No.229 * Collaborative operation strategy of integrated energy service providers considering carbon emission reduction

Kailang Wu, Jie Gu
School of Electronic Information and Electrical Engineering, Shanghai Jiao Tong University, China

1 Introduction

Through **electricity and heat trading**, some **IESPs** avoid high carbon fees, and some obtain higher income.

1) A cooperative operation model based on **Nash bargaining model** for IESPs **energy trading** is proposed.

2) Carbon allowances based on **Shapley are** introduced into the cooperative model .

2 Methods

1) Carbon fees:

$$C_{i,t}^{CO_2}=\begin{cases}\lambda^{CO_2}(E_{CO_2,i,t}-\sigma\phi_t(i)) & E_{CO_2,i}\geq\phi_t(i)\\ 0 & E_{CO_2,i}<\phi_t(i)\end{cases}$$

$\phi_t(i)$ → based Shapley

2) IESP costs before energy trading:

$$\min C_i^N=\sum_{t=1}^{24}\left(\lambda_t^E P_{i,t}^E+\lambda_t^H H_{i,t}^H+C_{i,t}^{CHP}+C_{i,t}^{CO_2}\right)$$

3) After trading: $C_i^C=C_i^N+C_{S,i}$ → Trading costs

$$\max\prod_{i=1}^{N}\left[C_i^{N0}-C_i^C\right]$$

$$s.t.\,C_i^{N0}-C_i^C\geq 0$$

Nash bargaining problem

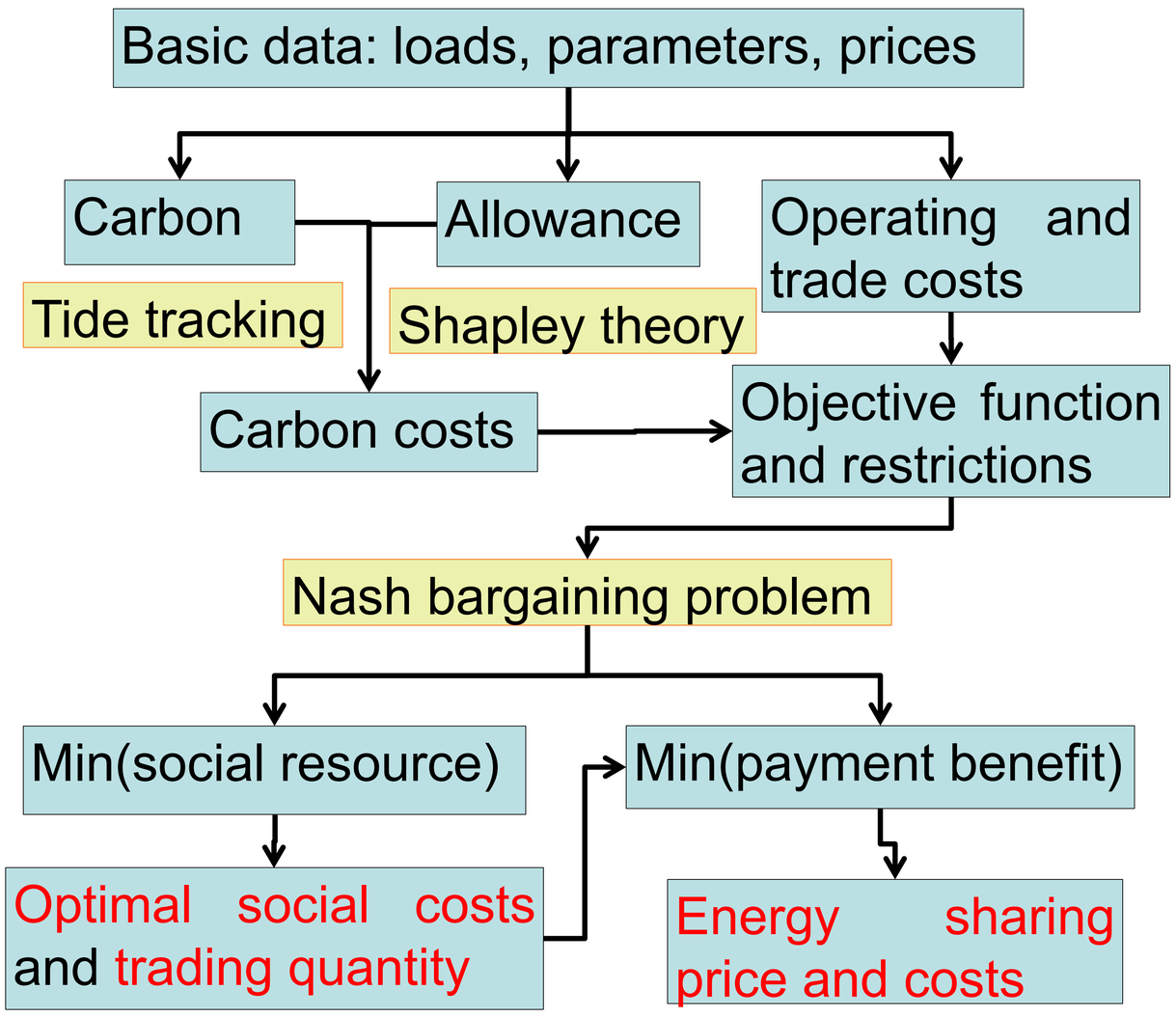
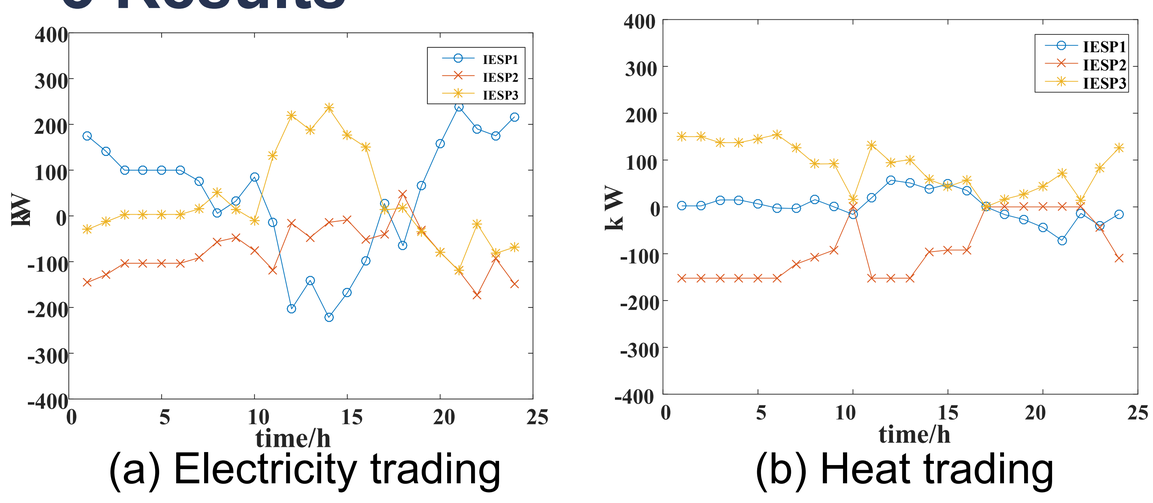


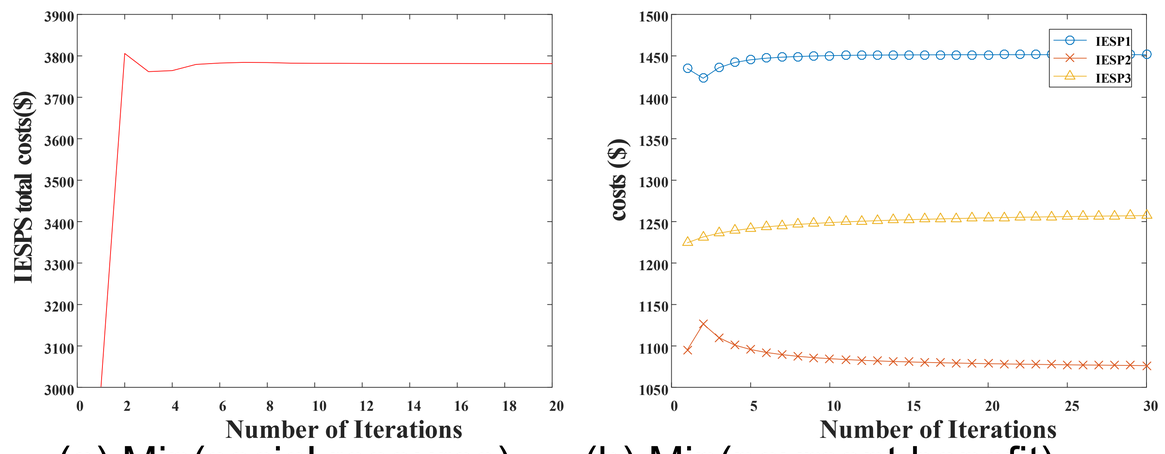
Fig. 2 Flow diagram of solving the model

3 Results



(a) Electricity trading (b) Heat trading

Fig. 3 Energy trading results



(a) Min(social resource) (b) Min(payment benefit)

Fig. 4 Convergence results

Tab.1 Gains from IESPs participation

	Before	After	**Gains**
IESP1 costs($)	1596	1453	**143**
IESP2 costs($)	1332	1077	**255**
IESP3 costs($)	1370	1256	**114**
Total costs($)	4298	3786	**512**

Tab.2 Emission and costs in different cases

	Case0	Case1	Case2	Case3	**Case4**
Emission(t)	18.26	18.20	18.04	16.52	**16.53**
C costs($)	0	372.65	29.91	333.90	**2.71**
T costs($)	3.92	4.30	3.96	4.12	**3.78**

4 Conclusions

- The Shapley-based carbon allowance method can effectively **reduce the carbon costs than fixed carbon allowance.**
- The cooperative strategy with Shapley theory can effectively **reduce the carbon emission and system operation costs.**