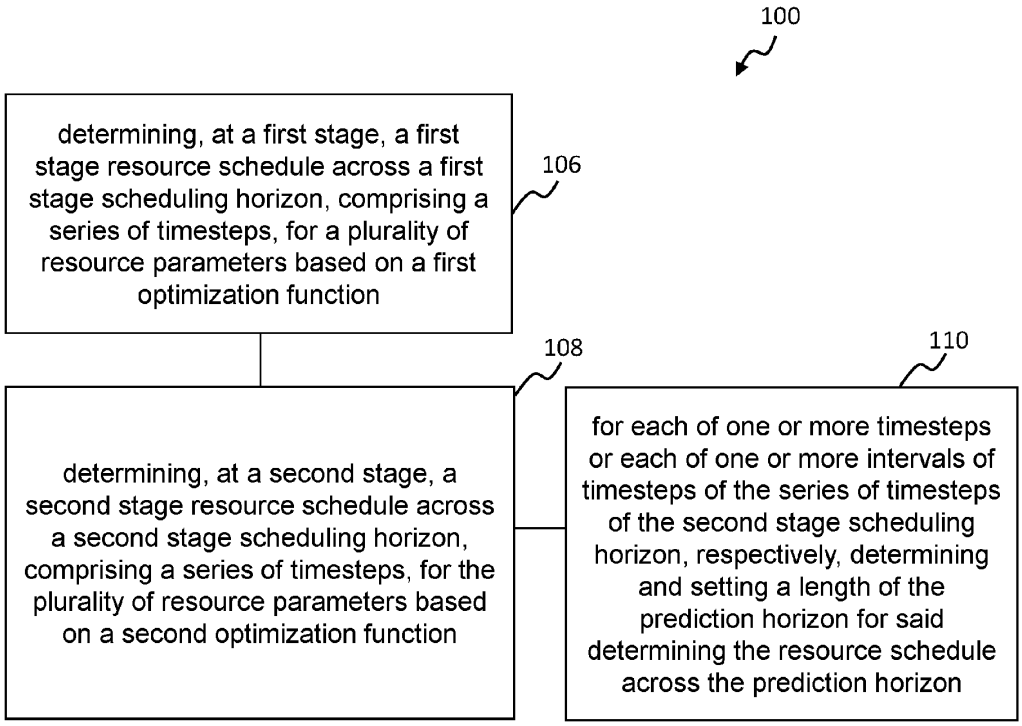

100
determining, at a first stage, a first stage resource schedule across a first stage scheduling horizon, comprising a series of timesteps, for a plurality of resource parameters based on a first optimization function
106
108
110
determining, at a second stage, a second stage resource schedule across a second stage scheduling horizon, comprising a series of timesteps, for the plurality of resource parameters based on a second optimization function
for each of one or more timesteps or each of one or more intervals of timesteps of the series of timesteps of the second stage scheduling horizon, respectively, determining and setting a length of the prediction horizon for said determining the resource schedule across the prediction horizon

FIG. 1

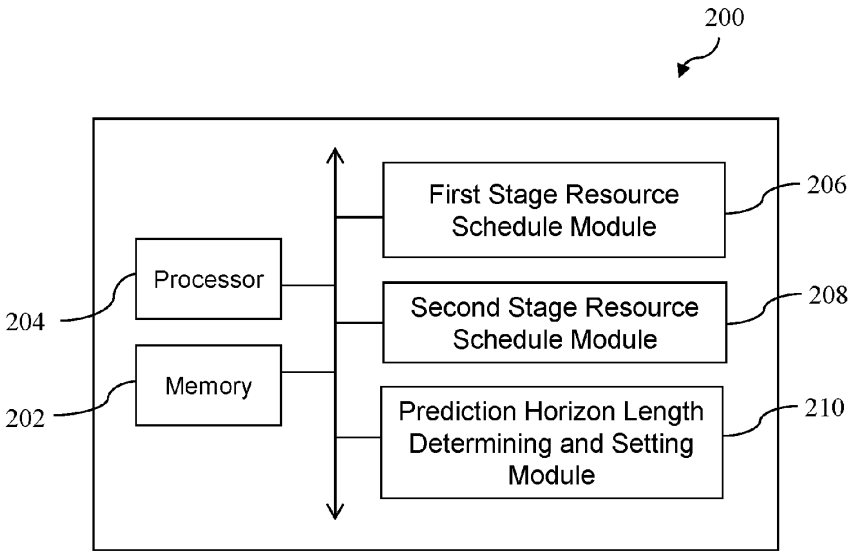
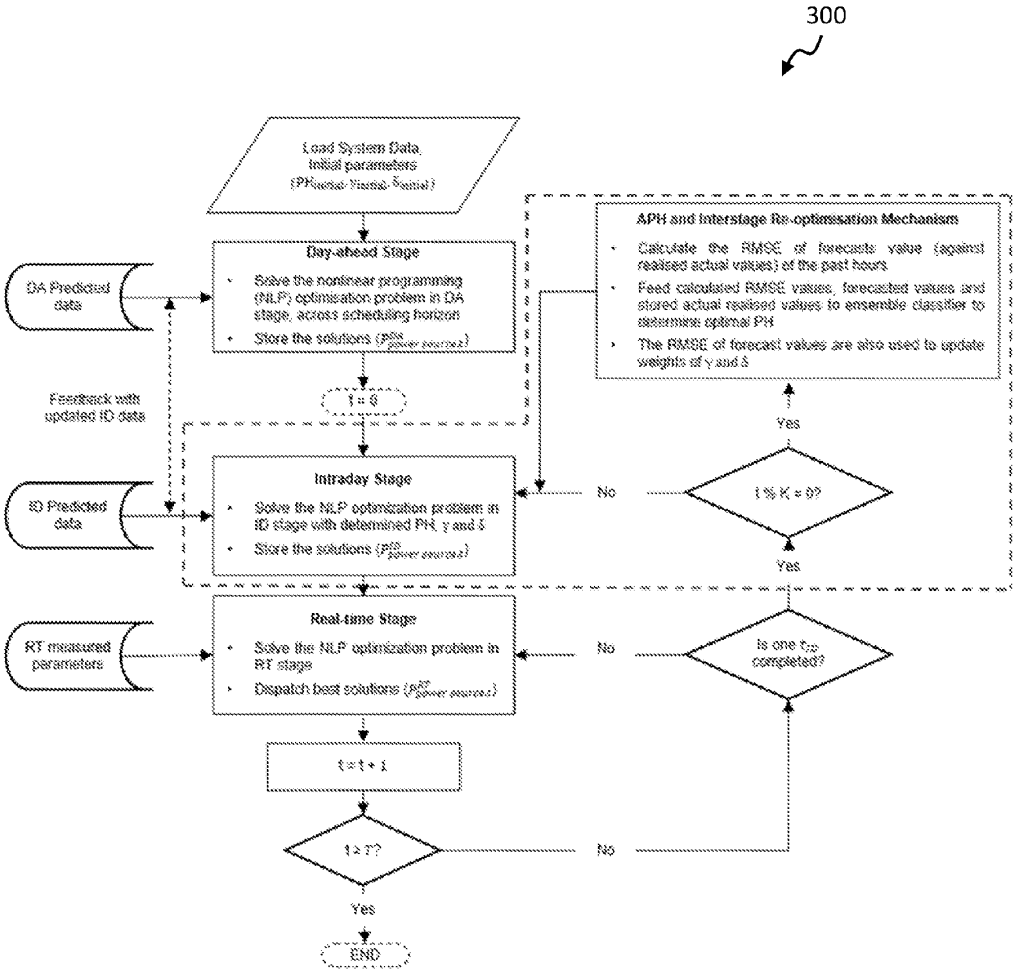

200
First Stage Resource Schedule Module
206
Processor
204
Second Stage Resource Schedule Module
208
Memory
202
Prediction Horizon Length Determining and Setting Module
210

FIG. 2



t_{DA}	Day-ahead stage timestep
t_{ID}	Intraday stage timestep
t	Real-time stage timestep
γ	Weight of the deviation minimisation objective (interstage re-optimisation)
δ	Weight of the combined cost minimisation objective (interstage re-optimisation)
T	Scheduling horizon
K	Stipulated RT timestep interval length to run proposed mechanisms
PH	Intraday Prediction Horizon
$P_{power\ source,t}^{DA/ID/RT}$	Allocation decisions of power sources of the different stages

FIG. 3

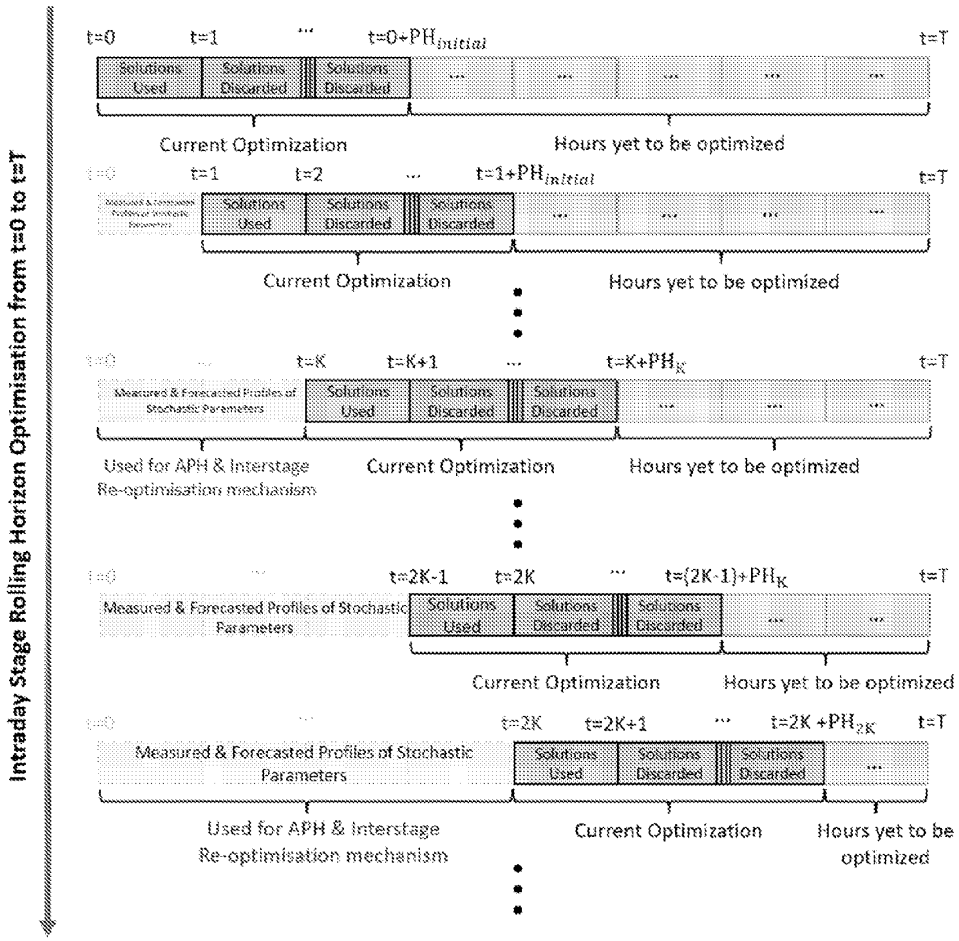
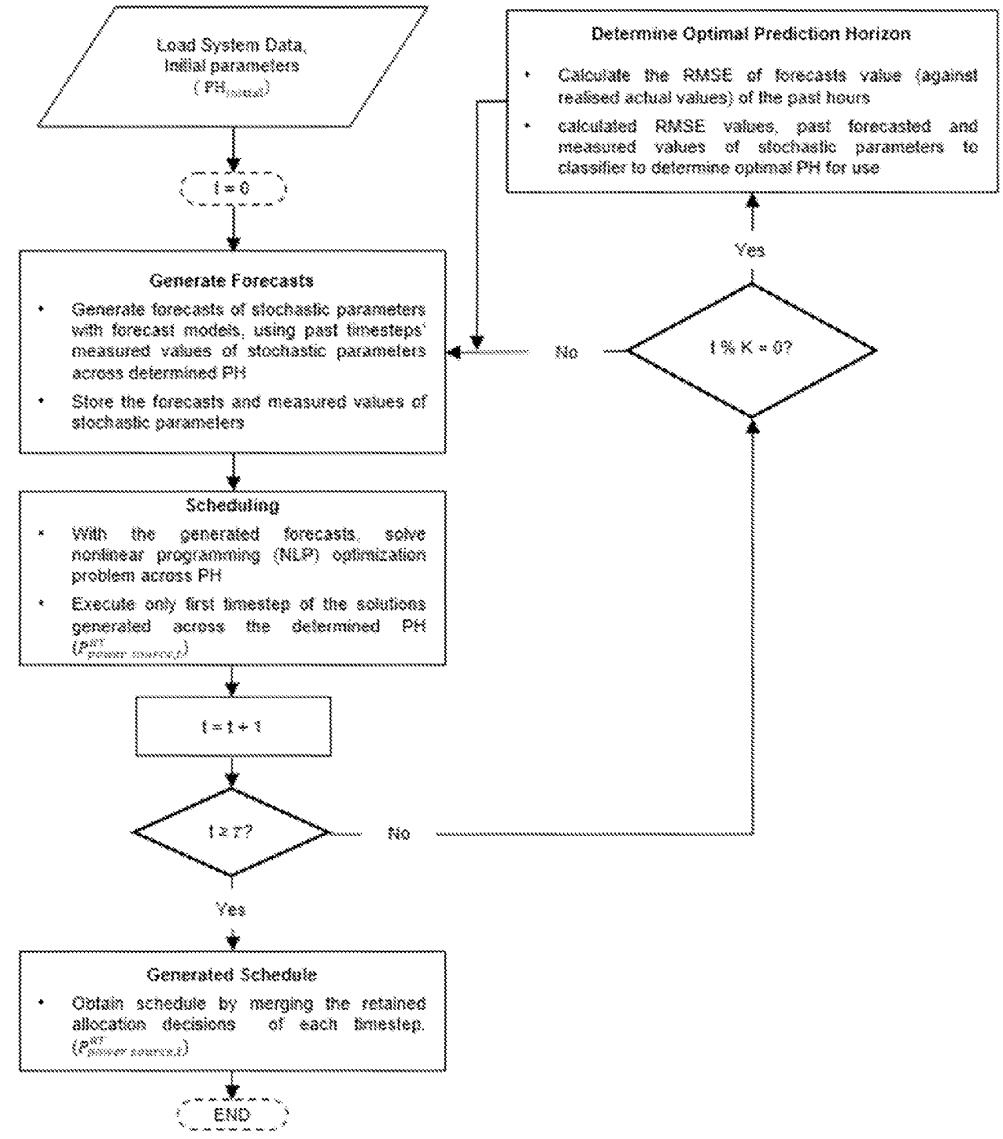

Intraday Stage Rolling Horizon Optimisation from t=0 to t=T
t=0
t=1
t=0+PH_initial
t=T
Solutions Used
Solutions Discarded
Solutions Discarded
Current Optimization
Hours yet to be optimized
t=1
t=2
t=1+PH_initial
Solutions Used
Solutions Discarded
Solutions Discarded
Current Optimization
Hours yet to be optimized
t=K
t=K+1
t=K+PH_K
Measured & Forecasted Profiles of Stochastic Parameters
Solutions Used
Solutions Discarded
Solutions Discarded
Used for APH & Interstage Re-optimisation mechanism
Current Optimization
Hours yet to be optimized
t=2K-1
t=2K
t=(2K-1)+PH_K
Measured & Forecasted Profiles of Stochastic Parameters
Solutions Used
Solutions Discarded
Solutions Discarded
Current Optimization
Hours yet to be optimized
t=2K
t=2K+1
t=2K +PH_2K
Measured & Forecasted Profiles of Stochastic Parameters
Solutions Used
Solutions Discarded
Solutions Discarded
Used for APH & Interstage Re-optimisation mechanism
Current Optimization
Hours yet to be optimized

FIG. 4



t	Scheduling timestep
T	Scheduling horizon
K	Stipulated RT timestep interval length to run proposed mechanisms
PH	Intraday Prediction Horizon
$P^{RT}_{power\ sources,t}$	Allocation decisions of power sources of the different stages

FIG. 5

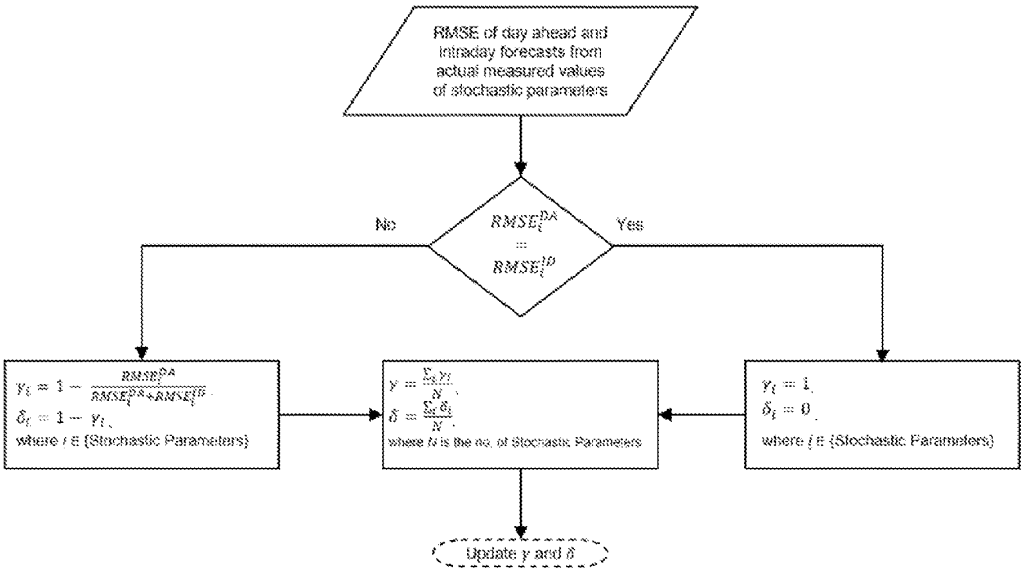

RMSE of day ahead and intraday forecasts from actual measured values of stochastic parameters
$RMSE_i^{DA} = RMSE_i^{ID}$
No
Yes
$\gamma_i = 1 - \frac{RMSE_i^{DA}}{RMSE_i^{DA}+RMSE_i^{ID}}$
$\delta_i = 1 - \gamma_i$
where $i \in$ {Stochastic Parameters}
$\gamma = \frac{\sum_N \gamma_i}{N}$
$\delta = \frac{\sum_N \delta_i}{N}$
where N is the no. of Stochastic Parameters
$\gamma_i = 1$
$\delta_i = 0$
where $i \in$ {Stochastic Parameters}
Update γ and δ

FIG. 6

Table 2

Fixed Parameters / Constraints	Symbol	Value
BESS charge/discharge power rating	P_{BESS}^{upper}	5 kW
BESS power capacity	$BESS_{Capacity}$	10 kW
WTE generator rating	P_{WTE}^{upper}	5kW
Solar PV resource cost	RC_{PV}	0.08346 SGD/kWh
WTE resource cost	RC_{WTE}	0.20000 SGD/kWh
BESS (charging) resource cost	$RC_{BESS,C}$	0.08346 SGD/kWh
BESS (discharge) resource cost	$RC_{BESS,D}$	0.19000 SGD/kWh
Solar PV carbon emission cost	EC_{PV}	0.09258 kgCO2-Eq/kWh
WTE carbon emission cost	EC_{WTE}	0.40320 kgCO2-Eq/kWh
Main grid carbon emission cost	EC_{Grid}	0.40800 kgCO2-Eq/kWh
BESS (charging) carbon emission cost	$EC_{BESS,C}$	0.09258 kgCO2-Eq/kWh
BESS (discharge) carbon emission cost	$EC_{BESS,D}$	0.08000 kgCO2-Eq/kWh

FIG. 7A

Table 3

		Proposed novel 3-stage algorithm	Rana et al. 3-stage algorithm	Jeong et al. 2-stage algorithm
Day-ahead	Objective function	Min $(\alpha \cdot \omega \cdot F_{RC}^{DA} + \beta \cdot F_{EC}^{DA})$ $\alpha = 0.5, \beta = 0.5$ and $\omega = 1$		
	Timestep	1 hour		
	Prediction Horizon	24 hours		
Intraday	Objective function	Min $(\gamma \cdot F_{Dev}^{ID} + \delta \cdot F_{EC}^{ID})$ γ and δ are adaptive	Min F_{Dev}^{ID}	N.A.
	Timestep	1 hour	1 hour	
	Prediction Horizon	Assigned	Assigned	
Real-Time	Objective function	Min $(0.99F_{Dev}^{RT} + 0.01F_{EC}^{RT})$	Min F_{Dev}^{RT}	Min F_{Dev}^{RT}
	Timestep	15 minutes	15 minutes	15 minutes
	Prediction Horizon	N.A.	N.A.	N.A.

FIG. 7B

Table 4

Fixed prediction horizon length used in ID stage	Proposed novel 3-stage algorithm	Rana et al. 3-stage algorithm	Jeong et al. 2-stage algorithm
	Power Allocation MAE (kW)	Power Allocation MAE (kW)	Power Allocation MAE (kW)
1	0.2551	0.5986	0.5869*
2	0.2598	0.6923	
3	0.2862	0.6944	
4	0.2459	0.6768	
5	0.2449	0.6645	
6	0.2653	0.7100	
7	0.2810	0.7115	
8	0.2389	0.6678	
9	0.2782	0.6687	
10	0.2847	0.6611	*2-stage algorithm does not have an intraday (ID) stage
11	0.2446	0.6879	
12	0.2783	0.7377	

FIG. 7C

Table 5

Fixed prediction horizon length used in ID stage	Proposed novel 3-stage algorithm	Rana et al. 3-stage algorithm	Jeong et al. 2-stage algorithm
	Combined cost index (SGD)	Combined cost index (SGD)	Combined cost index (SGD)
1	1.0687	1.1287	1.1170*
2	1.0698	1.1350	
3	1.0708	1.1417	
4	1.0663	1.1350	
5	1.0657	1.1293	
6	1.0718	1.1391	
7	1.0772	1.1467	
8	1.0614	1.1339	
9	1.0752	1.1387	
10	1.0788	1.1398	*2-stage algorithm does not have an intraday (ID) stage
11	1.0645	1.1379	
12	1.0766	1.1441	

FIG. 7D

Table 6

Fixed prediction horizon length used in ID stage	Proposed novel 3-stage algorithm	Rana et al. 3-stage algorithm	Jeong et al. 2-stage algorithm
	Resource cost index (SGD)	Resource cost index (SGD)	Resource cost index (SGD)
1	1.1507	1.2097	1.2195*
2	1.1499	1.2171	
3	1.1573	1.2361	
4	1.1520	1.2109	
5	1.1509	1.2130	
6	1.1527	1.2313	
7	1.1551	1.2388	
8	1.1480	1.2100	
9	1.1538	1.2243	
10	1.1567	1.2128	*2-stage algorithm does not have an intraday (ID) stage
11	1.1511	1.2060	
12	1.1551	1.2260	

FIG. 7E

Table 7

Fixed prediction horizon length used in ID stage	Proposed novel 3-stage algorithm	Rana et al. 3-stage algorithm	Jeong et al. 2-stage algorithm
	Carbon emission cost index (kgCO2-Eq)	Carbon emission cost index (kgCO2-Eq)	Carbon emission cost index (kgCO2-Eq)
1	1.0355	1.0960	1.0756*
2	1.0375	1.1018	
3	1.0485	1.1036	
4	1.0317	1.1043	
5	1.0313	1.0955	
6	1.0391	1.1019	
7	1.0457	1.1095	
8	1.0264	1.1031	
9	1.0434	1.1041	
10	1.0473	1.1103	*2-stage algorithm does not have an intraday (ID) stage
11	1.0295	1.1104	
12	1.0449	1.1111	

FIG. 7F