澳門電力系統低碳發展探討

Discussion on Low Carbon Development of Macau Power System

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大綱 (Outline)

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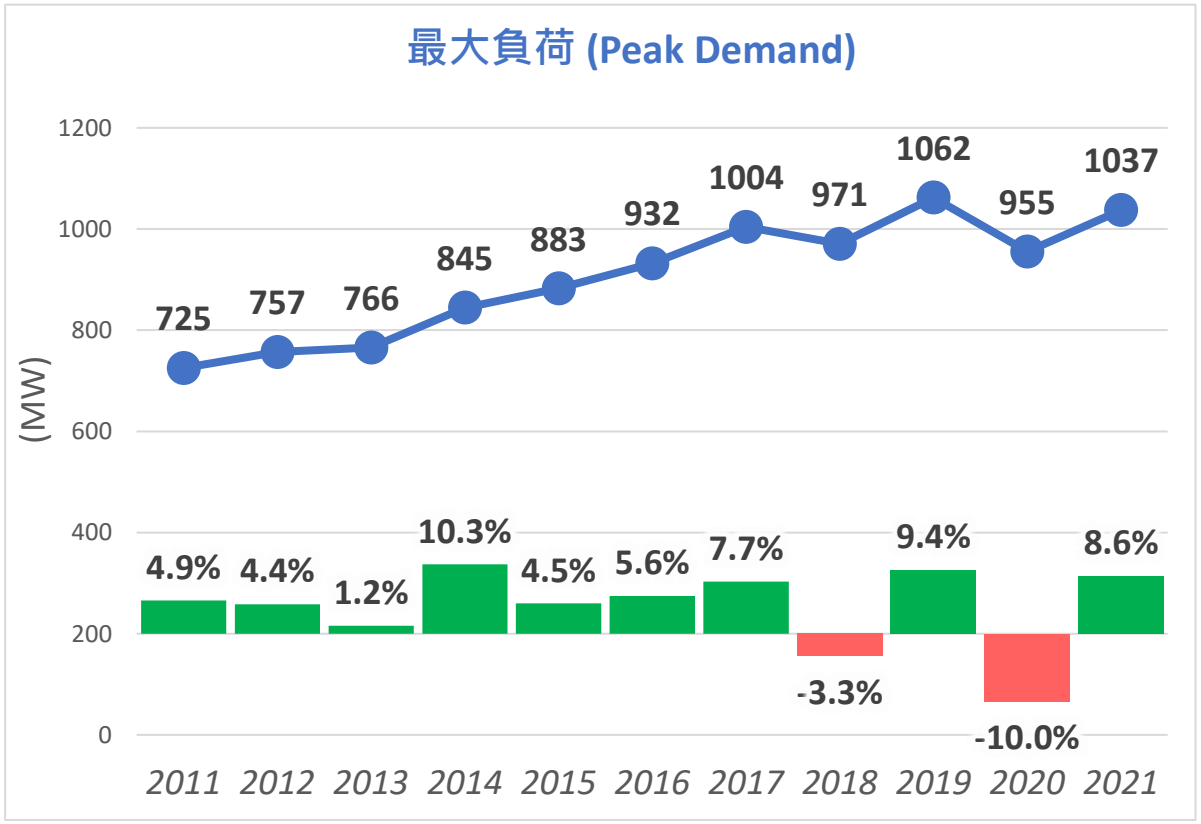
1 關於澳電
About CEM

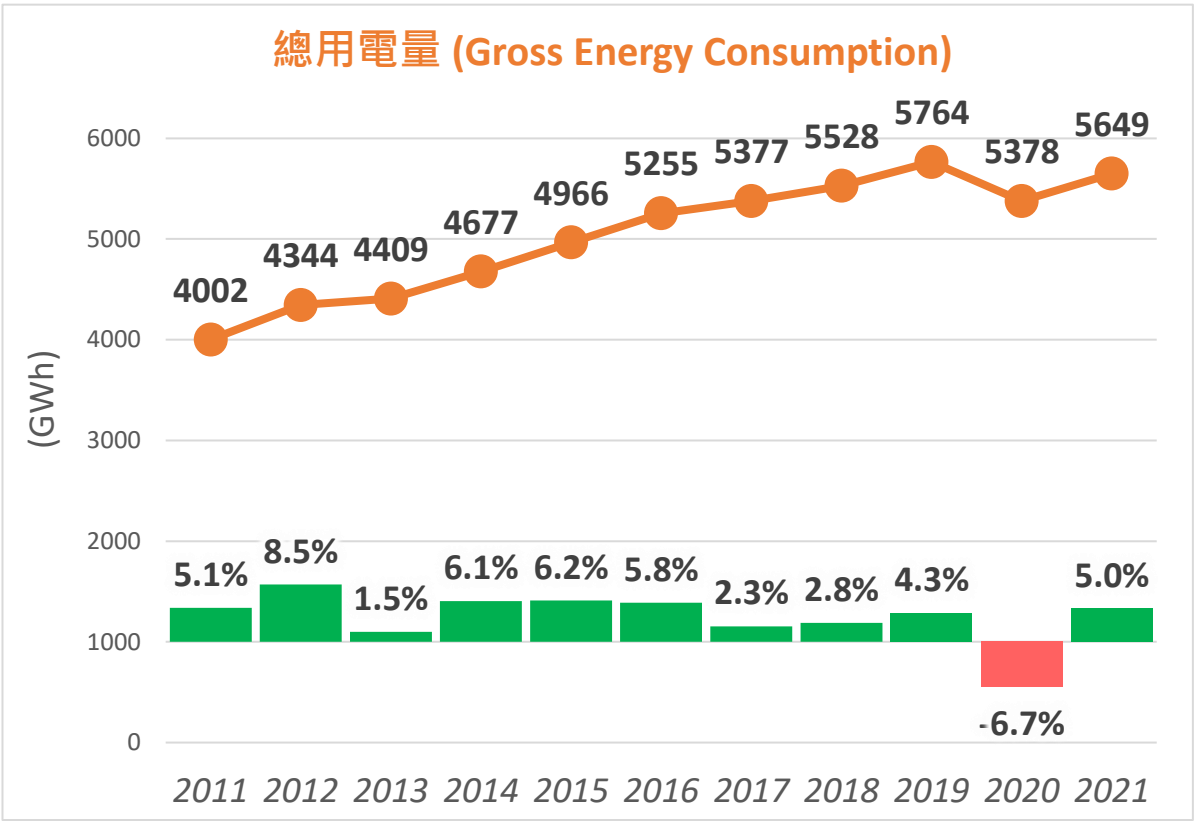
1.1 關於澳電 (About CEM)

澳門電力股份有限公司（澳電）是在澳門特別行政區提供輸送、分配及出售高、中和低壓電力公共服務的專營機構。澳電亦擁有發電設施，同時為澳門共同管道管理公共服務之專營機構。

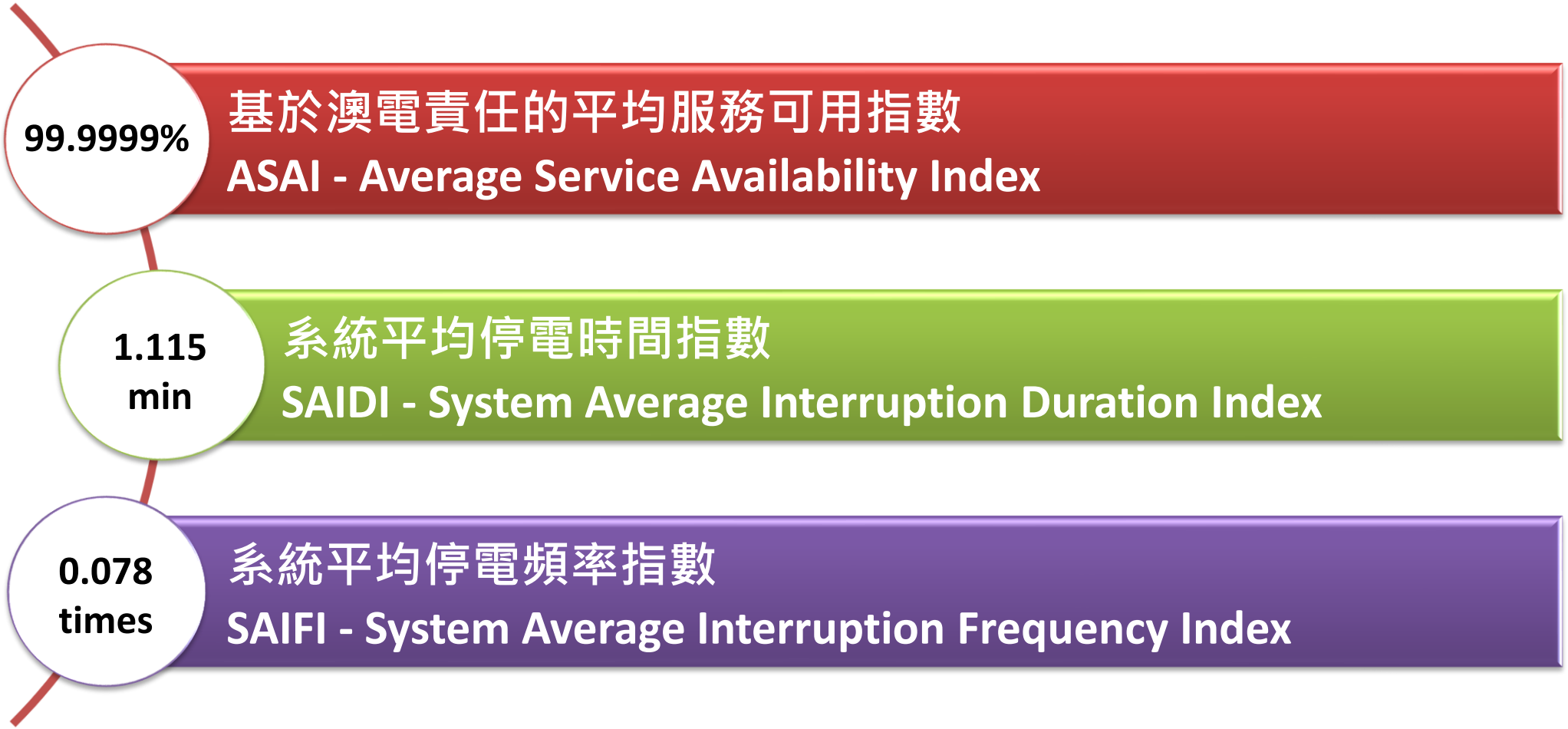
CEM is a public utility company with the sole concession to transmit, distribute and sell high, medium and low-voltage electricity in Macau. CEM also owns power generation facilities and holds the concession for the provision of public maintenance service for the common services tunnels in Macau.

1.2 關於澳電 – 歷年負荷 (Historical Loading)





1.3 關於澳電 – 2021年供電可靠性指標 (2021 Reliability Index)



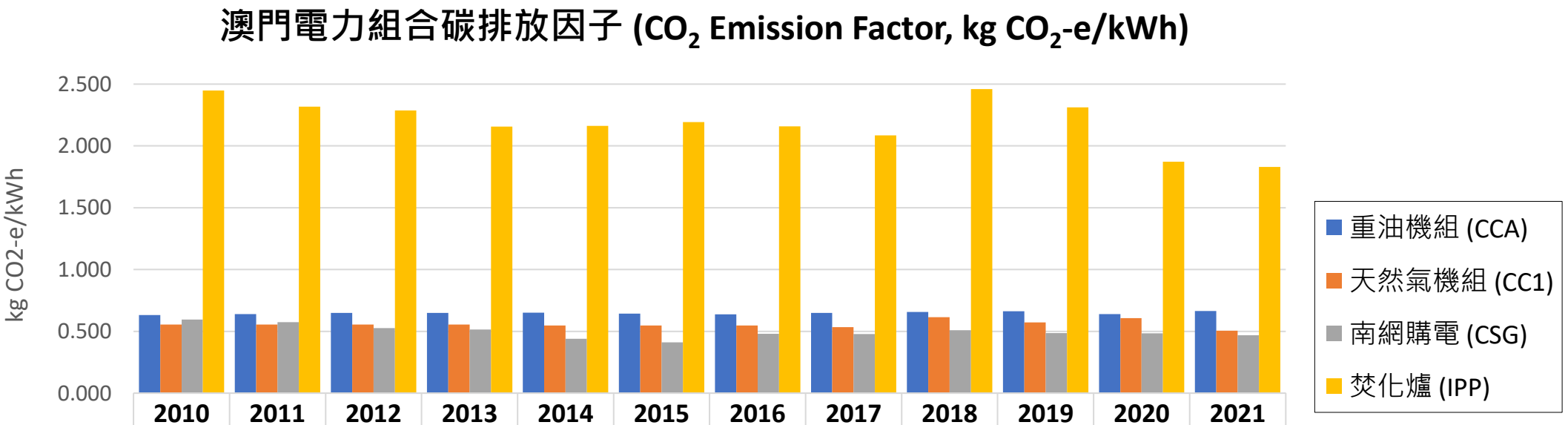
註: SAIDI 及 SAIFI 包括高/中/低壓電網的故障情況;

Remarks: SAIDI and SAIFI included the faults happened in HV/MV/LV network.

2 澳門電力系統碳排放現狀及預測
Current and Forecast Status of Carbon Emissions in Macau Power System

2.1 澳門電力系統碳排放現狀 (2010 – 2021年)

Current Status of Carbon Emissions in Macau Power System (2010 – 2021)



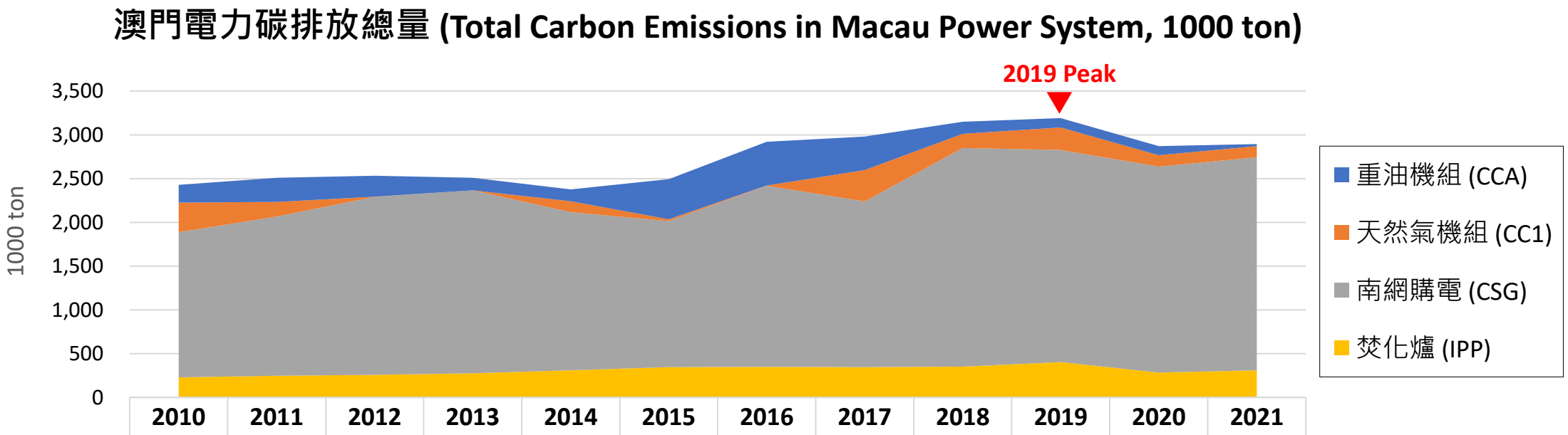
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
重油機組 (CCA)	0.632	0.640	0.649	0.650	0.651	0.643	0.637	0.649	0.657	0.662	0.640	0.665
天然氣機組 (CC1)	0.555	0.555	0.555	0.555	0.548	0.548	0.548	0.534	0.614	0.573	0.608	0.506
南網購電 (CSG)	0.595	0.575	0.527	0.515	0.441	0.411	0.481	0.479	0.509	0.487	0.485	0.469
焚化爐 (IPP)	2.447	2.318	2.287	2.155	2.161	2.193	2.158	2.085	2.460	2.311	1.871	1.829

註: 南網購電碳排放因子 - 2010-2015年數據自《中國外購電溫室氣體排放因子研究》; 2016-2021年數據為南方電網非正式公布數據。

Remarks: CSG CO_2 Emission Factor - 2010-2015 data are from "Research on Greenhouse Gas Emission Factors of China Purchased Electricity"; 2016-2021 data are informally provided by CSG.

2.1 澳門電力系統碳排放現狀 (2010 – 2021年)

Current Status of Carbon Emissions in Macau Power System (2010 – 2021)



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
重油機組 (CCA)	201	277	239	144	135	457	499	383	137	106	103	26
天然氣機組 (CC1)	339	165	4	0	125	23	3	358	163	260	129	126
南網購電 (CSG)	1,658	1,819	2,032	2,090	1,808	1,666	2,070	1,894	2,497	2,421	2,354	2,434
焚化爐 (IPP)	230	248	258	276	309	348	349	346	352	404	284	310
總量 (Total)	2,427	2,509	2,533	2,511	2,376	2,494	2,920	2,980	3,149	3,191	2,870	2,896

2.2 澳門電力系統碳排放預測 (2022 – 2060年)

Forecast of Carbon Emissions in Macau Power System (2022 – 2060)

假設條件

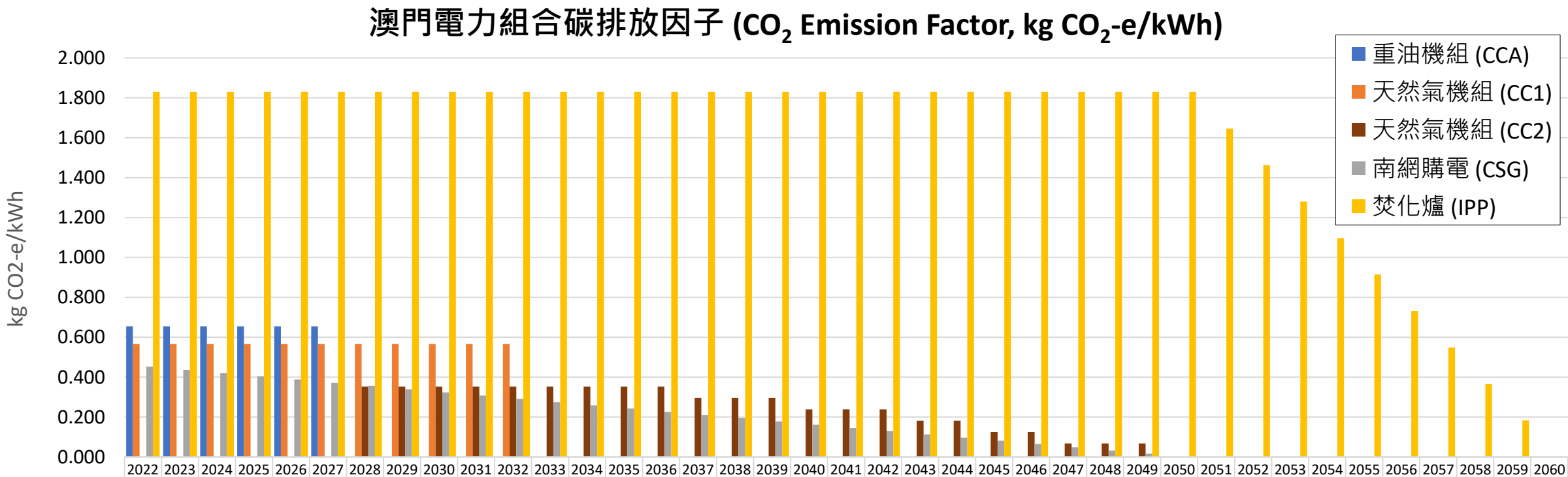
- **本地發電**
  - **重油機組**：2022-2027年期間作緊急備用，2028年重油機組退役；
  - **天燃氣機組**：2028年新天然氣機組(CC2)投運，天然氣機組(CC1)將作備用並於2033年退役；假設2037年開始引入碳中和技術，2050年實現零碳發電；
- **南網購電**
  - 隨著碳達峰碳中和政策實施，南網購電碳排放因子將逐漸降低，假設2050年實現零碳排放；
- **焚化爐**
  - 2025年新焚化爐投運，假設2050年開始引入碳中和技術，2060年實現零碳排放；
- **分佈式光伏**
  - 假設2060年全澳光伏總裝機容量達45兆瓦 (按年線性遞增) ；

Assumptions

- **CEM Generation**
  - **CCA:** For emergency backup during 2022-2027 and decommissioned in 2028;
  - **CC1 & CC2**：New natural gas unit CC2 will be commissioned in 2028 and CC1 will be used for backup and will be retired in 2033. Assumed that carbon neutral technology will be applied starting from 2037 and achieve zero emissions in 2050.
- **CSG Importation**
  - With China Gov Policies, the CSG emission factor will gradually decrease. Assumed that CSG achieve zero emissions in 2050.
- **IPP**
  - New IPP will be put in service in 2025. Assumed that carbon neutral technology will be applied starting from 2050 and achieve zero emissions in 2060.
- **PV**
  - Assumed that total PV capacity will reach 45MW in Macau (linear increase by year)

2.2 澳門電力系統碳排放預測 (2022 – 2060年)

Forecast of Carbon Emissions in Macau Power System (2022 – 2060)

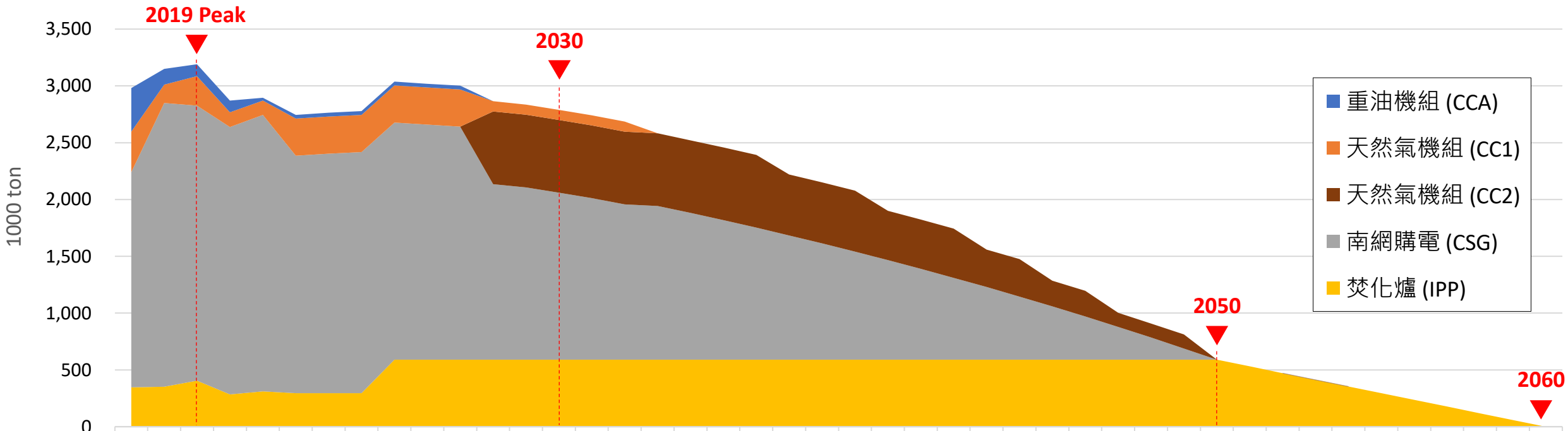


	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
重油機組 (CCA)	0.65	0.65	0.65	0.65	0.65	0.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
天然氣機組 (CC1)	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
天然氣機組 (CC2)	0	0	0	0	0	0	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.29	0.29	0.29	0.23	0.23	0.23	0.18	0.18	0.12	0.12	0.06	0.06	0.06	0	0	0	0	0	0	0	0	0	0	0
南網購電 (CSG)	0.45	0.43	0.42	0.40	0.38	0.37	0.35	0.34	0.32	0.30	0.29	0.27	0.25	0.24	0.22	0.21	0.19	0.17	0.16	0.14	0.12	0.11	0.09	0.08	0.06	0.04	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0
焚化爐 (IPP)	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.64	1.46	1.28	1.09	0.91	0.73	0.54	0.36	0.18	0

2.2 澳門電力系統碳排放預測 (2022 – 2060年)

Forecast of Carbon Emissions in Macau Power System (2022 – 2060)

澳門電力碳排放總量 (Total Carbon Emissions in Macau Power System, 1000 ton)



	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060
重油機組 (CCA)	383	137	106	103	26	33	33	33	33	33	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
天然氣機組 (CC1)	358	163	260	129	126	327	327	327	327	327	327	90	90	90	90	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
天然氣機組 (CC2)	0	0	0	0	0	0	0	0	0	0	0	640	640	640	640	640	640	640	640	640	537	537	537	433	433	433	330	330	227	227	123	123	123	0	0	0	0	0	0	0	0	0	0	0
南網購電 (CSG)	1,89	2,49	2,42	2,35	2,43	2,09	2,10	2,12	2,08	2,06	2,05	1,54	1,51	1,47	1,42	1,36	1,35	1,29	1,22	1,16	1,09	1,02	952	877	801	721	640	556	469	381	289	195	99	0	0	0	0	0	0	0	0	0	0	0
焚化爐 (IPP)	346	352	404	284	310	295	295	295	589	589	589	589	589	589	589	589	589	589	589	589	589	589	589	589	589	589	589	589	589	589	589	589	589	530	472	413	354	295	236	177	118	59	0

3 澳門電力系統低碳發展路徑
The Path of Low Carbon Development in Macau Power System

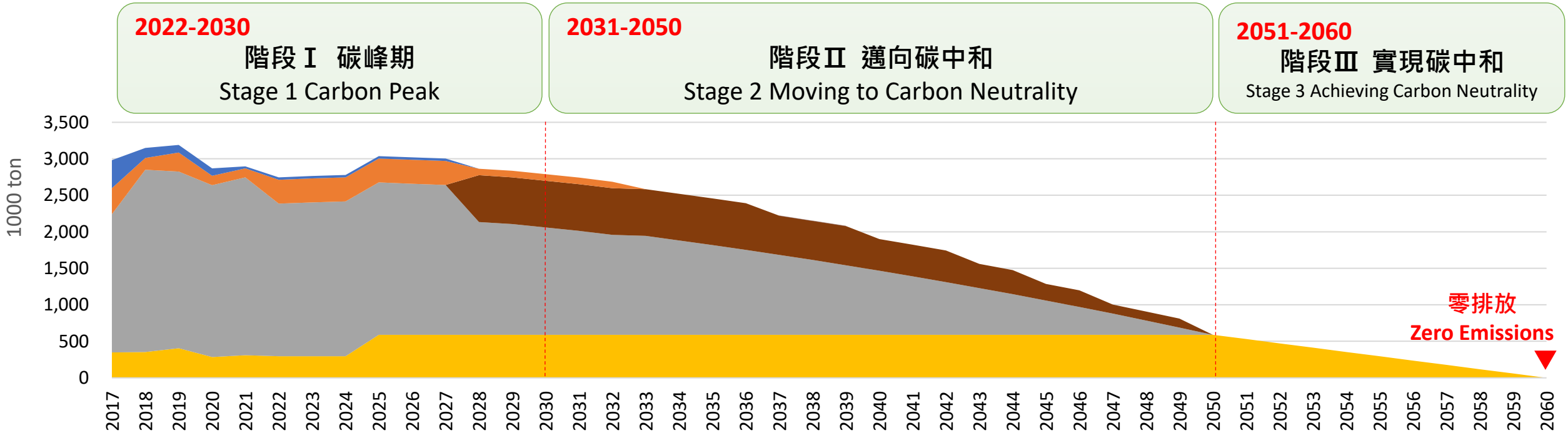
澳門是一個旅遊城市，沒有很多耗用大量能源的工業。在2017年，最大碳排放源是南網購電+本地發電 (56%)，其次是跨境交通 (18%) 及運輸業 (15%)，這些主要排放源合共佔總排放量約九成。因此，澳電為實現本澳「雙碳」目標扮演著舉足輕重的角色，給企業帶來是新的挑戰與機遇。

Macau is a tourist city without many high-consumption industries. In 2017, the largest source of carbon emissions was CSG Importation + CEM Generation (56%), cross-border transportation (18%) and the transportation industry (15%), which together accounted for about 90% of total emissions. Therefore, CEM plays a critical role in achieving the "Carbon Neutrality" goal in Macau, bringing new challenges and opportunities to CEM.

註：數據源自澳門科技大學環境研究院2020年發布《澳門溫室氣體排放特徵與減排策略研究》 (Remarks: Data are from MUST 2020 paper.)

3.1 澳電低碳發展路徑 (CEM Low Carbon Development Path)

- 澳電在 2018 年開始了**「綠色澳門、低碳澳門」的前瞻性研究**，並於 2021 年制定了**「澳電低碳發展路徑報告」**，其中把2022年至2060年劃分成**三個階段**，並於電力全產業鏈的各個環節制定了相應的**減排行動計劃**。
- In 2018, CEM started the study on “Green Macau, Low Carbon Macau”, and defined the “CEM Low-Carbon Development Path Report” in 2021. It divided the period from 2022 to 2060 into three stages, and corresponding emission reduction action plans have been formulated for each area throughout Macau Power System.



3.2 澳電低碳發展路徑 (源頭減碳 – 南網購電)
Source Carbon Reduction - CSG

不斷監測與追蹤南網碳排放因子

- 由於澳門外購電量佔比較大，南網碳排放因子至關重要，目前國內仍**存在多類的電網碳排放因子計算結果。**根據國家發改委2012年發布的數據，南方電網的碳排放為每千瓦時527克；
- 南方電網非正式公布的2020年碳排放因子為 0.485 kg/kWh，澳電與南方電網一直保持緊密溝通，以**收集更完整的碳排放因子數據**；
- 預期隨著碳達峰碳中和政策的實施，**南網購電碳排放因子將逐漸降低**；

Continuously Monitor and Track CSG Emission Factor

- Due to the large proportion of purchased electricity, the CSG emission factor is very important. Currently, there are still many kind of emission factor calculation results. According to formal releasing, emission factor 0.527 kg/kWh in 2012.
- 2020 emission factor informally provided by CSG is 0.485 kg/kWh. CEM has been in close communication with CSG to collect more complete emission factor data.
- It is expected that with the China Government Policies, the CSG emission factor will gradually decrease.

3.3 澳電低碳發展路徑 (源頭減碳 – 本地發電)
Source Carbon Reduction – CEM Generation

採用天然氣為主的本地發電策略
本地發電**採用全天然氣**，**重油發電機組轉入備用**，作為緊急保供電電源；

興建新天然氣發電機組 (CC2)
新型天然氣發電機組 (CC2) 的**碳排放因子可降至 0.353 kg/kWh**，優於現有天然氣機組 (CC1) 的碳排放因子 0.551 kg/kWh；

引入可再生燃料發電技術 / 碳捕集與封存技術 (CCUS)
適時對天然氣機組進行改造，目標實現全氫氣的**零碳發電**，倘若需要進一步提升減排成效，可考慮引入碳捕集與封存技術 (CCUS) ；

Adopt Natural Gas-Based Local Generation Strategy
The local power generation all adopts natural gas and the heavy fuel oil generators used for emergency backup.

Construction of New Natural Gas Generator (CC2)
The emission factor of new natural gas generator (CC2) can be reduced to 0.353 kg/kWh, which is better than the emission factor 0.551 kg/kWh of existing natural gas generator (CC1).

Apply Renewable Fuel Technology / Carbon Capture and Storage Technology (CCUS)
The natural gas unit would be renovated, aiming to achieve zero-carbon power generation with all hydrogen fuel. If the emission reduction effect needs to be further improved, carbon capture and storage technology (CCUS) can be considered.

3.4 澳電低碳發展路徑 (源頭減碳 – 清潔能源替代)

Source Carbon Reduction – Renewable Energy

發展分布式光伏發電

- 澳電於 2015 年進行了《澳門特區太陽能光伏可行性分析報告》，估算全澳光伏裝機潛力約 45 至 81 兆瓦，**未來仍有很大空間進行光伏系統建設 (目前總裝機不到1兆瓦)**；
- 政府近年與澳電透過 「**上網電價計劃**」推動社區發展分布式光伏的可再生能源建設，預期短期內將有十多個大型及中型光伏系統接入電網，進一步提升本澳清潔能源比例；
- 澳電現正研究**利用在電廠及周邊海域的空間開發光伏發電項目**；

Distributed PV System

- In 2015, CEM conducted "Macau Photovoltaic Feasibility Analysis Report" and estimated that the potential PV installed capacity is about 45 - 81 MW (The current total capacity is less than 1 MW).
- In recent years, the Macau Government and CEM have promoted the development of distributed photovoltaic renewable energy in communities through the "Feed-In Tariff Scheme". It is expected that more than ten large and medium-sized PV systems will be connected to the grid in short term, further increasing the proportion of clean energy in Macau.
- CEM is currently studying to make use of space in the power plant and surrounding sea areas to develop PV systems.

3.4 澳電低碳發展路徑 (源頭減碳 – 清潔能源替代)

Source Carbon Reduction – Renewable Energy

發展海上風電

- 鄰近海上風電場規劃中，將來有潛力通過220kV海底電纜與澳門聯網，**這樣不僅可以增加向澳門送電的聯網通道**，同時又可以**將清潔能源送到澳門**；
- 推動粵澳清潔電能新合作，**參與投資內地海上風電建設項目**，實現澳門自南方電網內輸電力能源清潔化；

Developing Offshore Wind Power

- In the planning of adjacent offshore wind farms, there is potential to connect to Macau through 220kV submarine cable in future, which will not only establish the new interconnection, but also deliver clean energy to Macau.
- Promote new cooperation in clean energy between Guangdong and Macau to participate in investing in offshore wind power construction projects in the Mainland. It can realize the clean energy importation from China Southern Power Grid.

3.5 澳電低碳發展路徑 (輸配電網)
Transmission & Distribution Network

做好電網規劃、建設與運行，減低使用重油機組的需要

有序地進行做好主變電站的規劃與建設，以及主變電站之間的負荷轉移，**減低夏季因電網約束使用重油機組的需要**；

推進智能電錶的全覆蓋

2020 年正式開始全電網智能電錶安裝，至 2022 年10月，已安裝12萬個智能電錶，**預計 2025 年全面完成所有客戶以及配電房智能電錶的安裝使用**；

大力發展能耗監測和管理，降低配網線損

提高電能管理信息化水平，完善配網能耗的在線監測，針對配網線損異常的電網環節，**深度分析因由及重點優化電網結構**；

Reduce the Use of Fuel Oil Through Improving Planning, Construction and Operation of Power Grid

Orderly carry out the planning and construction of power grid, as well as the load transfer between the primary substations, to reduce the use of fuel oil generators due to network constraints in summer.

Promote the Full Coverage of Smart Meter

CEM has started to install smart meters since 2020. 120k smart meters have been installed by Oct, 2022. It is expected that the smart meters will fully cover in all customers and PTs in 2025;

Reduce Distribution Loss by Improving Energy Consumption Monitoring and Management

Improve the energy data management and online monitoring. For the abnormal distribution loss, it can analyze the root cause and optimize the power network structure.

3.6 澳電低碳發展路徑 (其他減排措施)
Other Emissions Reduction Measures

數字化客服
推廣使用**電子賬單**、**電子支付**等數字化客戶服務，減少社會活動的能源消耗和碳排放；

跟踪及參與碳交易市場運作
了解碳交易市場**運行機制**， 做好參與碳交易市場的準備；

推廣電能替代及社會節能降耗
在用戶終端推動使用**電能替代**碳含量高的能源。利用**智能電錶及相關應用程式**讓客戶更了解自己的用電習慣，以及透過推動市民參加**節能比賽**，加強節約能源的意識；

造林碳匯
通過合作方式**評估實施造林碳匯**的可行性；

Digital Customer Service – To reduce energy consumption and carbon emissions from social activities through e-billing, e-payment, etc.

Carbon Trading Market – To understand and prepare the future participation in carbon trading market.

Promote Electric Energy Substitution & Social Energy Saving – To promote electric energy substitution, and encourage energy saving through smart meters and relevant applications, competitions, etc.

Afforestation – To evaluate the possibility of achieving carbon sink through cooperation in afforestation.

4 推動電動出行，促進澳門低碳發展
EV Promotion to Accelerate Low Carbon Development in Macau

4.1 現有充電網絡和基礎設施 (Existing EV Charging Facilities)

- 為配合澳門特區政府的綠色出行政策，澳電一直積極完善電動車充電網絡，目標於2022年底增加公共充電位至2,000個，基本全覆蓋澳門公共停車場，並引入中國國家標準充電制式。另爭取今年底在42個可停泊電單車的公共停車場設置約500個充電位，完善電動電單車充電配套。

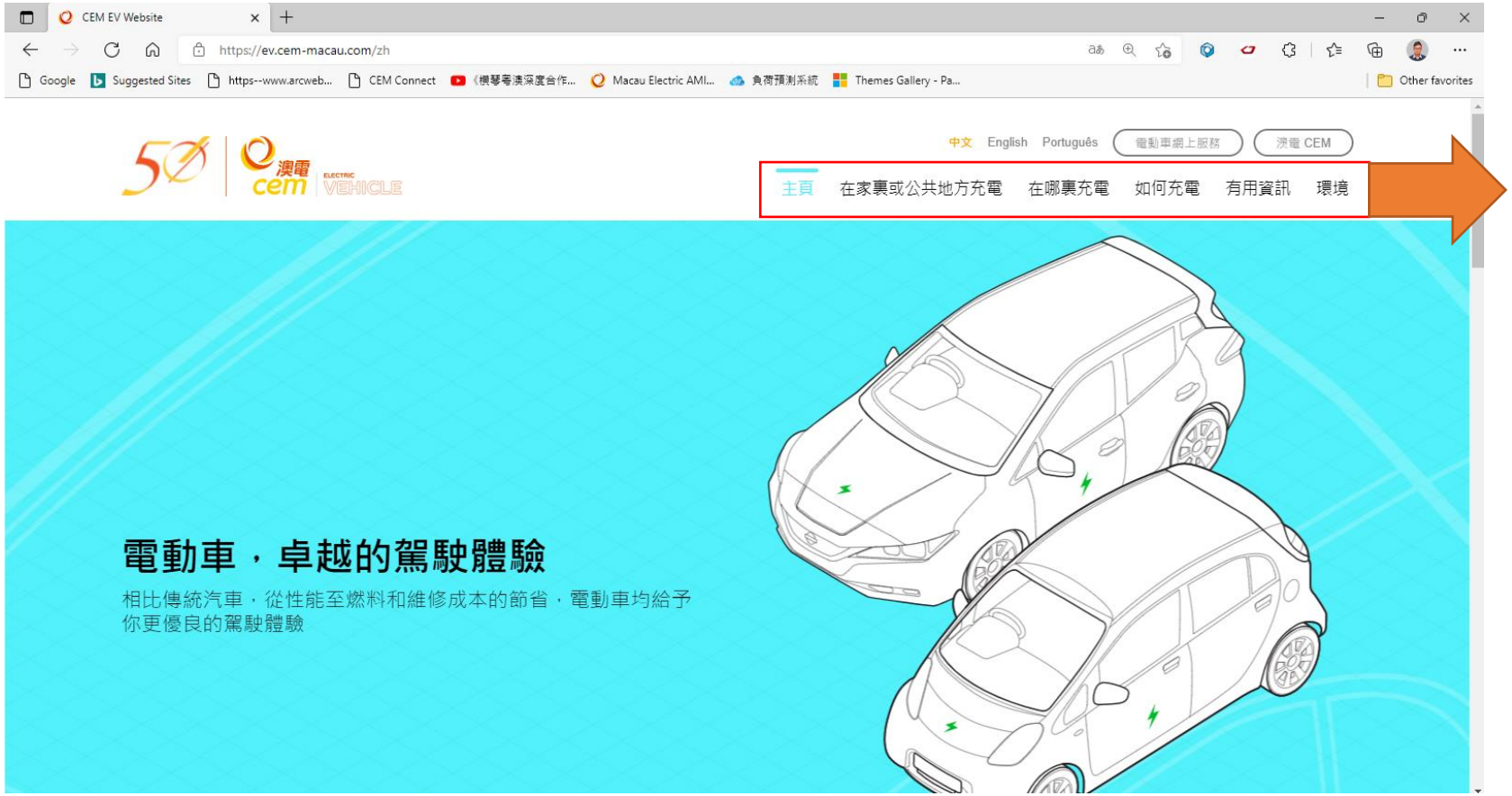
- To cope with the green mobility policy by the MSAR, by end of 2022 CEM's target is to increase the public chargers for light EVs to 2,000 with introduction of GB standard, basically covering all the public car parks and will try to install around 500 e-Motorcycle charging points.

澳門 (Macau)

氹仔、路環 (Taipa, Coloane)

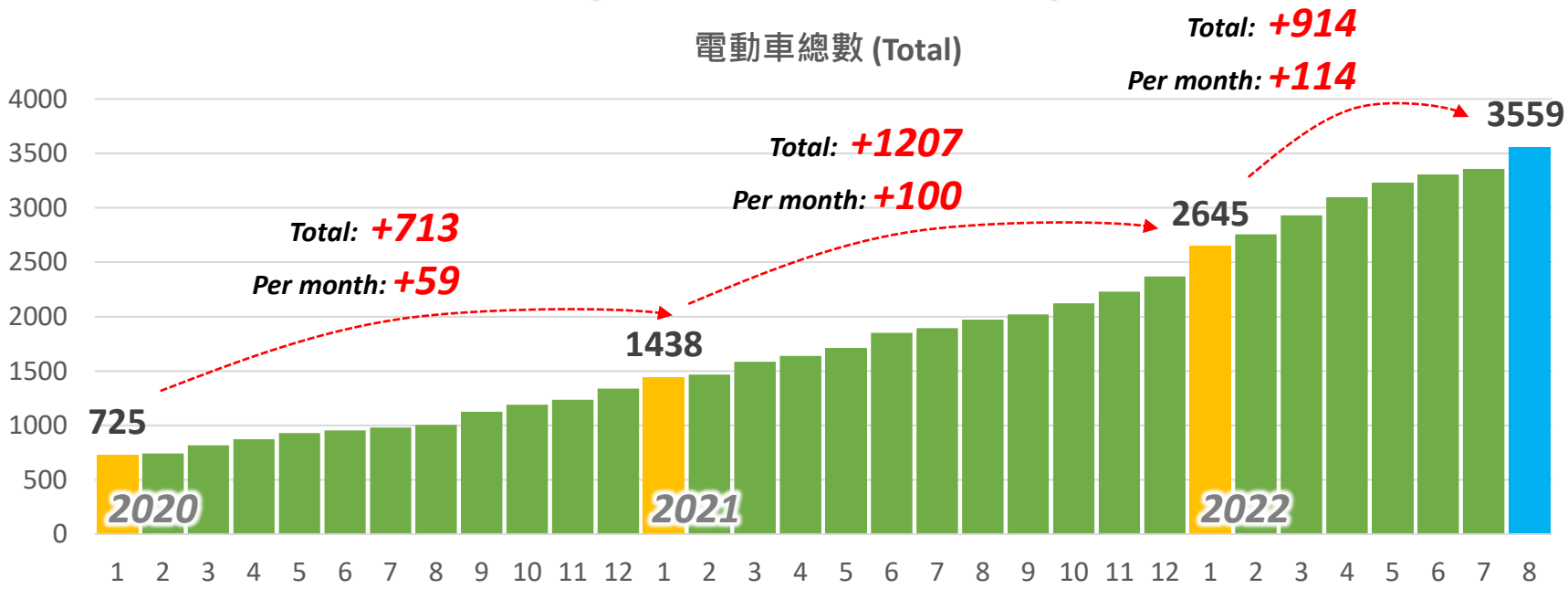
4.1 現有充電網絡和基礎設施 (Existing EV Charging Facilities)

https://ev.cem-macau.com/

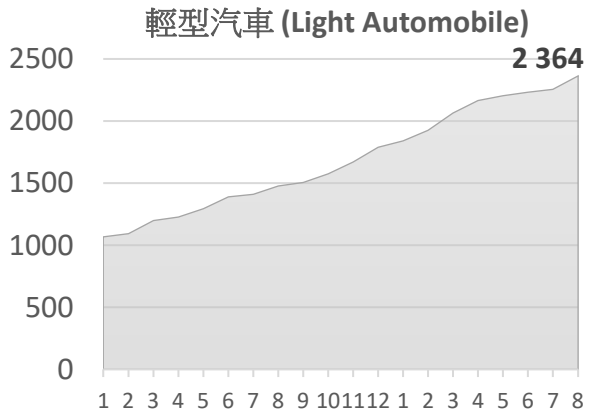


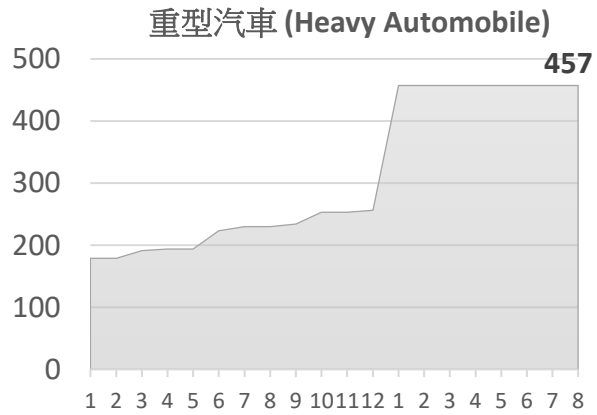
- 主頁 (Home)
- 在家裏或公共地方充電 (Charge At Home Or Public)
- 在哪裏充電 (Where To Charge)
- 如何充電 (How To Charge)
- 有用資訊 (Useful Info)
- 環境 (Environment)

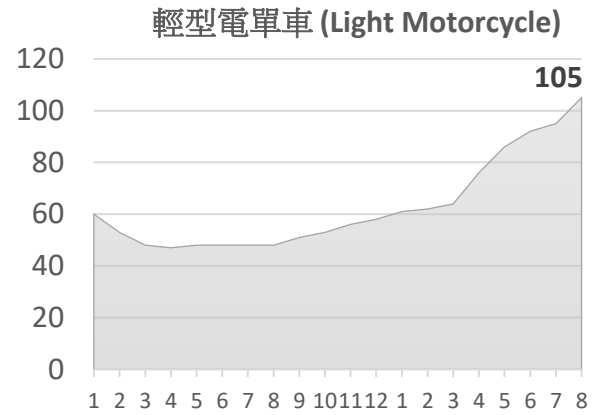
4.2 電動車數量 (Number of EV)

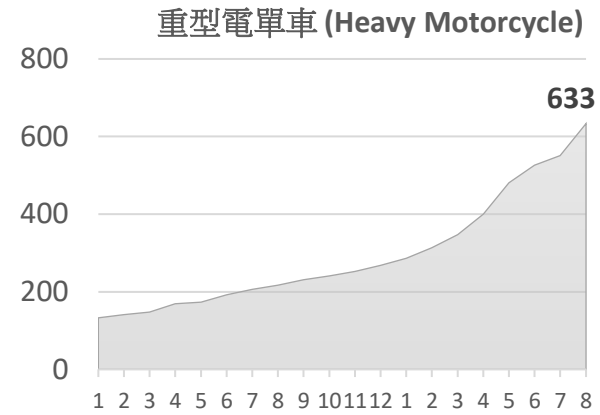


類別	電動	總數	佔比
輕型汽車 (Light Automobile)	2,364	113,373	2.1%
重型汽車 (Heavy Automobile)	457	6,930	6.6%
輕型電單車 (Light Motorcycle)	105	20,396	0.5%
重型電單車 (Heavy Motorcycle)	633	106,944	0.6%
工業機器車 (Industrial Vehicle)	---	72	---
總數 (Total)	**3,559**	**247,715**	**1.4%**









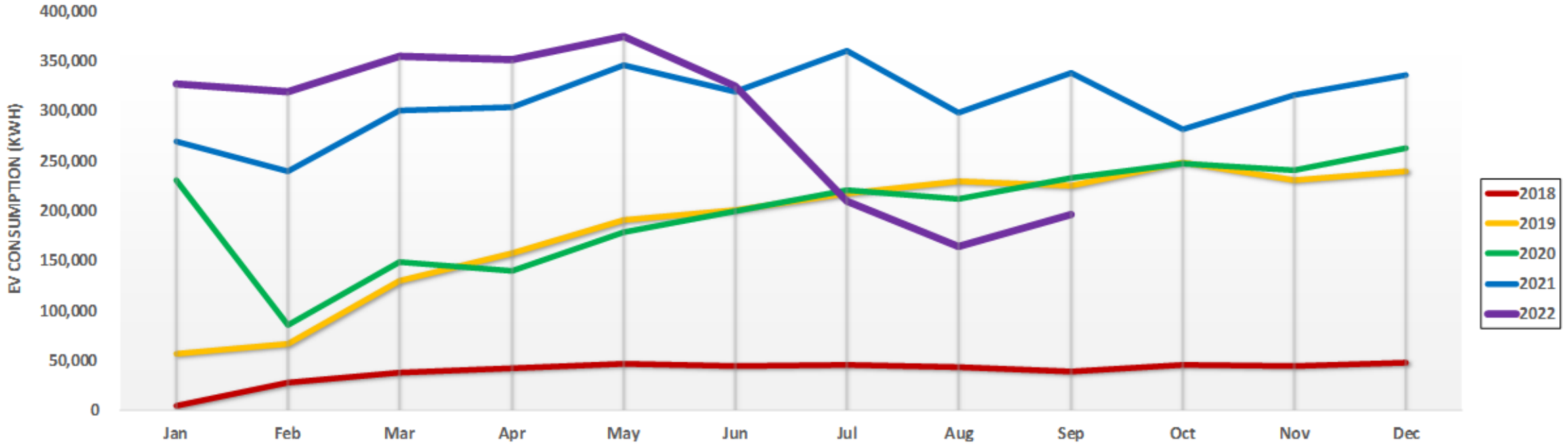
運輸、倉儲及通訊業 -- 統計數據 -- 澳門統計暨普查局 (dsec.gov.mo)

4.3 公共充電位用電量 (Energy Consumption in Public Charging Stations)

kWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	698	770	954	942	1,534	1,411	1,860	1,858	2,409	2,591	4,088	3,567
2018	4,436	28,135	37,767	42,320	47,266	44,615	45,677	43,970	38,992	45,512	44,167	47,684
2019	56,830	67,262	129,388	157,680	191,217	201,202	217,147	229,992	225,612	247,953	230,562	239,233
2020	230,382	86,027	148,529	140,038	178,309	199,796	220,632	212,032	232,790	247,065	240,057	262,423
2021	268,946	239,672	300,751	304,071	346,047	319,658	360,249	298,624	337,664	281,412	316,271	336,289
2022	327,176	319,368	354,127	350,941	374,213	324,659	210,043	164,015	195,947			

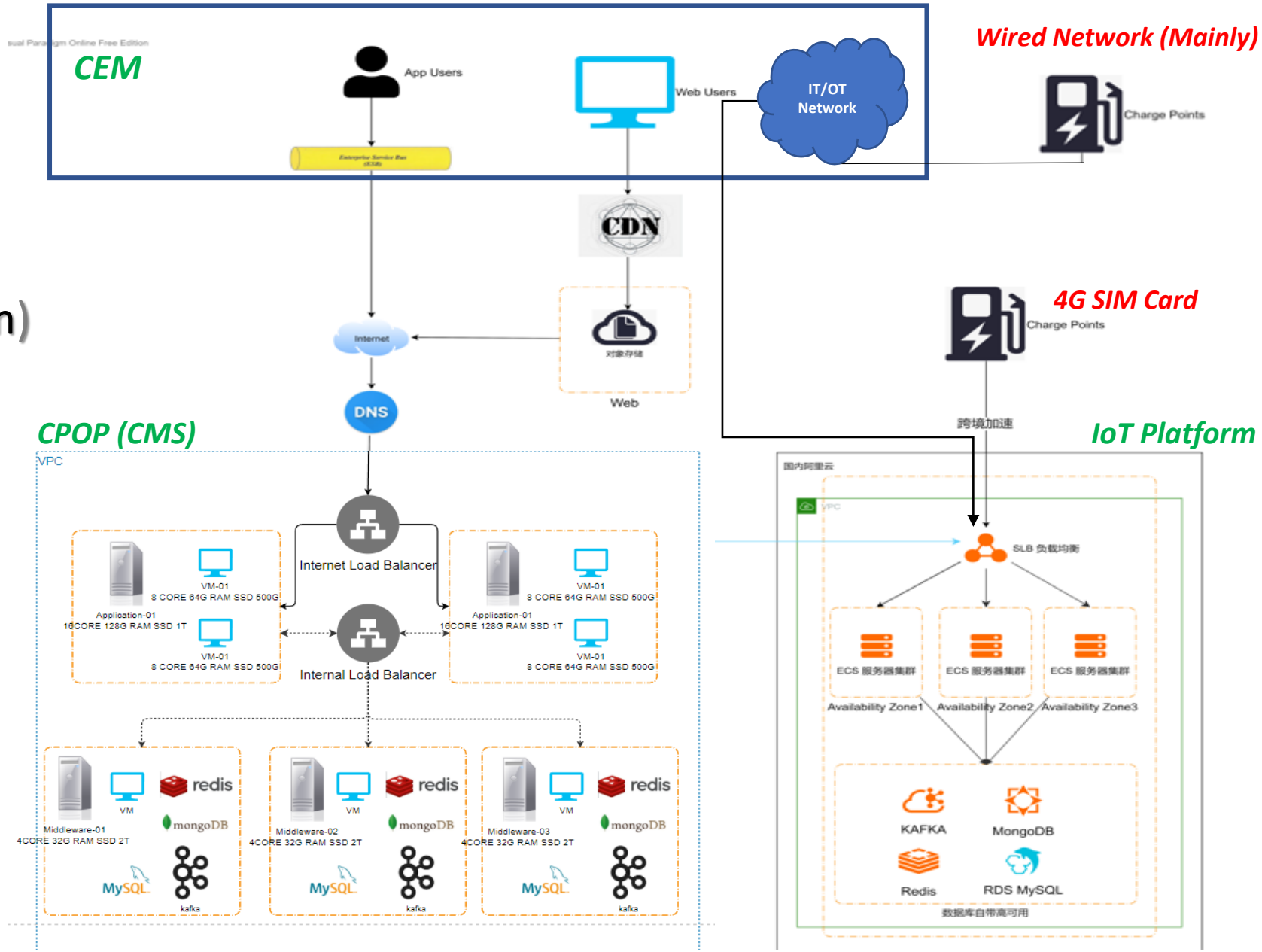
YTD (Jan-Sep)	kWh	Growth
2017	12,436	---
2018	333,178	2579%
2019	1,476,331	343%
2020	1,648,534	12%
2021	2,775,682	68%
2022	2,620,490	-6%

Yearly (Jan-Dec)	kWh	Growth
2017	22,682	---
2018	470,541	1975%
2019	2,194,079	366%
2020	2,398,080	9%
2021	3,709,653	55%
2022		



4.4 新型充電管理系統
(New EV Management System)

- 系統將使用公有雲技術，服務整個大灣區的客戶。
- The system will base on public cloud technology, and serve to the Greater Bay Area customers.



4.5 電動車充電設施規劃
Planning for EV Charging Facility

完善電動汽車充電配套設施，助力電動車普及

合理規劃並投資建設更完善的充電網絡，構建**電動私家車在家及工作地點充電為主，公共充電設施充電為輔**的電動車充電網絡；

電動電單車推行更換電池服務

透過合作方式評估**電動電單車普及化**的可行性；

實施充電費率調控機制

引導有序充電並減低電網峰谷差；

Improve EV Charging Facilities to Accelerate EV promotion

Reasonably plan and invest in the construction of more mature EV charging network, with standard charging in private car parks and supplemented by charging in public car parks.

Implementation of Battery Replacement Service for E-Motorcycles

To evaluate the feasibility of e-Motorcycles through cooperation.

Implementing tariff adjustment to EV charging

To guide orderly charging and reduce peak valley difference of power grid.

4.5 電動車充電設施規劃
Planning for EV Charging Facility

新建大廈充電設施

按2019年修訂的供電技術規範，新建大廈停車場須100%配備充電基礎設施，如電線托架、電櫃等。

現有屋苑加裝充電設施

現有私有屋苑無配備充電設施，未來主要安裝標準充電設施，方便電動私家車利用在住宅及辦公附近停車時段充電。

NCEM C14-100 建築物電氣裝置低壓供電 一般技術規範 v1.2　　2019年1月

Charging Facilities in New Buildings

According to the "CEM Norm" (NCEM) revised in 2019, all of the car parks in new buildings should have basic EV charging infrastructures including cable trays, switchboards, etc.

Installation of Charging Facilities in Existing Buildings

At present, private housings are not equipped with charging facilities. In future, standard charging facilities will be installed to facilitate the EV charging during parking periods near residences and offices.

2.4 社會設施	0.160 千伏安/平方米
2.5 建築物公共設施	34.5 千伏安/電梯
帶電梯	34.5 千伏安/電梯
不帶電梯	3.4 千伏安
2.6 建築物停車場	0.008 千伏安/平方米，不包括通風系統
電動車充電插座（*）	6.9 千伏安/插座
工業場所	
3.1 工廠	0.200 千伏安/平方米

5 總結
Conclusion

總結 (Conclusion)

- 澳電將緊隨特區政府雙碳政策，爭取在2030年或之前實現碳達峰，憑着電力行業的專業知識和經驗，已準備就緒為澳門長遠減碳作出貢獻；
- 根據澳門科技大學的研究，本澳2017年最大碳排放源是南網購電+本地發電 (56%)，其次是跨境交通 (18%)及運輸業 (15%)，這些主要排放源合共佔總排放量約九成；
- 澳電已制定了「澳電低碳發展路徑報告」，其中把2022年至2060年劃分成三個階段，並於電力全產業鏈的各個環節制定了相應的減排行動計劃；
- 澳電亦鼓勵社會大眾上下一心，攜手同行，共同為減碳工作出一分力。

- Following Macau Government's policies to **reach carbon peak by 2030 or before**, CEM is ready to contribute to the long-term carbon reduction through our expertise and experience in the power industry.
- According to MUST research, the largest source of 2017 carbon emissions was CSG Importation + CEM Generation (56%), cross-border transportation (18%) and the transportation industry (15%), which **together accounted for about 90% of total emissions**.
- CEM has defined the "**CEM Low-Carbon Development Path Report**" in 2021, which divided the period from 2022 to 2060 into three stages, and corresponding emission reduction action plans have been formulated for each area throughout Macau Power System.
- CEM also encourages the public to **work together for the contribution in carbon reduction**.

www.cem-macau.com