Paper 61 - Discussion about the low-carbon conservation mode of inland waterways in Jiangsu Province

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ABSTRACT: Conservation is an important part of protecting waterway resources, continuing waterway's life, and achieving waterway's sustainable development. According to the definition of international standard for low carbon concept, this paper researched the concept of low-carbon mode in waterway conservation, and analyzed the connotation of low-carbon waterway conservation mode. From technical and management levels, this paper put forward low-carbon maintenance modes of routine maintenance observation, navigation mark and signage maintenance. Low-carbon mode of routine maintenance observation includes low-carbon mode based on field observation and low-carbon mode based on informationized observation. Low-carbon mode of navigation mark and signage maintenance includes low-carbon mode of informationized navigation mark observation and low-carbon mode of navigation mark repair. Based on carbon emission model, this paper calculated carbon emissions of various modes of routine maintenance observation, navigation mark and signage maintenance in waterway conservation. As the results shown, after introducing the low-carbon modes, carbon emissions of routine maintenance observation, navigation mark and signage maintenance will reduce obviously. Regarding the routine maintenance observation, low-carbon mode based on field observation can reduce carbon emissions by 44.1% at most, and low-carbon mode based on informationized observation can reduce carbon emissions by 72.1% at most. Regarding the navigation mark maintenance, carbon emissions can reduce 50% at least. Through concept innovation, technological improvement and so on, the traditional waterway conservation way is changed to low-carbon way, helping to reduce carbon emissions of waterway conservation and to build ecological low-carbon waterway.

1 INTRODUCTION

Jiangsu is a large water transportation province. Since the "twelfth five-year", inland waterway construction has been accelerated; high-grade waterway mileage has been increasing year by year, and the demand and quantity of waterway conservation have been increasing too. From the point of comprehensive utilization of water transportation resources, waterway construction is not a substitute for conservation. We must adhere to the principle of paying equal attention to construction and conservation. Basically, the waterway conservation mode and related technology used by Jiangsu Province so far are still extensive and traditional mode . But looking at the industry development trend, the low-carbon conservation mode will be adopted in the future, helping to reduce carbon emissions of waterway conservation and to build ecological low-carbon waterways.

2 CONCEPT AND CONNOTATION OF THE LOW-CARBON WATERWAY CONSERVATION MODE

The low-carbon mode of waterway conservation refers to a new conservation mode that achieve reductions of energy consumptions and carbon emissions through improving, optimizing, or innovating the concepts and activities of the waterway conservation based on the existing conservation mode, applied new technologies, new materials, and new ways of operations etc. The low-carbon conservation mode mentioned here does not mean to create an entirely new mode, but to derive a low-carbon way to reduce carbon emissions of waterway conservation. To achieve this goal, we need to investigate the lacks and problems of the existing mode, and then improve technologies, innovate concepts or take other steps on the basis of the existing mode.

Specifically, the connotation of low-carbon waterway conservation mode mainly includes the following aspects:①reducing carbon emissions of used raw materials, mechanical equipment and all kinds of structure construction processes in waterway conservation engineering; ② paying attention to energy and material saving, using environmental energy-saving new materials, structures, technologies and so on, and reducing carbon emissions through technical means; ③ helping to reduce carbon emissions by improving management means in the aspect of management; ④ introducing information technology to conservation management work, in order to reduce the investment of manpower and material resources, and to implement low carbon emissions.

3 LOW-CARBON MODE OF ROUTINE MAINTENANCE OBSERVATION

3.1 *Existing mode of routine maintenance observation*

Routine maintenance observation of waterway refers to that waterway maintenance management personnel drive a patrol ship or patrol vehicle to make an on-site investigation, and use observation equipment to measure the waterway itself, waterway facilities, waterway constructions, etc.

So far the work mode of routine maintenance observation used by inland waterway management institutions in Jiangsu Province is called artificial traditional model, which archive and report the observation results by an on-site inspection, measurement, and recording. This work is done by using observation instruments or equipment, through patrol ships, patrol vehicles, surveillance ships or other ways according to the observation plans made by the relevant departments. The carbon emissions of this mode mainly come from the consumption of fuel oil used by observation ships and vehicles.

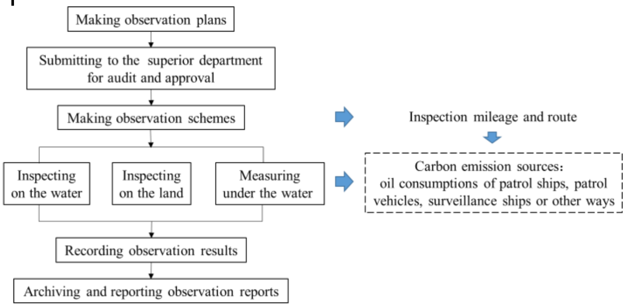

Figure 1: Workflow and carbon emission sources of the existing mode of routine maintenance observation

There are also non-artificial ways. For example, by installing surveillance cameras in the waterway site, administrative staff can timely and accurately grasp the waterway and coastal conditions through the monitor screen in the room; and that through intelligent water level measuring instruments, the water level measurement results can be directly fed back to the indoor control center. This way can greatly reduce the use of ships and vehicles in routine maintenance observation, and effectually reduce carbon emissions. But it is not widely used and still in the pilot phase.

3.2 *Low-carbon mode building of routine maintenance observation*

3.2.1 Low-carbon mode based on field observation

In the near future, the existing artificial traditional model will continue to exist and dominate. So we proposed carbon emission reduction measures against the main carbon emission points in the existing mode, to constraint and reduce carbon emissions, and further to make the low-carbon mode based on field observation. We can build the low-carbon mode based on field observation from the following three aspects.

(1)Integration of observation equipment

The carbon emissions of the existing mode mainly come from the consumption of fuel oil used by observation ships and vehicles. So reducing the use of observation ships and vehicles will help to reduce carbon emissions. Integration of observation equipment refers to that through technological improvement, a number of observation equipment with different purposes are installed in the same observation ship or vehicle, building multifunctional observation ships and vehicles, in order to implement maximum observation tasks and achieve maximum observation goals with minimal investment of ships and vehicles. The observation contents include panoramic waterway, sounding, ranging, facility location, bed sweeping, etc.

(2)Employing social ships for routine inspection

There is another way of reducing the use of observation ships and vehicles to reduce carbon emissions. That is, social ships are employed instead of part observation ships to implement routine inspection tasks. Social ships can achieve to inspect waterways and carry out other tasks through installed observation equipment at the same time of transporting goods. Employed ships must have some specific conditions as follows:①having long-term fixed lanes to provide stable inspection services for a certain reach of the waterway;② having long-term fixed sailing time to feed back inspection information periodically to waterway management departments;③having better hardware and software equipment to easily install observation equipment and make them operate normally.

(3)Application of energy-saving and emission-reducing ships and vehicles

Carbon emissions in the process of routine maintenance observation ultimately come from the combustion of oil fuel providing driving force for ships and vehicles. If the consumptions of oil fuel can be reduced, or clean energy replaces oil fuel directly to provide driving force for observation ships and vehicles, it will be very beneficial to reduce carbon emissions. Compared to combust gasoline and diesel oil, observation vehicles driven by natural gas can reduce carbon emissions by 19%~25%[1], and small vehicles driven by electric power can almost realize zero emissions. Compared to use diesel oil, ships whose driving force is transformed from oil to gas, forming a diesel-LNG mixed combustion mode, can reduce carbon emissions by 20%~25%. At the same time, this mode also has an obvious cost advantage, lowering fuel cost by more than 20% compared with the diesel mode.

3.2.2Low-carbon mode based on informationized observation

With the development of modern science and technology, the future of waterway conservation will gradually tend to be informationized and intellectualized. The artificial traditional model of routine waterway maintenance observation will also gradually lose its dominant position, and be replaced by the informationized mode. The low-carbon mode based on informationized observation refers to that in routine waterway maintenance observation, electronics, communication, computer, Internet of Things, satellite positioning and other modern information technologies are used to integrate various kinds of waterway resources, achieve informationized and intellectualized waterway observation, reduce the workload of artificial observation, and improve the efficiency of observation.

According to the work contents of routine maintenance observation, informationized waterway observation can be divided into four modules as follows:①video monitoring of navigation conditions; ②video monitoring of physical waterway facilities;③ data information collection of waterway dimensions, bed topography, etc;④informationized observation of other aspects, such as electronic cruise, vessel traffic flow monitoring, freight volume monitoring, etc. Informationized waterway observation is quite a popular technical trend in the current field of waterway management. It can not only overcome all kinds of flaws of the traditional methods, improve the measurement precision, realize the dynamic monitoring of 24 hours, but also can significantly reduce carbon emissions in the process of observation. In the process of waterway observation, with modern information technologies to replace traditional ships and vehicles to accomplish observation tasks, with electricity consumption to replace oil fuel consumption, it can radically reduce carbon emissions produced by waterway observation.

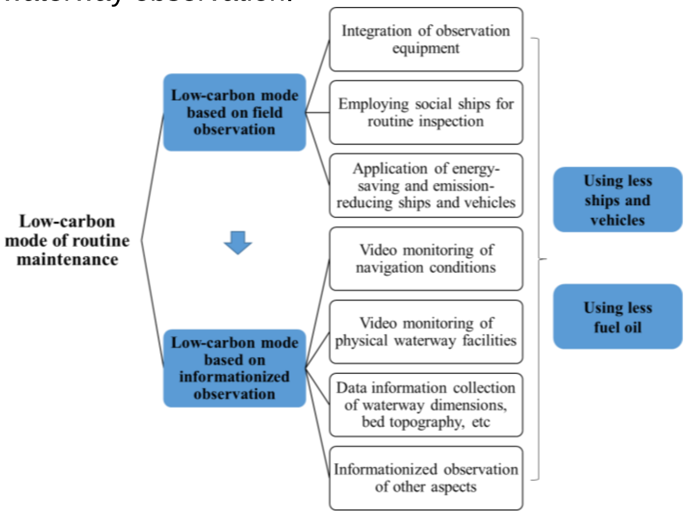

Figure 2: Low-carbon mode of routine maintenance observation

3.3 *Carbon emission calculation and comparison of different modes*

Waterway conservation technologies, equipment, and other situations are diverse in each waterway management department of Jiangsu Province, and it is not easy to collect data and calculate, so we took Nanjing waterway management department for example to calculate carbon emissions.

According to waterway conservation ship parameters collected from Nanjing waterway management department, we chose the 17-meter navigation administration ship as representative to roughly estimate carbon emissions of routine maintenance observation. The fuel tank capacity of 17-meter navigation administration ship is 3000 kg, and the navigation radius is 970 km. Then we calculated that the average diesel consumptions per kilometer are 3.1 kg. Reference to the calculating formula about carbon emissions from a certain related literature[2], that is, "carbon emissions=Σ(fuel consumptions × carbon emission factor)", with 19.8 as the usual value of carbon emission factor, we calculated that the average carbon emissions per kilometer of 17-meter navigation administration ship are 61.38 kg.

Inland navigable mileage of Nanjing in 2013 was totally 630.06 km, including 17.17 km of the 4th level waterway, 156.11 km of the 6th level, 75.68 km of the 7th level, and 381.1 km of the substandard level. Through the investigation results of Nanjing waterway management department, inland waterway depths in its jurisdiction are measured 1 time every year, waterway beds above level 6 are swept 2 times a year, and there are no bank revetments which the waterway departments responsibly maintain. Annual waterway inspection times are 4. Calculating formulas are as follows.

total carbon emissions = $\sum$ partial carbon emissions

= $\sum$ (carbon emissions of a unit mileage $\times$ mileage of one time $\times$ annual times)

Carbon emission calculation results of the existing mode of routine maintenance observation of Nanjing waterway management department are shown in the following table.

Table1: Carbon emissions of the existing mode of routine maintenance observation of Nanjing waterway management department

observation items	mileage of one time(km)	annual times(time)	carbon emissions of a unit mileage of a ship(kg/km)	partial carbon emissions(kg)
waterway inspection	630.06	4	61.38	154692.33
sounding(typical sections)	630.06	1	61.38	38673.08
bed sweeping	173.28	2	61.38	21271.85
total carbon emissions				214637.26

The annual total carbon emissions of the existing mode of routine maintenance observation of Nanjing waterway management department are 214637.26 kg, that is, about 214.64 t. Carbon emissions per kilometer are 340.66 kg. Inland navigable mileage of Jiangsu Province in 2013 was totally 23945.4 km. Then we estimated that the annual total carbon emissions of the existing mode of routine maintenance observation of Jiangsu Province are 8157239.96 kg, that is, about 8157.24 t.

Introducing the low-carbon modes built above, we estimated carbon emissions of various kinds of low-carbon modes. The results are shown in the following table. Low-carbon mode based on field observation includes four parts as follows: ① integration of observation equipment, in this part we incorporated sounding and bed sweeping into waterway inspection for carbon emission calculation; ② employing social ships for routine inspection, carbon emissions of this part are impossible to calculate and therefore temporarily ignored; ③ application of energy-saving and emission-reducing ships, carbon emissions of transformed ships can reduce by 20%~25%, and here we used the value of averaged 22.5%; ④ integration of observation equipment and application of energy-saving and emission-reducing ships, on the basis of equipment integration, driving force of ships is transformed from oil to gas further. Low-carbon mode based on informationized observation is that waterway inspection, sounding and bed sweeping can be completed by video monitoring, underwater sensors and other intellectualized ways, but it is still stipulated to inspect waterways on site in the flood and dry seasons every year, and energy-saving and emission-reducing measures can be jointly used for transforming ships.

Table2: Carbon emissions of the low-carbon mode of routine maintenance observation of Nanjing waterway management department

kind of low-carbon modes		carbon emissions(kg)	carbon emission reduction quantity(kg)	carbon emission reduction rate
low-carbon mode based on field observation	integration of observation equipment	154692.33	59944.93	28%
	employing social ships for routine inspection	—	—	—
	application of energy-saving and emission-reducing ships	166343.88	48293.38	22.5%
	integration of observation equipment and application of energy-saving and emission-reducing ships	119886.56	94750.7	44.1%
low-carbon mode based on informationized observation	not using energy-saving and emission-reducing measures for ships	77346.16	137291.1	64%
	using energy-saving and emission-reducing measures for ships	59943.27	154693.99	72.1%

According to the data in the table above, carbon emissions of routine maintenance observation of Nanjing waterway management department will reduce obviously after adopting the low-carbon mode. Low-carbon mode based on field observation can reduce carbon emissions by 44.1% at most, and low-carbon mode based on informationized observation can reduce carbon emissions by 72.1% t. According to these two ratios, we further estimated the carbon emission reduction quantity of Jiangsu Province. Low-carbon mode based on field observation can reduce carbon emissions of 3597.34 t t, and low-carbon mode based on informationized observation can reduce carbon emissions of 5881.37 t.

4 LOW-CARBON MODE OF NAVIGATION MARK AND SIGNAGE MAINTENANCE

4.1 Existing mode of navigation mark maintenance

Navigation mark maintenance refers to that full-time navigation mark management personnel routinely inspect, maintain and repair navigation marks. The specific work contents include the following aspects: ① examining whether the mark body part is defiled and destroyed; ② examining whether the electrical part work normally; ③ examining water depth, position and other indexes of navigation marks; ④ telemetering periodically navigation marks with telemetry and telecontrol systems.

According to the survey, the existing mode of navigation mark maintenance in inland waterways of Jiangsu Province is mainly as follows: the primary means of routine observation is the telemetry and telecontrol system, and the complementary means is on-site inspection including using ships on the water and using vehicles on the land; regarding ways of repairing navigation marks, the mark body material is mainly steel galvanizing reflective film, the energy is mainly solar combined with lithium battery, and the light source is mainly LED. A figure is shown below.

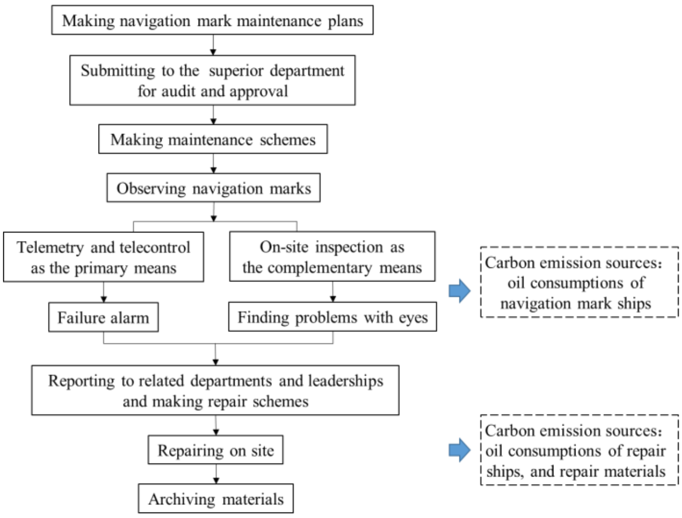

Figure 3: Workflow and carbon emission sources of the existing mode of navigation mark maintenance

4.2 Low-carbon mode building of navigation mark maintenance

4.2.1 Low-carbon mode of informationized navigation mark observation

Regarding the navigation mark observation, so far Jiangsu Province has basically popularized the telemetry and telecontrol technology, which conforms to the low carbon concept very much. To further entirely promote informationized navigation mark observation technologies including the telemetry and telecontrol system, and to build the low-carbon mode of informationized navigation mark observation, there are several things needed to be done. Firstly, inland navigation marks in the entire province should be equipped with telemetry and telecontrol systems. Secondly, auxiliary observation technologies of the telemetry and telecontrol system should be researched and developed, such as on-site video monitoring, in order to reduce the on-site navigation mark inspections. Lastly, other informationized navigation mark observation technologies should be researched, such as collision and theft prevention technologies, virtual navigation mark technology, etc.

(1) Telemetry and telecontrol technology of the navigation mark

Telemetry and telecontrol technology of the navigation mark is a new navigation mark maintenance technology, which refers to that mobile phones, local calls, microcomputers and other ways are used to remotely telemeter and monitor navigation marks far away from waterway management departments, in order to relieve the labor intensity of navigation mark maintenance personnel, to reduce the fuel consumptions and equipment wastages of navigation mark ships, and to ensure the light emitting rate of navigation marks. The use of telemetry and telecontrol technology of the navigation mark reduces the patrol cycle of navigation mark inspection, relieves the work intensity of navigation mark management personnel, improves the quality and efficiency of navigation mark maintenance, and effectively ensures the navigation safety. At the same time, it also reduces the use of navigation mark ships and their fuel consumptions, and therefore reduces the carbon emissions of navigation mark maintenance.

(2)On-site video monitoring technology

In the existing telemetry and telecontrol mode of navigation mark observation, it is still unavoidable to drive patrol ships (vehicles) or navigation mark ships to inspect on-site, and to produce carbon emissions from oil fuel consumptions of ships (vehicles). So we need to use on-site video monitoring as the auxiliary observation method of navigation mark telemetry and telecontrol. If video monitoring equipment can be installed on the navigation mark or its nearby facility, navigation mark maintenance personnel will be able to observe the operating conditions of electrical and mark body parts through only the indoor display screen, greatly reducing the workload of navigation mark inspection and the carbon emissions produced by ships and vehicles using.

(3)Other informationized technologies

Once navigation marks are damaged or stolen, ships and vehicles must be used to go on site to investigate, obtain evidence, repair or set new marks, inevitably producing new carbon emissions. So it's necessary to research navigation mark collision and theft prevention technologies, and to apply navigation marks with collision and theft prevention functions on the inland waterways in Jiangsu Province, helping to reduce navigation mark collision and theft accidents and carbon emissions from this part.

Virtual navigation mark technology. Virtual navigation mark technology is an emerging navigation mark application technology which comprehensively applies computer, satellite navigation and positioning, electronic sea chart, AIS and other modern high technologies [3]. Different from the physical navigation mark, the virtual navigation mark doesn't have an actual body, but shows a navigation mark symbol on the specific position of AIS information display screen. As the navigation aid mark of ship navigating, the maintenance, setting and modification of the virtual navigation mark are all completed on the AIS equipment of the base station [3]. At the same time of providing safe navigation aids, the virtual navigation mark avoids using batteries and ships like the physical navigation mark, not only saving a large number of manpowers, material resources and energies, but also reducing carbon emissions of navigation mark maintenance.

4.2.2Low-carbon mode of navigation mark repair

The low-carbon mode of navigation mark repair refers to that in the process of navigation mark repair, new technologies, new materials, new crafts and other ways are used to reduce carbon emissions of navigation mark repair. To achieve this goal, we can begin from the following points.

(1)Solar energy integration navigation mark light technology

Solar energy integration navigation mark light integrates the light seat, lens, flasher, charge and discharge protector, LED light source, inside and outside telemetry system device in one, and combines the advanced solar photovoltaic technology, lighting technology, high-energy lithium battery combination technology, and microcomputer flasher control technology. After connecting the navigation mark management system, it provides three data models of instant failure alarm, timing data report and real-time data query, realizing intellectualized navigation mark management. The low-carbon nature of this technology is that besides navigation mark telemetry and telecontrol system can be installed, energy and light source used also have the effect of energy conservation and emission reduction.

Solar energy integration navigation mark light, whose energy is non-polluting and clean, uses solar energy for charging, and lithium battery for powering. It reduces the charging link of using electricity, the fuel and material consumption links of replacing batteries, and has very good effect of energy saving and emission reduction. The LED light source used by solar energy integration navigation mark light has stable lighting, bright lamplight and color quality, low light appliance breakdown and repair rate, less power consumption, and long service life. It not only has the good effect of energy saving and emission reduction, but also can produce very great economic and social benefits.

(2)Mark body repair technology

In navigation mark maintenance, the mark body structure and material used should be durable, and have long service life and fewer subsequent repeat repair times, helping to reduce carbon emissions. So far the material of inland navigation mark body in Jiangsu Province is mostly steel, with galvanizing technology to make antiseptic treatments and reflective film to mark colors. This way is also usually used to repair the damaged mark bodies. Relative to the way of painting steel mark body before, the existing way not only prolongs the service life of the mark body, but also reduces the on-site maintenance from paint detachment by replacing painting with sticking reflective film to mark colors, and reduces the fuel consumptions and carbon emissions from using ships.

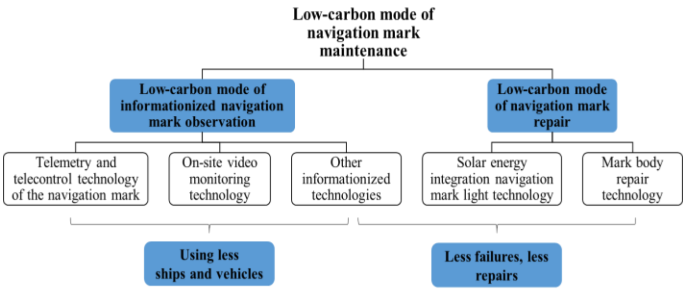

Figure 4: Low-carbon mode of navigation mark maintenance

4.3 Carbon emission calculation and comparison of different modes

When calculating the carbon emissions of navigation mark maintenance, we didn't consider the repair part temporarily, but only calculated the carbon emissions produced by oil fuel consumption of navigation mark observation ships. Because the carbon emission reductions from navigation mark collision and theft prevention technologies and virtual navigation mark technology are difficult to calculate, we didn't consider these too. The existing mode refers to that navigation mark telemetry and telecontrol is regarded as the main way with 4 times of on-site inspection every year. The low-carbon mode refers to combine navigation mark telemetry and telecontrol with on-site video monitoring, and to inspect navigation marks 2 times in the flood and dry seasons every year because of using on-site video monitoring technology.

Table3: Carbon emissions of navigation mark observation modes of Nanjing waterway management department

kind of observation modes	mileage of one time(km)	annual times(time)	carbon emissions of a unit mileage of a ship(kg/km)	partial carbon emissions(kg)
existing mode	630.06	4	61.38	154692.33
low-carbon mode	630.06	2	61.38	77346.17

According to the data in the table above, carbon emissions of navigation mark observation of Nanjing waterway management department will reduce by 50%. Through further calculation, carbon emissions of the total Jiangsu Province can reduce about 2939.54 t. If energy-saving and emission-reducing measures are used to transform ships, the carbon emissions will reduce more.

5 CONCLUSION

This paper researched and put forward the concept and connotation of low-carbon waterway conservation mode, respectively built the low-carbon modes of routine maintenance observation, navigation mark and signage maintenance on the basis of analyzing the existing mode, and estimated the carbon emissions of various modes. As the results shown, after introducing the low-carbon modes, the carbon emissions of routine maintenance observation, navigation mark and signage maintenance will reduce obviously. Regarding the routine maintenance observation, low-carbon mode based on field observation can reduce carbon emissions by 44.1% and low-carbon mode based on informationized observation can reduce carbon emissions by 72.1% . Regarding the navigation mark maintenance, carbon emissions can reduce 50% at least.

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