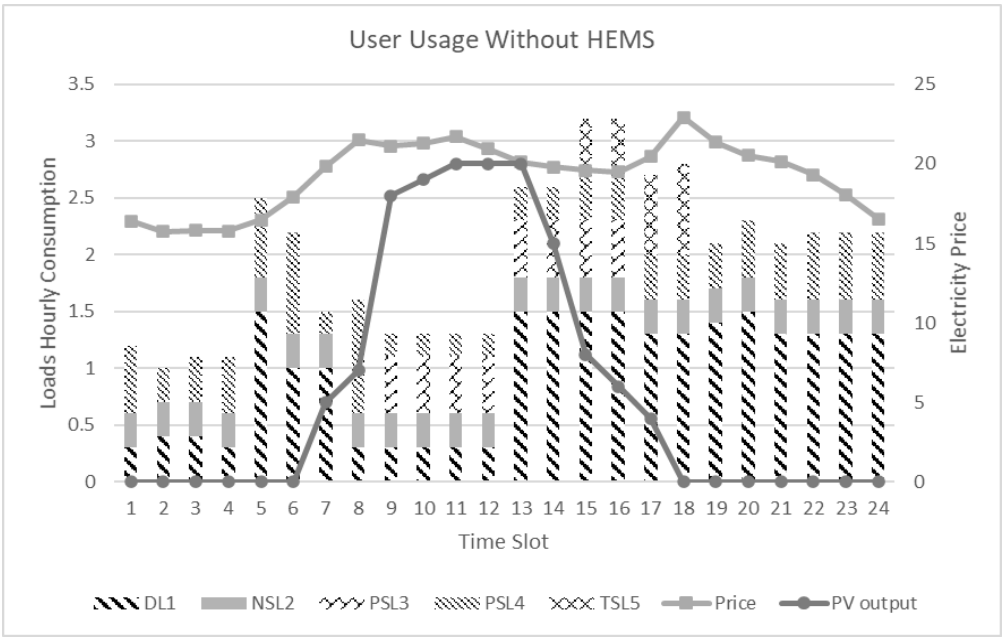

User Usage Without HEMS
Loads Hourly Consumption
Electricity Price
Time Slot
DL1
NSL2
PSL3
PSL4
TSL5
Price
PV output

FIG.9

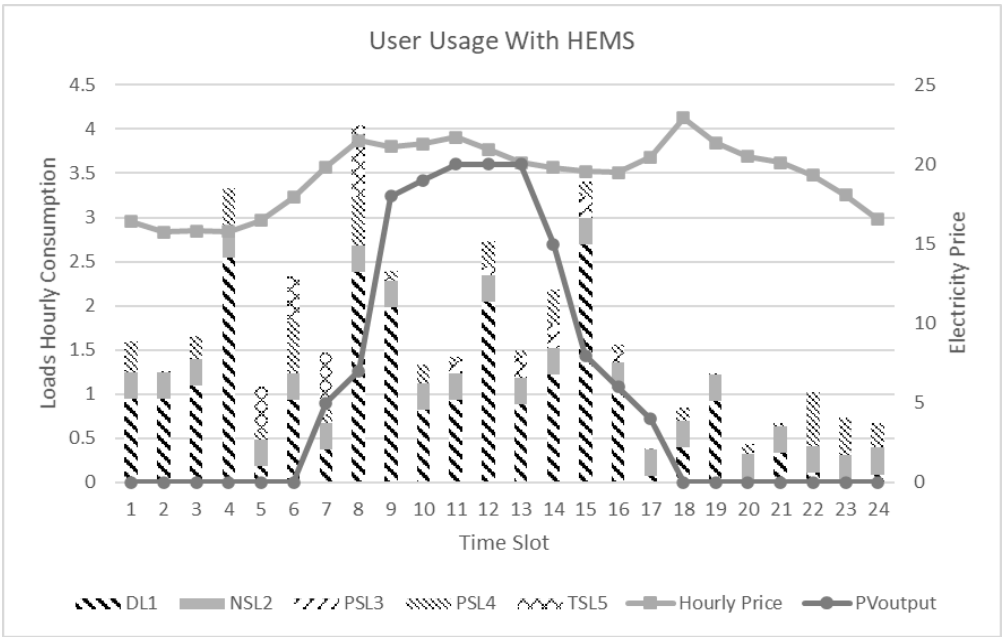

User Usage With HEMS
Loads Hourly Consumption
Electricity Price
Time Slot
DL1
NSL2
PSL3
PSL4
TSL5
Hourly Price
PVoutput

FIG.10

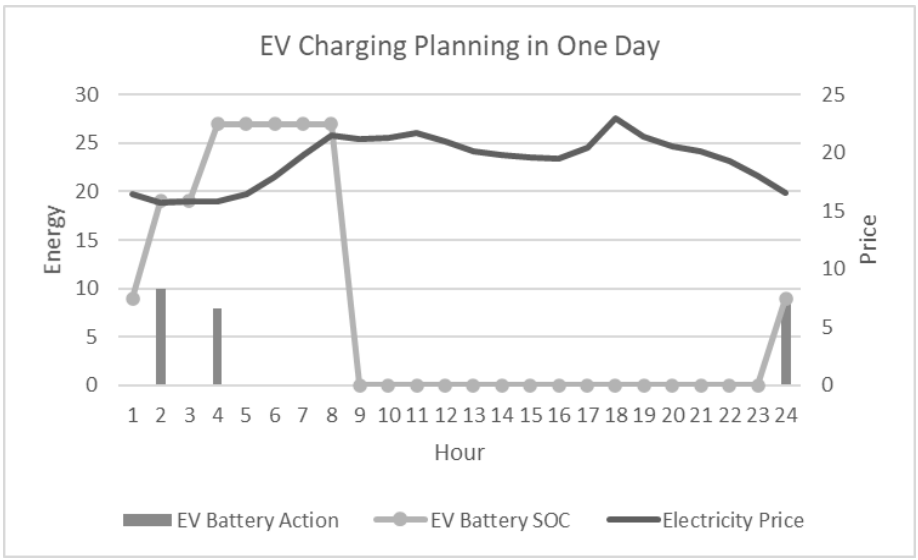

EV Charging Planning in One Day
Energy
Price
Hour
EV Battery Action
EV Battery SOC
Electricity Price

FIG.11

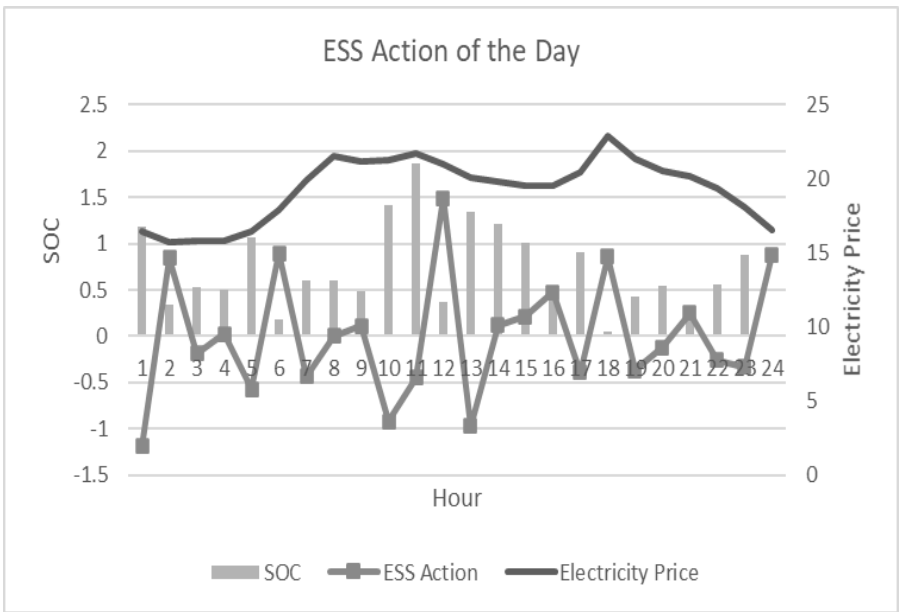

ESS Action of the Day
SOC
Electricity Price
Hour
SOC
ESS Action
Electricity Price

FIG.12