Case settings

According to the data from a container terminal of real world, there are available 5 berths and 8 QCs in the case study with 5 ships to be berthed, occupying about 1.5 km of the shoreline. The scheduling horizon is 8:00-16:00 of one day and 15 minutes is a time interval (i.e. 32 time units).

The information on berths and ships to arrive in the cases is shown in Table 1-3. As the stochastic parameter in the model, ships' arrival times are randomly generated following the Gaussian distribution. Based on the historical data, the average values of the 5 ships' estimated arrival time as listed in Table 2 and the variance is taken as 2.

Two types of ships are considered in the cases, which are container ships and reefer ships. Both of them need to handle the cargo and consume the shore power. However, there is an additional cooling load for reefer ships to insulate the containers as listed in Table 1. The operation efficiency and power consumption of QCs in the port are fixed at 20TEU per unit time and 2 MWh per move, respectively.

Parameters of the energy supply cost are shown in Table 4. The equipment parameters in the energy system are listed in Table 5. The natural gas price, carbon emission coefficients and available output datas of renewable energy are referred from [1]. The unit carbon cost is the opening price of carbon quotas in the China Carbon Emission Trading Market in 2021.

Table 1 - Consumption of ships

Ship	Type	Power load for cold-ironing per unit time (MWh)	Cooling load per unit time (MWh)	Containers to be handled (TEU)
1	Reefer	7.5	3.5	360
2	Reefer	10	4	480
3	Reefer	5	2.5	200
4	Container	10	0	560
5	Container	5	0	240

Table 2 - Estimated arrive, departure time and draft depth of ships

Ship	Estimated arrival time	Estimated departure time	delay penalty unit cost ($)	Draft depth (m)	Limits on numbers of QCs assigned
1	1	10	22.4	10	4/1
2	15	21	28	16	5/1
3	20	30	16.8	8	3/1
4	7	19	28	16	5/1
5	5	22	16.8	8	3/1

Table 3 - Depth of berths

Berth	Draft depth (m)
1	14
2	10
3	16
4	16
5	16

Table 4 - Parameters for the cost of energy supply

Parameter	Value
ρ_{gas}	0.32$/m^3
c_{carbon}	6.7$/t
α	0.581tCO_2/MW per unit time
β	0.002165tCO_2/m^3
$c_{loss}^{PV/WT}$	13.86$/MW per unit time

Table 5 - Parameters for the energy supply system

Unit	Parameter	Value
Internal Power Generation Units	Output Limits	30/0MW per unit time
	Ramping up/down rate	5/5MW per unit time
	η_e	0.3
	H_g	0.0108MWh/m^3
Grid	Output Limits	30/0MW
ESS	$P^{max}_{ESS,dch/ch}$	8/8MW per unit time
	CAP	40MWh
	η_{dch}/η_{ch}	0.85/0.98
	SOC_0	0.2
EC	COP_{EC}	2

[1] Y. Huang, W. He, W. Wei, N.Tao, R. Li, " Logistics-energy Collaborative Optimization Scheduling Method for Large Seaport Integrated Energy System", *Proc. Chinese Soc. Electr. Eng.* 2022:42. https://doi.org/10.13334/j.0258-8013.pcsee.211093.