Appendix-A

This section gives the hyperparameters of the proposed algorithms, including the numbers of layers and neurons of several modules in GGIRL.

***Parameters setting for IEEE33 case*:**

Parameters setting of actor network of GGIRL (Generator):

Actor network (Generator)		
1	Full connection Layers	
	Number of inputs	47
	Number of outputs	256
	Activation function	ReLU
2	Full connection Layers	
	Number of inputs	256
	Number of outputs	256
	Activation function	ReLU
3	Full connection Layers	
	Number of inputs	256
	Number of outputs	9
	Activation function	ReLU

Parameters setting of critic network of GGIRL:

Critic network		
1	Full connection Layers	
	Number of inputs	56
	Number of outputs	256
	Activation function	ReLU
2	Full connection Layers	
	Number of inputs	256
	Number of outputs	256
	Activation function	ReLU
3	Full connection Layers	
	Number of inputs	256
	Number of outputs	1
	Activation function	ReLU

Parameters setting of discriminator (Reward function):

Discriminator (Reward function)		
1	Feature transformation	
	Number of inputs	7
	Number of outputs	16
	Activation function	ReLU
2	Feature transformation	
	Number of inputs	16
	Number of outputs	3
	Activation function	ReLU
3	GCN	
	Convolutional core	3*3
4	GCN	
	Convolutional core	3*3
5	Full connection Layers	
	Number of inputs	3*39
	Number of outputs	256
	Activation function	ReLU
6	Full connection Layers	
	Number of inputs	256
	Number of outputs	256
	Activation function	ReLU
7	Full connection Layers	
	Number of inputs	256
	Number of outputs	1
	Activation function	ReLU

***Parameters setting for IEEE118 case*:**

Parameters setting of actor network of GGIRL (Generator):

Actor network (Generator)		
1	Full connection Layers	
	Number of inputs	160
	Number of outputs	512
	Activation function	ReLU
2	Full connection Layers	
	Number of inputs	512
	Number of outputs	512
	Activation function	ReLU
3	Full connection Layers	
	Number of inputs	512
	Number of outputs	30
	Activation function	ReLU

Parameters setting of critic network of GGIRL:

Critic network		
1	Full connection Layers	
	Number of inputs	190
	Number of outputs	512
	Activation function	ReLU
2	Full connection Layers	
	Number of inputs	512
	Number of outputs	512
	Activation function	ReLU
3	Full connection Layers	
	Number of inputs	512
	Number of outputs	1
	Activation function	ReLU

Parameters setting of discriminator (Reward function):

Discriminator (Reward function)		
1	Feature transformation	
	Number of inputs	7
	Number of outputs	16
	Activation function	ReLU
2	Feature transformation	
	Number of inputs	16
	Number of outputs	3
	Activation function	ReLU
3	GCN	
	Convolutional core	3*3
4	GCN	
	Convolutional core	3*3
5	Full connection Layers	
	Number of inputs	3*118
	Number of outputs	512
	Activation function	ReLU
6	Full connection Layers	
	Number of inputs	512
	Number of outputs	512
	Activation function	ReLU
7	Full connection Layers	
	Number of inputs	512
	Number of outputs	1
	Activation function	ReLU

Appendix-B

This section presents a modeling approach for the DED problem and solves it based on the methodology described in [23]. Furthermore, it assumes that the data collected were obtained by human dispatchers who made decisions based on a predefined objective function, which serves as human knowledge guidance for training the GGIRL.

Expert demonstrations are generated according to the economic dispatch optimization programming with objective function shown in (B1).

$$\min \mathbf{E}(\sum_{t=1}^{T} F(t)) = \mathbf{E}(\sum_{t=1}^{T}(F_{\mathrm{MT}}(t) + F_{\mathrm{RES}}(t) + F_{\mathrm{ESS}}(t))) \tag{B1}$$

where $\mathbf{E}(\cdot)$ denotes the expectation operator; $F_{\mathrm{MT}}(t)$, $F_{\mathrm{RES}}(t)$ and $F_{\mathrm{ESS}}(t)$ present the operation cost function of MT, curtailment of RES, and ESS at stage t, respectively. And they are detailed formulated as

$$F_{\mathrm{MT}}(t) = \sum_{i=1}^{N^{\mathrm{MT}}} (a_i \Delta t + b_i P_i^{\mathrm{MT}}(t)\Delta t + c_i (P_i^{\mathrm{MT}}(t))^2 \Delta t) \tag{B2a}$$

$$F_{\mathrm{RES}}(t) = \sum_{i}^{N^{\mathrm{RES}}} (\beta_{\mathrm{RES}}(\overline{P}_i^{\mathrm{RES}}(t) - P_i^{\mathrm{RES}}(t))\Delta t) \tag{B2b}$$

$$F_{\mathrm{ESS}}(t) = \sum_{i=1}^{N^{\mathrm{ESS}}} \beta_{\mathrm{ESS}}(P_{\mathrm{c},i}^{\mathrm{ESS}}(t) + P_{\mathrm{d},i}^{\mathrm{ESS}}(t))\Delta t \tag{B2c}$$

here, $F_{\mathrm{MT}}(t)$ and $F_{\mathrm{ESS}}(t)$ tend to reduce the cost of MT and ESS as much as possible on the premise of maintaining the stable operation of the system. To encourage more RES absorption, $F_{\mathrm{RES}}(t)$ is the penalty term for abandoned energy of RES.

The operation of distribution network must satisfy the following operation constraints, including:

1) Power balance constraints:

$$\begin{aligned} P_i(t) = &\sum_{a \in N_i^{\mathrm{MT}}} P_a^{\mathrm{MT}}(t) + \sum_{a \in N_i^{\mathrm{RES}}} P_a^{\mathrm{RES}}(t) \\ &- \sum_{b \in N_i^{\mathrm{ESS}}} (P_{\mathrm{c},b}^{\mathrm{ESS}}(t) - P_{\mathrm{d},b}^{\mathrm{ESS}}(t)) - P_i^{\mathrm{D}}(t) \end{aligned} \tag{B3a}$$

$$Q_i(t) = \sum_{a \in N_i^{\mathrm{MT}}} Q_a^{\mathrm{MT}}(t) + \sum_{a \in N_i^{\mathrm{RES}}} Q_a^{\mathrm{RES}}(t) - Q_i^{\mathrm{D}}(t) \tag{B3b}$$

$$P_i(t) = u_i(t) \sum_{j=1}^{N^{\mathrm{BUS}}} \begin{aligned} &(u_j(t)(G_{ij}\cos(\theta_i(t) - \theta_j(t)) \\ &+ B_{ij}\sin(\theta_i(t) - \theta_j(t)))) \end{aligned} \tag{B3c}$$

$$Q_i(t) = u_i(t) \sum_{j=1}^{N^{\mathrm{BUS}}} \begin{aligned} &(u_j(t)(G_{ij}\sin(\theta_i(t) - \theta_j(t)) \\ &+ B_{ij}\cos(\theta_i(t) - \theta_j(t)))) \end{aligned} \tag{B3d}$$

Equations (3a) – (3d) ensure the power balance of the buses in the distribution network, where $P_i(t)$ represent the injected power of bus i.

2) Branch flow constraints:

$$\begin{aligned} P_{ij}(t) = &-u_i^2(t)G_{ij} + u_i(t)u_j(t)(G_{ij}\cos(\theta_i(t) - \theta_j(t)) \\ &+ B_{ij}\sin(\theta_i(t) - \theta_j(t)) \end{aligned} \tag{B4a}$$

$$\begin{aligned} Q_{ij}(t) = &-u_i^2(t)B_{ij} + u_i(t)u_j(t)(B_{ij}\cos(\theta_i(t) - \theta_j(t)) \\ &- G_{ij}\sin(\theta_i(t) - \theta_j(t)) \end{aligned} \tag{B4b}$$

$$P_{ij}^2(t) + Q_{ij}^2(t) \le \overline{S}_{ij}^2 \tag{B4c}$$

Equations (15a) – (15b) represent the power balance of the branches in the distribution

network, where (15c) limits the maximum power transmission of branches.
3) Voltage constraints:

$$\underline{u}_i \le u_i(t) \le \overline{u}_i \tag{B5}$$

4) MT constraints include the output and ramping limitations:

$$\underline{P}_i^{\mathrm{MT}} \le P_i^{\mathrm{MT}}(t) \le \overline{P}_i^{\mathrm{MT}} \tag{B6a}$$

$$-\underline{\eta}_i^{\mathrm{MT}} \Delta t \le P_i^{\mathrm{MT}}(t) - P_i^{\mathrm{MT}}(t-1) \le \overline{\eta}_i^{\mathrm{MT}} \Delta t \tag{B6b}$$

5) ESS constraints:

$$0 \le P_{\mathrm{d},i}^{\mathrm{ESS}}(t) \le \overline{P}_{\mathrm{d},i}^{\mathrm{ESS}} \tag{B6a}$$

$$0 \le P_{\mathrm{c},i}^{\mathrm{ESS}}(t) \le \overline{P}_{\mathrm{c},i}^{\mathrm{ESS}} \tag{B6b}$$

$$\underline{E}_i^{\mathrm{ESS}} \le E_i^{\mathrm{ESS}}(t) \le \overline{E}_i^{\mathrm{ESS}} \tag{B6c}$$

$$E_i^{\mathrm{ESS}}(t) = E_i^{\mathrm{ESS}}(t-1) + (\eta_{\mathrm{c}}^{\mathrm{ESS}} P_{\mathrm{c},i}^{\mathrm{ESS}}(t) \text{-} P_{\mathrm{d},i}^{\mathrm{ESS}}(t) / \eta_{\mathrm{d}}^{\mathrm{ESS}}) \Delta t \tag{B6d}$$

$$P_{\mathrm{c},i}^{\mathrm{ESS}}(t) P_{\mathrm{d},i}^{\mathrm{ESS}}(t) = 0 \tag{B6e}$$

Equations (B6a) - (B6c) define the upper and lower charging, discharging, and state of capacity limits of ESS. Equation (B6d) formulates the transition of energy stored in ESS at each stage regarding to charging and discharging power. Equation (B6e) ensures charging and discharging cannot be taken place simultaneously.
6) RES power output constraint:

The generation output of RES is assumed controllable and should be within its maximum available output.

$$0 \le P_i^{\mathrm{RES}}(t) \le \overline{P}_i^{\mathrm{RES}}(t) \tag{B7}$$

Appendix-C

Small size ADN:

Expectation of load profile at each time is listed in Table C1. Expectation of RES is listed in Table C2. The forecasting errors of demand load, the error between actual RES output and its expectation value is assumed to follow the normal distribution N(0,0.03^2) and N(0,0.1^2), respectively.

Table C1 Expectation of demand load

Time-slot	1	2	3	4	5	6
$P_i^{\mathrm{D}}(t)$ (kW)	720.29	780.31	840.34	870.35	876.35	840.34
$Q_i^{\mathrm{D}}(t)$ (kVAR)	360.14	390.16	420.17	435.18	438.18	420.17
Time-slot	7	8	9	10	11	12

$P_i^{\mathrm{D}}(t)$ (kW)	780.31	757.50	753.90	744.30	739.50	737.10
$Q_i^{\mathrm{D}}(t)$ (kVAR)	390.16	378.75	376.95	372.15	369.75	368.55
Time-slot	13	14	15	16	17	18
$P_i^{\mathrm{D}}(t)$ (kW)	732.30	720.29	660.26	540.22	480.19	420.17
$Q_i^{\mathrm{D}}(t)$ (kVAR)	366.15	360.14	330.13	270.11	240.10	210.08
Time-slot	19	20	21	22	23	24
$P_i^{\mathrm{D}}(t)$ (kW)	450.18	510.21	570.23	600.24	660.26	690.28
$Q_i^{\mathrm{D}}(t)$ (kVAR)	225.09	255.10	285.12	300.12	330.13	345.14

Table C2 Expectation of maximum output of RES

Time-slot	1	2	3	4	5	6
$P_i^{\mathrm{RES}}(t)$ (kW)	100	150	250	300	320	350
Time-slot	7	8	9	10	11	12
$P_i^{\mathrm{RES}}(t)$ (kW)	320	300	250	140	100	150
Time-slot	13	14	15	16	17	18
$P_i^{\mathrm{RES}}(t)$ (kW)	150	170	150	200	220	260
Time-slot	19	20	21	22	23	24
$P_i^{\mathrm{RES}}(t)$ (kW)	300	320	330	220	200	100

Medium size ADN:

Expectation of load profile at each time is listed in Table C3. Expectation of RES is listed in Table C4. The forecasting errors of demand load, the error between actual RES output and its expectation value is assumed to follow the normal distribution $N(0,0.03^2)$ and $N(0,0.1^2)$, respectively.

Table C3 Expectation of demand load

Time-slot	1	2	3	4	5	6
$P_i^{\mathrm{D}}(t)$ (kW)	1350.54	1463.09	1575.63	1631.91	1643.16	1575.63
$Q_i^{\mathrm{D}}(t)$ (kVAR)	675.27	731.54	787.82	815.96	821.58	787.82
Time-slot	7	8	9	10	11	12
$P_i^{\mathrm{D}}(t)$ (kW)	1463.09	1420.32	1413.57	1395.56	1386.56	1382.06
$Q_i^{\mathrm{D}}(t)$ (kVAR)	731.54	710.16	706.79	697.78	693.28	691.03
Time-slot	13	14	15	16	17	18
$P_i^{\mathrm{D}}(t)$ (kW)	1373.06	1350.54	1238.00	1012.91	900.36	787.82
$Q_i^{\mathrm{D}}(t)$ (kVAR)	686.53	675.27	619.00	506.45	450.18	393.91
Time-slot	19	20	21	22	23	24
$P_i^{\mathrm{D}}(t)$ (kW)	844.10	956.64	1069.19	1125.45	1238.00	1294.28
$Q_i^{\mathrm{D}}(t)$ (kVAR)	422.05	478.32	534.59	562.73	619.00	647.14

Table C4 Expectation of maximum output of RES

Time-slot	1	2	3	4	5	6
$P_i^{\mathrm{RES}}(t)$ (kW)	40	60	100	120	128	140
Time-slot	7	8	9	10	11	12
$P_i^{\mathrm{RES}}(t)$ (kW)	128	120	100	56	40	60
Time-slot	13	14	15	16	17	18

$P_i^{\mathrm{RES}}(t)$ (kW)	60	68	60	80	88	104
Time-slot	19	20	21	22	23	24
$P_i^{\mathrm{RES}}(t)$ (kW)	120	128	132	88	80	40