RGC Ref. No.:
UGC/IDS(C)14/B(E)01/19
(please insert ref. above)

RESEARCH GRANTS COUNCIL
COMPETITIVE RESEARCH FUNDING SCHEMES FOR
THE LOCAL SELF-FINANCING DEGREE SECTOR

INSTITUTIONAL DEVELOPMENT SCHEME (IDS)
COLLABORATIVE RESEARACH GRANT

Completion Report
(for completed projects only)

Submission Deadlines:	1. *Auditor's report with unspent balance, if any: within **six** months of the approved project completion date.*
	2. *Completion report: within **12** months of the approved project completion date.*

Part A: The Project and Investigator(s)

1.   Project Title

Development of Renewable Energy for Decarbonising and Modelling Sustainable Transport

and Logistics Operations in Smart Cities of Greater Bay Area

2.   Investigator(s) and Academic Department(s) / Unit(s) Involved[#]

Research Team	Name / Post	Unit / Department / Institution	Average Number of Hours Per Week Spent on this Project
Project Coordinator	Dr. WONG Eugene Yin-cheung/Associate Professor	Department of Supply Chain and Information Management, School of Decision Sciences, The Hang Seng University of Hong Kong	6
Co-Principal Investigator(s)	Ir. Dr. TSANG Chi Wing, Alex / Assistant Professor	Department of Construction Technology and Engineering, Faculty of Science and Technology, Technological and Higher Education Institute of Hong Kong (THEi)	3
	Ir. Mr. CHAN Fuk Cheung, Edward / Assistant Professor	Department of Construction Technology and Engineering, Faculty of Science and Technology, Technological and Higher Education Institute of Hong Kong (THEi)	1
Co-Investigator(s)	Dr. Danny Ho Chi-kuen/ Assistant Professor	Department of Supply Chain and Information Management, School of Decision Sciences, The Hang Seng University of Hong Kong	2
	Mr. FU Sze Wai, Raymond / Lecturer	Department of Construction Technology and Engineering, Technological and Higher Education	1

		Institute of Hong Kong	
	Dr. CHAN Man Hin, Eve / Assistant Professor	Department of Design, Faculty of Design and Environment, Technological and Higher Education Institute of Hong Kong	2
	Prof. LO Hong Kam / Chair Professor and Head of Civil and Environmental Engineering	Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology	1
	Prof. CHEN Guohua / Chair Professor and Associate Vice President (Research Support)	Department of Mechanical Engineering, The Hong Kong Polytechnic University	1
Others	Dr. Stuart So, Assistant Project Manager and Research Fellow	Department of Supply Chain and Information Management, School of Decision Sciences, The Hang Seng University of Hong Kong	40
	Dr. Wang Yuanhao Senior Research Assistant	Department of Supply Chain and Information Management, School of Decision Sciences, The Hang Seng University of Hong Kong	40
	Dr. Yang Fajun, Assistant Project Manager and Research Fellow	Department of Supply Chain and Information Management, School of Decision Sciences, The Hang Seng University of Hong Kong	40
	Dr. WEI Ran, Assistant Project Manager and Research Fellow	Department of Supply Chain and Information Management, School of Decision Sciences, The Hang Seng University of Hong Kong	40

(Please add row(s) as necessary.)

Please highlight the approved changes in project team composition and quote the date of RGC approval for such changes.

3. Project Duration

	Original	Revised	Date of RGC / Institution Approval (*must be quoted*)
Project Start Date	1 January 2020	N/A	N/A
Project Completion Date	31 December 2022	30 September 2023	23 August 2022
Duration (*in month*)	36	45	23 August 2022
Deadline for Submission of Completion Report	31 December 2023	30 September 2024	23 August 2022

4.4 Please attach photo(s) of acknowledgement of RGC-funded facilities / equipment.

- **Seminar on Development and Trends of Hydrogen in Transport and Logistics**

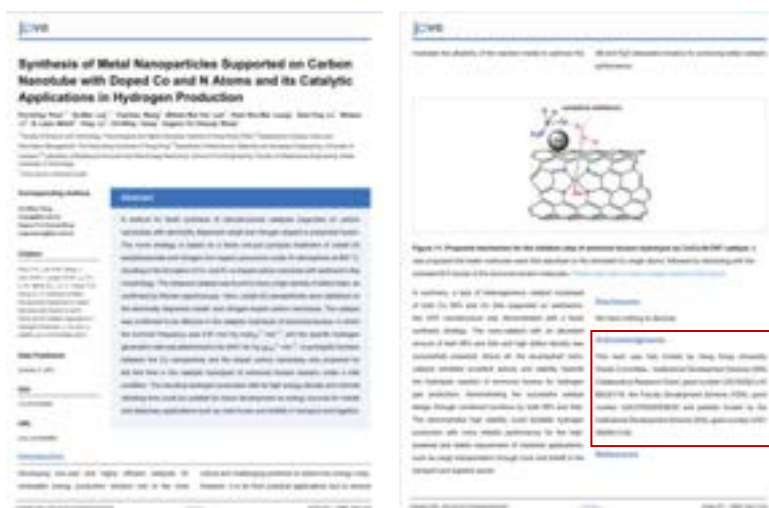- **Journal paper published in the Journal of Materials Chemistry A**

- **Journal paper published in the International Journal of Sustainable Transportation**

- **Journal paper published in the journal of Catalysts**

- **Journal paper published in the Journal of Visualised Experiments**

- **Journal paper published in the journal of Sustainability**

- **Seminar on Leadership Talk Series – Leading through uncertainty (Global Trends and Government policies on sustainability towards transport and logistics)**

Part B: The Final Report

5.   Project Objectives

5.1   Objectives as per original application

1.   To develop a novel hydrogen-powered fuel cell prototype using solid hydrogen storage materials for renewable energy of the selected vehicle type.

2.   To aggregate a database for fleet vehicles on fuel usage feedback, vehicle carbon emissions and the emission factors of various energy sources and types of vehicles for future database platform development.

3.   To model and analyse the economic and environmental impacts of mitigating vehicle emissions via renewable energy initiatives in Hong Kong and cities of the Greater Bay Area.

4.   To enhance educational and reference materials on sustainable transport related subjects.

5.   To raise public awareness on the importance of renewable energy and product carbon footprint on vehicles as well as their impact towards the environment.

5.2   Revised objectives

Date of approval from the RGC: N/A

Reasons for the change: N/A

1. N/A

2. N/A

3. N/A

5.3 Realisation of Objectives

(Maximum 1 page; please state how and to what extent the project objectives have been achieved; give reasons for under-achievements and outline attempts to overcome problems, if any)

1. *Objective 1: To develop a novel hydrogen-powered fuel cell prototype using solid hydrogen storage materials for renewable energy of the selected vehicle type*
   (1) Hydrogen fuel cells powered by solid-state storage hydrogen materials were developed, upon the catalytic reactions and hydrogen release experiments have been carried out with the catalytic hydrolysis of Ammonia Borane (AB), considering the advancement of single atom catalysis (SACs) in various catalytic applications. The development context, deliverables and results were published in journals, including Journal of Materials Chemistry A, Catalysts, and Journal of Visualised Experiments.
   (2) A vehicle life cycle assessment (LCA) model was built by analysing fuel cycles of gasoline, plug-in battery, and hydrogen fuel-cell vehicles, assessing energy efficiency, with analysis and results published in conference papers (DASA'20 and ICBET2021) and journal paper (Sustainability).

2. *Objective 2: To aggregate a database for fleet vehicles on fuel usage feedback, vehicle carbon emissions and the emission factors of various energy sources and types of vehicles for future database platform development.*
   (1) A set of data encompassing trade activities, vehicle types, energy sources, and carbon emissions from cities within the Greater Bay Area (GBA) was compiled, including data on trade flows, GDP, population statistics, throughput, imports, exports, vehicle classifications, gas emission inventories, container port traffic, and data from Green Source Technology Co., Ltd., regarding supercapacitors and solar panels in the GBA.

3. *Objective 3: To model and analyse the economic and environmental impacts of mitigating vehicle emissions via renewable energy initiatives in Hong Kong and cities of the Greater Bay Area.*
   (1) In analysing the econometric and environmental impacts from the GBA data collected for assessing CO_2 emissions influencers on cross-border trade and traffic, a modified hierarchical factor modelling approach was adopted for exploring the structure and relationship of regressors with factors tested from economic and transport variables over a 20-year period. The results and analysis were compiled into a journal paper.
   (2) Two enhanced Gravity Models (Trade flow- and Traffic flow-based) were developed to analyse and forecast the emissions of trade and traffic flow among GBA cities, with results published in VEHITS2021 conference.
   (3) Enhanced trade-based Gravity Model and four machine learning models were developed to evaluate and forecast the environmental and emission impact of cross-border traffic flow from diverse transport, economic, and demographic variables in Hong Kong and Shenzhen. The results were compiled into a journal paper.
   (4) A GREET Model (Greenhouse gases, regulated emissions, and energy use in transportation), with LCA process, was adopted in evaluating and comparing the product carbon footprint (PCF) of an electric vehicle and hydrogen fuel cell car. The studies were published in a journal paper.
   (5) A model on evaluating the impact of urbanisation and renewable energy on CO_2 emissions in developing countries was developed, exploring the moderating role of renewable energy and examining market dynamics factors like regulations and technological advancements. The results were compiled into a journal paper.

4. *Objective 4: To enhance educational and reference materials on sustainable transport related subjects.*
   (1) The project findings and deliverables were incorporated into academic modules, internship company projects, and final year/senior year group projects. The modules include Sustainable Supply Chain Management, Sustainable Transportation, Shipping and Transport Logistics, and Transport Logistics and Law. Projects about sustainable transportation have been carried out, e.g. (i) Analysing energy efficiency and carbon emissions of Toyota hydrogen trucks and cars, and (ii) Evaluating the carbon footprint of Tesla EVs and Semi-trucks.
   (2) Five internship projects and seventeen final-year/senior year projects, with a total of 40 students, were conducted on topics related to the funding project, e.g. (i) Sustainable vehicle carbon footprint in GBA cities, (ii) LCA of hydrogen trucks and their emission impacts in GBA, (iii) CO_2 emissions of hydrogen fuel cell passenger cars in three GBA cities, (iv) Development of novel supported cobalt catalysts for hydrogen release from ammonia borane, (v) Catalyst development for hydrogen release from ammonia borane: an experimental study, and (vi) Literature review on layered double hydroxide (LDH) materials for hydrogen release.
   (3) Educational reference materials on hydrogen fuel cell development, renewable energy vehicle, vehicle LCA, energy efficiency, and carbon emission calculation were developed and incorporated into teaching modules.
   (4) With the project initiatives and deliverables, the team and the university had identified the importance and potential in this discipline and planned to develop a Master programme related to this area for the students.
   (5) A book, titled "ESG 知多啲—綠色運輸物流邁向炭中和", including chapters on carbon footprint, renewable energy, and GBA, was compiled as an educational and referencing materials for students and practitioners.

5. *Objective 5: To raise public awareness on the importance of renewable energy and product carbon footprint on vehicles as well as their impact towards the environment*
   (1) Six workshops and seminars were organised. The team also shared project context and deliverables on renewable energy and product carbon footprint as invited speakers in 10 invited seminars and professional talks, raising the importance of these topics to students, scholars, practitioners and the public (Annex I).
   (2) PI and Co-I jointly carried out a special issue as guest editors in Frontiers in Chemical Engineering with the

topic on Catalytic Technology for Hydrogen Energy and its Application in Transportation and Logistics.

(3) In facilitating the continuity and sustainability of the research initiatives, with the project deliverables and the advocate and drive from PI as well as effort from university professors and donor, a centre was set up focusing on sustainability research development and green policy initiatives in Hong Kong and Asia Pacific, titled Asia-Pacific ASEAN Green Deal Centre. It aims to foster government-business community partnerships with impactful change for sustainable development, leveraging advocacy, research, education, and engagement as well as engage in exchanges and cooperation with ASEAN and Asia-Pacific countries.

5.4 Summary of objectives addressed to date

Objectives *(as per 5.1/5.2 above)*	Addressed *(please tick)*	Percentage Achieved *(please estimate)*
1. *To develop a novel hydrogen-powered fuel cell prototype using solid hydrogen storage materials for renewable energy of the selected vehicle type.*	✓	100%
2. *To aggregate a database for fleet vehicles on fuel usage feedback, vehicle carbon emissions and the emission factors of various energy sources and types of vehicles for future database platform development.*	✓	100%
3. *To model and analyse the economic and environmental impacts of mitigating vehicle emissions via renewable energy initiatives in Hong Kong and cities of the Greater Bay Area.*	✓	100%
4. *To enhance educational and reference materials on sustainable transport related subjects.*	✓	100%
5. *To raise public awareness on the importance of renewable energy and product carbon footprint on vehicles as well as their impact towards the environment.*	✓	100%

6 Research Outcome

6.1 Major findings and research outcome
(Maximum 1 page; please make reference to Part C where necessary.)

(1) *Development of Solid-state Storage Hydrogen Fuel Cell* – Hydrogen fuel cells powered by solid-state storage hydrogen materials were developed, upon the catalytic reactions and hydrogen release experiments have been carried out with the catalytic hydrolysis of Ammonia Borane (AB), considering the advancement of single atom catalysis (SACs) in various catalytic applications. Co nanoparticles embedded within graphitic carbon layers, featuring atomically dispersed CoNx and Co nanoclusters active sites on carbon nanotubes, were successfully synthesized. By adjusting the carbonization temperature and varying the Co metal content, the ratio of Co nanoparticles to atomically dispersed Co was optimised for enhanced reactivity and stability during the hydrolysis of ammonia borane. The findings revealed that the sample Co/CoNx-CNT-33-800T, with a nominal Co content of 3 wt% and carbonized at 800 °C, demonstrated superior reactivity and stability in ammonia borane hydrolysis. The synthetic approach described offered the flexibility to further fine-tune the ratio of nanoparticles to single metal atoms, potentially optimizing reactivity even further.

(2) *Enhanced Trade- and Traffic-based Gravity Models and Machine Learning Models for carbon emission forecasting and impact studies* – Novel models in forecasting traffic flow and the emission impact towards the cities were developed, including traffic- and trade-based Gravity model and machine learning regression models. The models were applied to the emissions study for the trade flow between Hong Kong and Shenzhen, with results indicated that port throughput and fixed asset investment are strong predictors of traffic flow. The results revealed a significant correlation between traffic flow between cities and the analysed factors. The model forecasted the carbon emission emitted from diesel and hydrogen vehicles along the traffic and logistics flow between the cities, providing valuable results and insights useful for further academic and research development on renewable energy and sustainable transportation.

(3) *A GREET Model on analysing LCA of EV and Hydrogen Fuel Cell* – A GREET Model (Greenhouse gases, regulated emissions, and energy use in transportation), with life cycle assessment (LCA) process, was adopted in evaluating and comparing the product carbon footprint (PCF) of an EV and hydrogen fuel cell car. The assessment quantifies environmental indicators, such as carbon emissions, energy consumption, and resource utilization of different modes of transportation over their life cycles. This quantification process provides a solid scientific basis for evaluating and comparing the sustainability of alternative energy transportation modes, enabling policymakers to make informed decisions based on data.

(4) *Machine Learning-based Model on evaluating vehicle purchasing behaviour against carbon emission* – A climate risk management framework on vehicle purchasing behaviour impact on carbon emissions was developed. A machine learning-based model was developed in analysing and estimating the impact of vehicle purchasing on carbon emissions, based on surveys and data collected. The results provide insights to scholar research and policy makers on transportation and climate risk regulation.

(5) *Seminars and workshops, journal paper, conference presentations, Final Year Projects, Book publication and Further funding projects* – 6 seminars and workshops were carried out with students, scholars, practitioners and general public. Survey conducted after the events indicated an average satisfaction rating of 5.6 (out of 7), with positive comments and feedback. Research deliverables were shared in 10 seminar/talk events as invited speakers. 5 internship projects and seventeen final-year/senior year projects were carried out in supporting the students carried out studies in this subject. A book has been published for students and practitioners, including carbon footprint, renewable energy and sustainability development in GBA. With the hydrogen fuel cell, carbon footprint and sustainability research conducted, further ideas and potential research was identified, further collaborations and research projects were submitted including RGC FDS, IIDS, PPR and ITF projects, with FDS and IIDS proposals successfully funded.

6.2 Potential for further development of the research and the proposed course of action
(Maximum half a page)

(1) Further development with a focus on Micro-environment modulation of metal catalysts for effective hydrogen production from ammonia borane methanolysis and the design of a mini-reactor for on-demand hydrogen generation was identified. The team had collaborated with SciCorp (China) Co. Ltd. and submitted a proposal to the Guangdong-Hong Kong Technology Cooperation Funding Scheme (TCFS) of the Innovation Technology Fund (ITF).

(2) The deliverable of solid-state storage hydrogen fuel cell development was discussed with DHL Express and explored with their management on the warehouse applications. Further exploration on the collaboration will be carried out.

(3) Further investigation on the tunable hydrogel electrolyte-integrated Covalent organic framework was explored. A research project proposal, titled "Development of Intrinsically Safe Rechargeable Nickel-Zinc Batteries with Tunable Hydrogel Electrolyte-Integrated Covalent Organic Frameworks" was submitted to the RGC FDS Competitive Research Funding Schemes for the Local Self-Financing Degree Sector. It was successfully funded (UGC/FDS25/P01/24) (Funded amount: HK$1,059,747).

(4) The research development on optmising the indirect emission of product along the shipping and transport operations was identified, with a RGC FDS project proposal titled "Development of a carbon neutrality model for optimising indirect shipping emissions from components in a multilevel bill of materials across the value chain in product life cycle" prepared and submitted. It was successfully funded (UGC/FDS14/E07/24) (Funded amount: HK$738,126).

(5) Further research was explored on investigating the sustainability initiatives on the cross-border e-commerce and logistics for GBA. A RGC IIDS proposal titled "Building and Sustaining the Momentum of Cross-border E-commerce for the Greater Bay Area" was submitted. It was successfully funded (UGC/IIDS24/B02/22) (Funded amount: HK$282,770).

(6) Further development with a focus on the environmental impact and the consumer behaviour on product carbon footprint was identified. Further proposal was submitted to the Public Policy Research (PPR) Funding Scheme with a longitudinal studies research perspective.

6.3 Research collaboration achieved
(Please give details on the achievement and its relevant impact.)

(1) The collaboration of THEi and HSUHK achieved the development of a solid-state storage hydrogen fuel cell with catalytic hydrolysis of AB in optimised reactivity and stability. Findings and deliverable were published in journals, including Journal of Materials Chemistry A (IF: 11.9), Catalysts (IF: 3.8) and Journal of Visualised Experiments (IF: 1.2).

(2) The development of vehicle LCA model was jointly collaborated among academics and researchers from HSUHK and THEi. The work was compiled in a paper and published in the conference DASA'20. It was further compiled into a journal paper and published in the journal of Sustainability (IF: 3.9).

(3) Enhanced Gravity Models in analysing the carbon emissions from logistics flow among countries were developed with the collaboration of HSUHK, PolyU and CUHK. The work was compiled into a journal paper and published in the International Journal of Sustainable Transportation (IF: 3.1).

(4) Two enhanced Gravity Models and four Machine Learning-based Models were developed with the collaboration of HSUHK and THEi in evaluating and forecasting the carbon emission impact from the trade and logistics flow among cities. The work was compiled and submitted to a journal paper.

(5) The project team has collaborated with Hong Kong Transport and Logistics Association (HKTLA), Zhuhai Port Association and Beijing Normal University Zhuhai (BNUZ), involving data collection for the Gravity Model analysis.

(6) This project initiated a collaboration with scholars from Shenzhen University in conducting research on modelling renewable energy market behaviours and predictive modelling for climate risk mitigation. The research predicted the future scenarios of the renewable energy market and climate risk. The article was compiled into a paper for submitting to the journal of Energy Strategy Reviews.

(7) This project initiated the cooperation with Shandong Vocational and Technical University of International Studies in setting up a sustainability related research centre in the Hang Seng University of Hong Kong. This research centre is dedicated to environmental and carbon reduction studies, with a primary focus on promoting the adoption and utilization of future new energy sources.

(8) The team engaged the collaboration with Green Source Technology Co., Ltd. in Shenzhen and Zhuhai in the GBA, with the aim of jointly promoting the development of renewable energy and the implementation of sustainable transportation. Through the collaboration, the specialized knowledge and resources of Green Source Technology Co., Ltd. (Shenzhen and Zhuhai) in renewable energy technologies was leveraged in enhancing the research depth and practicality of the project.

7 Layman's Summary
(Describe <u>in layman's language</u> the nature, significance and value of the research project, in no more than 200 words)

The need for sustainable low-carbon transport and logistics has become one of the top priorities in most countries since emission targets were set at the COP21. Carbon mitigation in the transport and logistics sector was emphasised in the recent World Economic Forums, as the sector is the second-largest carbon emitter in the world. Policy Address in Hong Kong stressed the role of renewable energy in combating climate change, aligning with its goal to reduce carbon intensity of 65-70% by 2030. This project focuses on the development of a novel solid-state storage hydrogen fuel cell, vehicle carbon footprint model, and a sustainable transport research database as well as their related assessments on the economic and environmental impacts in Hong Kong and the Greater Bay Area (GBA). Enhanced gravity models and machine learning-based algorithms are developed in evaluating the emission from the trade and logistics flow among these cities. The outcomes provide valuable insights across scholar, academia, and industry, enhancing sustainable transportation practices and supporting policy decisions. The project supplements teaching materials on sustainable transportation and logistics with useful materials and case studies. In the long run, the project contributes to achieving zero-carbon transport and logistics in the smart cities of GBA.

Part C: Research Output

8   Peer-Reviewed Journal Publication(s) Arising <u>Directly</u> From This Research Project
(Please attach a copy of the publication and/or the letter of acceptance if not yet submitted in the previous progress report(s).   All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				Author(s) *(denote the corresponding author with an asterisk*)*	Title and Journal /Book *(with the volume, pages and other necessary publishing details specified)*	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this Report *(Yes or No)*	Acknowledged the Support of RGC *(Yes or No)*	Accessible from the Institutional Repository *(Yes or No)*	This is a Collaborative Work *(Yes or No)*
Year of Publication	**Year of Acceptance** *(For paper accepted but not yet published)*	**Under Review**	**Under Preparation** *(optional)*							
2020				Li, Y., Tsang, C.W.*, Chan, E.M.H., Wong E.Y.C., Ho, D.C.K., Lu, X. and Liang C.*	**Title:** Sustainable Option for Hydrogen Production: Mechanistic Study of the Interaction between Cobalt Pincer Complexes and Ammonia Borane **Journal:** *Catalysts* 2020, 10(7), 723. **IF:** 3.8 **Doi:** 10.3390/catal10070723	2021	Yes (Annex II)	Yes	Yes https://research db.hsu.edu.hk/v iew/publication /202000263	Yes
2021				Wong, E.Y.C., Ho., D.C.K., So, S.*, Tsang, C.W. and Chan, E.M.H.	**Title:** Life Cycle Assessment of Electric Vehicles and Hydrogen Fuel Cell Vehicles Using the GREET Model – A Comparative Study **Journal:** *Sustainability,* 13(9), 4872 **IF:** 3.3 **Doi:** https://doi.org/10.3390/su13094872	2021	Yes (Annex III)	Yes	Yes https://research db.hsu.edu.hk/v iew/publication /202100249	Yes
2021				Poon, P.C. *, Lee, K.M. *, Wang, Y., Lam, W.W.Y., Leung, P.S.W., Lu, X.Y., Li, W., Mehdi, B.L., Lu, Y., Tsang, C.W. and Wong, E.Y.C.	**Title:** Synthesis of Metal Nanoparticles Supported on Carbon Nanotube with Doped Co and N Atoms and its Catalytic Applications in Hydrogen Production **Journal:** *Journal of Visualized Experiments* 178 (2021) **IF:** 1.4 **Doi:**10.3791/62965	No	Yes (Annex IV)	Yes	No	Yes
2022				Poon, P.C., Wang, Y., Li, W., Suen, D.W., Lam, W.W.Y., Yap, D.Z.J., Mehdi, B.L., Qi, J., Lu, X.Y., Wong, E.Y.C.*, Yang, C. *,	**Title:** Synergistic effect of Co catalysts with atomically dispersed CoNx active sites on ammonia borane hydrolysis for hydrogen generation. **Journal:** *Journal of Materials Chemistry A*	No	Yes (Annex V)	Yes	Yes https://researc hdb.hsu.edu.hk /view/publicati on/202200051	Yes

					Tsang, C.W. [*]	**IF:** 11.9 **Doi:** https://doi.org/10.1039/D1TA09750D				
2024					Wong, E.Y.C.[*], Ling, K.K.T., Tai, A.H. and Yuen, A.	**Title:** Two-stage multilateral trade-based prediction model for freight transport carbon emission of Belt and Road countries along Eurasian Landbridges **Journal:** *International Journal of Sustainable Transportation* (2024): 1-18 **IF:** 3.963 **Doi**: https://doi.org/10.1080/15568318.2024.2392190	No	Yes (Annex VI)	Yes	Yes https://research db.hsu.edu.hk/v iew/publication /202400156	Yes
			✔		Suen, D.W.S, Lu, X.Y., Yan, Y., Li, X., Feng, Z., Wong, E.Y.C., Tsang, C.W., Wang, B.	**Title:** Sustained Stability of Co and Mn4N Nanocluster for hydrogen release from Ammonia Borane. **Journal:** *International Journal of Hydrogen Energy*	No	Yes (Annex VII)	Yes	No	Yes
			✔		Chan, M.H.E., Yip, T.L., H.O. Nguyen, Wong E.Y.C. and Tsang, C.W.	**Title:** Integrating Artificial Neural Networks into the Gravity Trade Model: Analyzing Apparel Export Trends from Belt and Road Asian Countries to the United States. **Journal:** *Maritime Business Review*	No	Yes (Annex VIII)	Yes	No	Yes
			✔		Wong, E.Y.C., Wei, R., Ho, D.C.K., Tsang, C.W.	**Title:** An Enhanced Gravity Model of Sustainable Urban Development through Developing Optimization Models for reducing Emissions of Greenhouse Gases of the InterCity Transportation **Journal:** *Transportation Research Part D: Transport and Environment*	No	Yes (Annex IX)	Yes	No	Yes
				✔	Wong, E.Y.C., Wei, R. and Raza, A.	**Title:** Forecasting Future: A Study on Moderation Effects on Modelling and Assessing the Impact of Urbanization and Renewable Energy on Carbon Emissions **Journal:** *Energy Strategy Review*	No	Yes (Annex X)	Yes	No	Yes

9   Recognized International Conference(s) In Which Paper(s) Related To This Research Project Was / Were Delivered
   (Please attach a copy of each conference abstract)

Month / Year / Place	Title	Conference Name	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this Report *(Yes or No)*	Acknowledged the Support of RGC *(Yes or No)*	Accessible from the Institutional Repository *(Yes or No)*	This is a Collaborative Work *(Yes or No)*
8th – 9th November 2020 / Online	Comparative analysis on carbon footprint of hydrogen fuel cell and battery electric vehicles based on the GREET model	The 2020 International Conference on Decision Aid Sciences and Applications (DASA'20)	Yes (2021)	Yes (Annex XII)	Yes	Yes https://researchdb.hsu.edu.hk/view/publication/202000218	Yes
18th – 19th March 2021 / Online	On Sustainable Transportation – A Novel Model for Assessing the Environmental Impact of Zero-Emissions Vehicle (ZEV) Using Hydrogen Fuel-Cell	International Conference on Business, Economics, and Information Technology (ICBEIT2021)	Yes (2021)	Yes (Annex XIII)	Yes	Yes https://researchdb.hsu.edu.hk/view/publication/202100031	Yes
28th – 30th April 2021 / Online	A Novel Approach of Environment Impact Assessment and Emission Measurement on the Inter-City Transportation in the Greater Bay Area (GBA) of China Using a Modified Gravity Model	7th International Conference on Vehicle Technology and Intelligent Transport Systems (VEHITS2021)	Yes (2021)	Yes (Annex XIV)	Yes	Yes https://researchdb.hsu.edu.hk/view/publication/202100032	Yes
29th June – 1st July 2022 / Korea	A Feasibility Assessment of the Optimal Use of Hydrogen Drones in Fashion Item Replenishment Logistics	International Association of Maritime Economists Conference 2022 (IAME2022)	No	Yes (Annex XV)	Yes	Yes https://researchdb.hsu.edu.hk/view/publication/202200325	Yes
8th – 9th December 2022 / UK	Synergistic function of nanocluster and single atom catalysts for exceptional performance in the hydrogen production from solid hydrogen storage materials	Recent Advances in Chemistry, UK	No	Yes (Annex XVI)	Yes	Yes https://repository.vtc.edu.hk/cgi/viewcontent.cgi?article=1010&context=thei-dcee-sp	Yes

11st – 12th August 2023 / Hong Kong	An analysis of emission impact on the deployment of electric vehicles in Jingdong Logistics using the GREET model and LCA methodology	Conference 2023 – Building and Sustaining the Momentum of Cross-border E-commerce for the Greater Bay Area	No	Yes (Annex XVII)	Yes	No	Yes
11st – 12th August 2023 / Hong Kong	Supercapacitor energy storage for electric vehicles in the urban public transport system of the Greater Bay Area – A case study of GreenSource Technology Company	Conference 2023 – Building and Sustaining the Momentum of Cross-border E-commerce for the Greater Bay Area	No	Yes (Annex XVIII)	Yes	Yes https://researchdb. hsu.edu.hk/view/p ublication/202300 199	Yes
23rd – 25th October 2023 / Online	CoMnxNy supported on carbon nanotube with atomically dispersed Co active sites for efficient hydrogen generation from hydrolysis of ammonia borane.	The 3rd International Conference on New Carbon Chemistry and Materials 2023 (CCM 2023)	No	Yes (Annex XIX)	Yes	No	Yes

10 Whether Research Experience And New Knowledge Has Been Transferred / Has Contributed To Teaching And Learning
(Please elaborate)

1. Updates in Course Content

The research findings and results were incorporated into the teaching and learning of relevant courses, particularly in the field of supply chain management. The modules include Sustainable Supply Chain Management, Sustainable Transportation, Shipping and Transport Logistics, and Transport Logistics and Law, ensuring students are updated with latest research and industry developments.

2. Final Year Projects

With the project initiatives and support in the areas of renewable energy, carbon footprint and environmental impact analysis, these topics were incorporated into the final year projects of students.

3. Introduction of Practical Case Studies

Cases studies and scenarios were incorporated into the teaching modules. Students can better grasp the integration of theory and practice, thereby enhancing their interest and engagement in learning. For instance, case analyses on electric vehicles and hydrogen fuel cars enabled students to apply their theoretical knowledge in practical scenarios and engage in in-depth discussions.

4. Promotion of Interdisciplinary Projects

The research facilitated interdisciplinary collaboration projects, encouraging students from various disciplines to participate in research related to sustainable transportation. This collaboration not only enriched students' learning experiences but also nurtured their teamwork skills and innovative thinking.

5. Conducting Seminars and Workshops

Seminars and workshops were organised in which students studying in related modules could participate in the talk. The seminars and workshops provided students with opportunities to interact with industry experts and scholars, enhancing their understanding of renewable energy and sustainable transportation. These activities also served as practical platforms for students, facilitating in-depth learning and knowledge application.

11 Student(s) Trained

(Please attach a copy of the title page of the thesis)

Name	Degree Registered for	Date of Registration	Date of Thesis Submission / Graduation
	BBA-SCM*	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BEng (EEM)**	9/2017	05/2021
	BEng (EEM)	9/2017	05/2021
	BEng (EEM)	9/2017	05/2021
	BEng (EEM)	9/2018	June 2022/Dec 2022
	BEng (EEM)	9/2018	June 2022/Dec 2022

	BEng (EEM)	9/2018	June 2023/Dec 2023
	BEng (EEM)	9/2018	June 2023/Dec 2023
	BEng (EEM)	9/2018	June 2023/Dec 2023
	BEng (EEM)	9/2020	June 2022/Dec 2022
	BEng (EEM)	9/2020	June 2022/Dec 2022
	BEng (EEM)	9/ 2020	June 2024/Dec 2024
	BEng (EEM)	9/2021	June 2023/Dec 2023
	BBA-SCM*	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2017	05/2021
	BBA-SCM	9/2018	05/2022
	BBA-SCM	9/2018	05/2022
	BBA-SCM	9/2018	05/2022
	BBA-SCM	9/2018	05/2022
	BBA-SCM	9/2022	05/2024
	BBA-SCM	9/2022	05/2024
	BBA-SCM	9/2022	05/2024
	BBA-SCM	9/2022	05/2024
	BBA-SCM	9/2022	05/2024

 * BBA-SCM – BBA in Supply Chain Management
** BEng in Environmental Engineering and Management

12 Other Impact

(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, teaching enhancement, etc.)

- Collaborated with other research institutions: The development of the solid-state hydrogen fuel cell, carbon footprint and environmental impact analysis has been collaborated with HSUHK, THEi, The Hong Kong Polytechnic University, the Chinese University of Hong Kong, University of Science and Technology Liaoning and Dalian University of Technology.

- Collaborated with industry partners: The development of renewable energy and its applications have been liaised and collaborated with several industry partners, including SciCorp (China) Co. Ltd., Green Source Technology Co. Ltd., and DHL Express.

- Collaborated in conference papers and journal paper publication: The journal and conference papers have been collaborated with HSUHK, THEi, The Hong Kong Polytechnic University, The Chinese University of Hong Kong, University of Science and Technology Liaoning and Dalian University of Technology.

- Collaborated in renewable energy behaviour research with universities in GBA: This project collaborated with scholars from Shenzhen University to conduct research and jointly complete relevant papers on modelling renewable energy market behaviours and predictive modelling for climate risk mitigation. The research predicted the future scenarios of the renewable energy market and climate risk. The article has been submitted to the journal of Energy Strategy Reviews.

- Collaborated in research centre initiatives: This project explored and liaised with Shandong Vocational and Technical University of International Studies to set up a renewable energy and sustainability related research centre at the Hang Seng University of Hong Kong. This research centre is dedicated to environmental and carbon reduction studies as well as promoting the adoption and utilization of future new energy sources.

- Collaborated with industry in GBA: This project had been engaged with a further collaboration with Green Source Technology Co., Ltd. in Shenzhen and Zhuhai within the GBA, with the aim of jointly promoting the development of renewable energy and the implementation of sustainable transportation. Through this collaboration, the specialized knowledge and resources of Green Source Technology Co., Ltd. (Shenzhen and Zhuhai) in renewable energy technologies could be leveraged to enhance the research depth and practicality of the project.

13 Statistics on Research Outputs

	Peer-reviewed Journal Publications	Conference Papers	Scholarly Books, Monographs and Chapters	Patents Awarded	Other Research Outputs (please specify)	
No. of outputs arising directly from this research project	9 (5 papers have been published, and 3 papers have been submitted and under review, and 1 paper under preparation)	8	1		Type	No.

14 **Public Access Of Completion Report**
(Please specify the information, if any, that cannot be provided for public access and give the reasons.)

Information that Cannot Be Provided for Public Access	Reasons
N/A	N/A

15 **Technology Transfer Plan (Optional)** *(Please write on separate page)*

For project coordinator who may wish to apply for funding support from the Government's Innovation and Technology Fund at a later stage, he / she may provide a technology transfer plan or an update of the technology transfer plan previously submitted in the proposal in a separate page. The plan / update will be passed to the Innovation and Technology Commission for advance information. This update will not be assessed by the RGC. The update should include information such as:

1.   Are there any applications that can be spawned from the new ideas evolved? If yes, what are these potential applications?
2.   Are there any potential users identified for the new ideas evolved?
3.   Are the new ideas evolved patentable or capable of protection by IP laws?
4.   Details of the technology transfer activities conducted during the report period.