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"SCIENTIFIC MAPPING OF STUDIES CONDUCTED ON THE ADOPTION OF ELECTRIC AND HYBRID VEHICLES"

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ABSTRACT:

This paper provides an in-depth analysis of research areas about the uptake of charging and hybrid automobiles. utilizing co-citation, co-occurrence, and bibliographic coupling methodologies. The analyses cover a wide range of topics including factors influencing consumer adoption, policy interventions, technological advancements, and environmental ramifications.

For electric car adoption, the co-citation analysis revealed clusters focusing on consumer behavior, government incentives, and market potential. In contrast, the co-occurrence analysishighlighted research areas such as demand-side incentives, charging infrastructure, and technological developments. Additionally, the bibliographic coupling analysis identified clusters addressing barriers, policy effectiveness, and environmental impacts of electric vehicle adoption. Similarly, for hybrid car adoption, the analyses unveiled clusters examining factors such as risk perceptions, cultural dimensions, and individual values influencing consumer behavior. The co-occurrence analysis identified research areas related to policy incentives, technology adoption life cycle, and sustainable transportation. The bibliographic coupling analysis further highlighted clusters investigating consumer behavior, policy effectiveness, andtechnology advancements in the hybrid & widespread use of automobiles powered by electricity.

Overall, these analyses provide Beneficial insights into the complex landscape of electric and hybrid vehicle adoption, offering researchers and policymakers a deeper understanding of the various factors influencing adoption rates and informing strategies to promote the widespread uptake of environmentally friendly transportation options.

Difference Between Electric Vehicles and Hybrid Vehicles

Certainly! Electric vehicles (EVs) exclusively rely on electricity stored in rechargeable batteries to power electric motors, resulting in zero tailpipe emissions. They typically have a limited range determined by battery capacity and require access to electric charging stations for recharging. In contrast, hybrid vehicles (HEVs) make use of both an electric motor and a fuel-injected engine, allowing them to operate on a

combination of gasoline and electricity. HEVs do not need to be plugged in for charging, as they use regenerative braking and the gasoline engine to charge their batteries while driving. While EVs offer emissions-free drivingand instant torque, HEVs provide a compromise between fuel efficiency and electric propulsion, making them suitable for drivers with varying range requirements and access to charging infrastructure.

Why Do We Want to Do the Comparison Between EV And HV

Comparing electric vehicles (EVs) and hybrid vehicles (HVs) serves several purposes, including:

- **Consumer Education:**
  Comparing EVs and HVs helps consumers understand the differences between these two types of vehicles, enabling them to make informed decisions when purchasing a new car. By becoming knowledgeable of the unique features, and advantages coupled with restrictions of each type, consumers canopt for the vehicle that best satisfies their expectations, driving habits, and environmental preferences.
- **Environmental Impact:**
  Comparing the environmental impact of EVs and HVs helps policymakers, researchers, and consumers assess which type of vehicle is more environmentally friendly. This comparison considers factors such as tailpipe emissions, energy efficiency, and lifecycle greenhouse gas emissions associated with manufacturing, operating, and vehicle disposal.
- **Technology Advancements**:
  Analyzing the technological differences between EVs and HVs facilitates the identificationof areas for innovation and improvement. Understanding the strengths and weaknesses of each
  technology can drive advancements in battery technology, electric drivetrains, charging infrastructure, and hybrid systems, ultimately leading to more efficient and sustainable transportation solutions.
- **Market Analysis**:
  Comparing the market trends, sales figures, and consumer preferences for EVs and HVs provides valuable insights into the automotive industry. By monitoring the adoption rates,market penetration, and consumer acceptance of each type of vehicle, automakers, investors, and policymakers can anticipate future trends, adjust production strategies, and develop supportive policies to promote sustainable transportation solutions.
- **Policy Development:**
  Evaluating the regulatory landscape, incentives, and policy interventions for EVs and HVs helps policymakers design effective measures to promote clean transportation and reduce greenhouse gas emissions. By understanding the economic, social, and environmental implications of different policy options, policymakers can implement targeted initiatives toaccelerate the utilization of electric power and hybrid cars, such as incentives for acquiring EVs, investment in charging infrastructure, and emissions standards for conventional vehicles.

Overall, comparing EVs and HVs contributes to a comprehensive understanding of theautomotive industry, informs consumer choices, drives technological innovation, and supports policy development efforts to achieve sustainable transportation systems.

INTRODUCTION

Electric cars are powered solely by electricity or electric power. They run on a large battery pack thatplugs into a station, like your phone. Electric power products are ecologically beneficial since they have no tailpipe emissions at all. However, their range on a single charge is typically shorter than gasoline cars. Hybrid vehicles (HEVs), however, pair an engine made of gasoline with an electric motor (Vk Chakravarthy and Cs Daw (2011), Zlatina Dimitrova, and Francois Marechal (2015)). They use a smaller battery charged by the engine and regenerativebraking, capturing energy during slowdowns. While offering better fuel efficiency and lower emissions than gasoline cars, HEVs still produce some emissions because they have a gasoline engine. The key difference is that EVs rely solely on clean electricity, while hybrids use a combination of

gasoline and electricity.

Electric vehicles are experiencing explosive growth, with sales zooming past 10 million globally in 2022. This surge is driven by a confluence of factors. Government incentives are making EVs more affordable for consumers (Graciela Metternicht and Danielle Drozdzewski (2019)), while breakthroughs in the discipline of batteries are decreasing charge times and increasing range.

Hybrids, which combine gasoline engines with electric motors, are also seeing growth, but at a slower pace. In some regions with developing charging infrastructure, hybrids offer a practical and less expensive option compared to fully electric vehicles. This makes them a stepping stone for consumers who are interested in the fuel efficiency and environmental benefits of electric technology but may not be quite ready to fully commit to an EV. Looking ahead, experts predict a tipping point for electric vehicles around 2026, with sales accelerating rapidly. Major car manufacturers are already shifting gears, prioritizing electric vehicle development, and announcing plans to phase out gasoline-powered cars. With these trends in motion, it is clear that electric automobiles are not just a fad, but the driving force behind the futureof transportation.

Till now the authors have conducted research on a wide range of topics related to the adoptionof hybrid and electric automobiles. These topics include consumer behavior and preferences,barriers to acquiring such as pricing, range anxiety, and charging equipment availability, theinfluence of government incentives & policy interventions on adoption rates, socio-technical barriers influencing consumer acceptance of EVs, factors influencing consumers' willingness to pay for hybrid and electric vehicles, identifying potential early adopters and market segments, and the influence of individual values, attitudes, and perceptions on purchase intentions. Additionally, studies have examined the effectiveness of different types of incentives, the role of charging infrastructure and range limitations in EV adoption, and the significance of local policies and demographic factors in shaping adoption patterns. Overall, this research contributes to a better understanding of the complexities surrounding hybrid andelectric vehicle adoption and offers insightful information to manufacturers, lawmakers, and other stakeholders seeking to advance sustainable transportation alternatives.

We are engaging in science mapping on the adoption of hybrid and electricity-powered cars to gain a comprehensive understanding of the research landscape in this field. By analyzing co-citationand co-word patterns, mapping research networks, and tracking trends over time, we aim to identify key research areas, collaborations, and emerging trends. This analysis allows us to uncover prevalent concepts, methodologies, and interdisciplinary connections, providing insights into the complex factors influencing adoption dynamics. Understanding the geographical distribution of research activities and synthesizing findings with empirical data helps inform evidence-based policymaking and industry strategies to promote electric and hybrid vehicle adoption. Ultimately, our goal is to contribute to advancing knowledge in this area and facilitating the transition towards sustainable transportation solutions.

METHODOLOGY:

- **MATERIALS AND METHODS:**

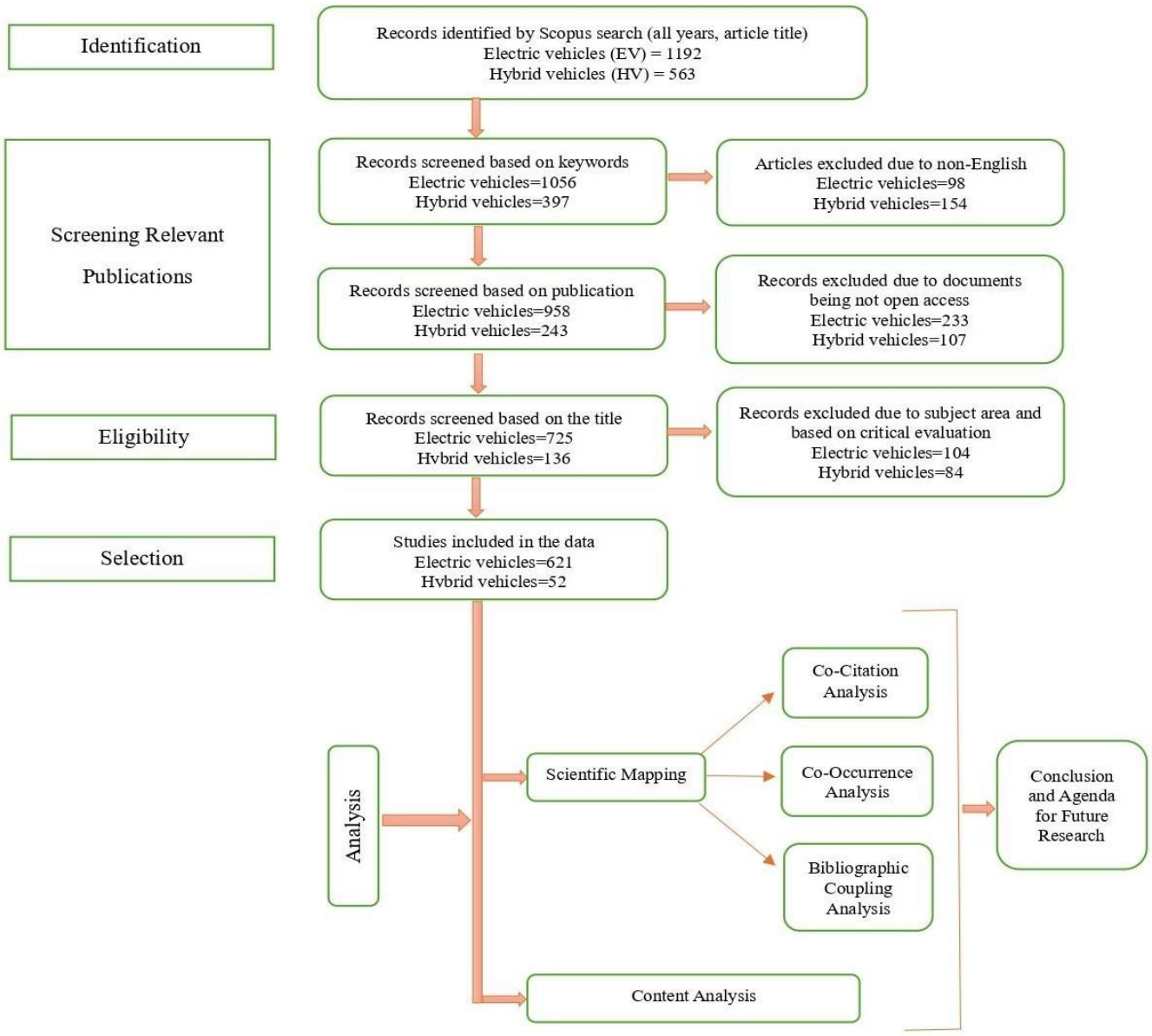
This study deployed the use of bibliometric analysis to accomplish the stated research questions. Since Bibliometrics empowers researchers to do scientific descriptive analysis, beginning with bibliographic databases, it has attracted the attention of scholars from a plethora of fields from different authors like Axsen (2013), Sova cool, B. K., & Hirsh, R. F. (2009), Gillingham, K., & Stock, J. H. (2018), Lie, T. (2017), Gillingham, K., & Stock, J. H. (2018), & Rashid, M. H. A. (2021). These researchers help to unveil the "hidden patterns" that define the field, as well as enable exploring vistas for future research. This section focuses on the methodology employed to accomplish the stated research questions.

- **DATABASE CURATION:**

To accomplish the foregoing goals of the study, a bibliometric analysis of academic workspublished between 1973 and 2023 was conducted. SCOPUS was chosen to compilebibliometric data because of its extensive database. This advisory council ensures only the best quality publications are indexed, and continual evaluation and upgrade of quality control mechanisms.

- **KEYWORD IDENTIFICATION:**

Keywords used to find relevant literature on 'adoption of electric & hybrid vehicles' werechosen using a two-way strategy. The authors began by reviewing fifteen open-access publications (from SCOPUS). In the next stage, our professor with relevant experience were shown the list of keywords that had been compiled in the previous phase. Academicswere briefed on the study's research questions and asked to evaluate the preliminary list of keywords.



SCIENCE MAPPING

Co-citation analysis:

Co-citation facilitates the assessment of two research publications' subject similarity. A pair of research documents are considered co-cited when they are mentioned in a third document. The degree of co-citation between two publications is determined by the quantity of identically cited items. The degree of link or relationship between documents as judged by the group of citing writers is known as co-citation intensity.

Hybrid car (co-citation analysis)

Cluster 1:

The main areas of exploration Cluster 1 represented by red color in Fig.1.1 highlights key researchareas that appeared from this cluster and were investigated by Axsen and Kurani (2013) who surveyed new car buyers

in San Diego County to assess interest levels in pure electric, plug into hybrid, hybrid, and conventional combustion automobiles. the factors influencing consumer adoption of electric vehicles (EVs) and alternative energy vehicles. These studies delve into various aspects of consumer behavior, preferences, and barriers associated with adopting electric and hybrid vehicles.

Egbue and Long (2012) Cluster 1 represented by red colour identifies socio-technical obstacles to EV adoption among customers and stresses the importance of addressing critical consumer concerns in policymaking. Initially, the papers examine consumer interest in EVs and electric-driven vehicles through surveys, focusing on their preferences, concerns, and motivations (Paper1). They identify barriers like limited range, charging availability, and higher automobile purchase prices while highlighting normal +ve interest integrated with vehicle picture of intelligence, responsibility & environmental support.

Subsequently, the research explores socio-technical barriers to EV adoption and assesses the influence of sustainability issues on consumer decisions (Paper 2). By targeting technology enthusiasts and early adopters, the study aims to understand their preferences and perceptions,which could play an important role in driving Electric automobile adoption.

Cluster 2:

The key areas of cluster 2 are represented by blue color in Fig.1.1. Research that we see fromthis cluster was Identified by Campbell et al. (2012) conducted a case study in Birmingham, United Kingdom, utilizing cluster analysis of Census information to identify potential early adopters of alternative fuel vehicles. Potential Early Acquirers of Alternative Vehicle Drivers, utilizingthis cluster analysis on this data, this study aims to pinpoint potential early adopters ofalternative fuel vehicle drivers in Birmingham, UK. It examines socio-economic characteristicsto discern geographical patterns and potential infrastructure requirements. The findings aid local and national authorities in policy development and marketing strategies.

Factors Influencing Customers' Willingness to Pay for Hybrid Cars: In Turkey, a questionnaire investigates the factors affecting customers' willingness to pay a premium for hybrid cars. Results reveal that income, education level, environmental concerns, and attitudes toward alternative energy sources influence willingness to pay. The study provides valuable insights for policymakers and Stated Preference Study of Electric Vehicle Choice: Conducted in the US, this study explores customers' preferences and willingness to pay for electric automobiles through a stated preference study. The findings highlight preferences for driving efficiency, charge time, and diesel or petrol cost savings, informing pricing strategies and the marketpotential of electric automobiles & the automotive industry.

Cluster 3:

The main areas of exploration in Cluster 3 are represented by blue color. This cluster was Identifying Consumer Intentions towards PHEVs in Malaysia: Adnan et al. (2018)investigated Malaysian consumers' inclination to acquire PHEVs by applying the Theory of Planning Behaviour (TPB). The study identifies subjective norms, personal moral norms, perceived behavioral control, and attitude as significant determinants of PHEV adoption intention, influenced by environmental concern and moderated by hyperbolic discounting.

Determinants of Hybrid Vehicle Purchase Intentions in Malaysia: Hamzah et al. (2021) explorethe areas influencing Malaysians' intentions to purchase hybrid automobiles by integrating the Norm Activation Model (NAM) and TPB. Their findings indicate that perceived green value, perceived behavioral control, subjective norm, and environmental knowledge positively impactgreen purchase intentions.

Consumer Adoption Intentions for Electric Vehicles in China: Han et al. (2017) analyze customers' intentions to adopt electric vehicles in Hefei, China, using consumption value theory. They categorize value perceptions into useful and ineffective values, finding that perceived functional value, directly and indirectly, affects adoption intentions, while in-effective value impacts adoption intentions indirectly through attitude.

Cluster 4:

The main area of exploration in the cluster was Identifying the Theory of Reasoned Action (TRA): Ajzen and Fishbein (1980) delve into the theory of reasoned action, which proposes that attitudes, subjective requirements, and perceived behavioral control shapebehavioral intentions and subsequent actions. This foundational work sheds light on the psychological mechanisms driving social behavior and finds applications across disciplines such as psychology, sociology, and communication.

Impact of Government Incentives: Diamond (2009) and Gallagher and Muehlegger (2011) investigate in cluster 4 represented by yellow & purple colour. the ramifications of governmentincentives on HEV adoption. Through the analysis of cross-sectional data from US states, theyscrutinize the association between hybrid adoption and diverse policy variables. Diamond underscores the efficacy of incentives that provide upfront payments, while Gallagher and Muehlegger emphasize the significance of the type of tax incentive offered in influencing adoption rates.

Evaluation of Structural equation models: Fornell and Larcker (1981) scrutinize the statisticaltests employed in analyzing structural equation models with unobservable variables and measurement errors. They identify limitations in commonly used tests and propose an alternative testing framework based on common variance measurements within the structural and measurement models to evaluate a model's explanatory capacity.

Cluster 5:

The main area of exploration in the cluster was Identified by Gallagher and Muehl Egger (2011) represented by the purple color in Fig.1.1. which delves into the effectiveness of government incentives aimed at promoting HEV adoption in the United States.Their findings reveal that sales tax waivers significantly boost hybrid sales compared to incometax credits, highlighting the importance of the type of tax incentive offered. Additionally, the study explores how consumer reactions to incentives fluctuate with fuel prices, shedding lighton implicit discount rates concerning future fuel savings.

Mohamed et al. (2016) employ a 2-stage modeling approach to identify potential Electric automobile adopters in Canada. They analyze the influence of personal beliefs, encompassing attitudes, perceived behavioral control, and norms, on individual adoption intentions. The study also identifies socio-demographic factors shaping adoption intentions and categorizes likely early adopters into distinct socio-economic profiles.

Ozaki and Sevastyanova (2011) represented by purple & red colour investigate consumer motivations behind purchasing hybrid vehicles, underscoring the significance of financial benefits and social norms in driving adoption. The study underscores the importance of conveying practical, experiential, and affective values to consumers to encourage hybrid adoption.

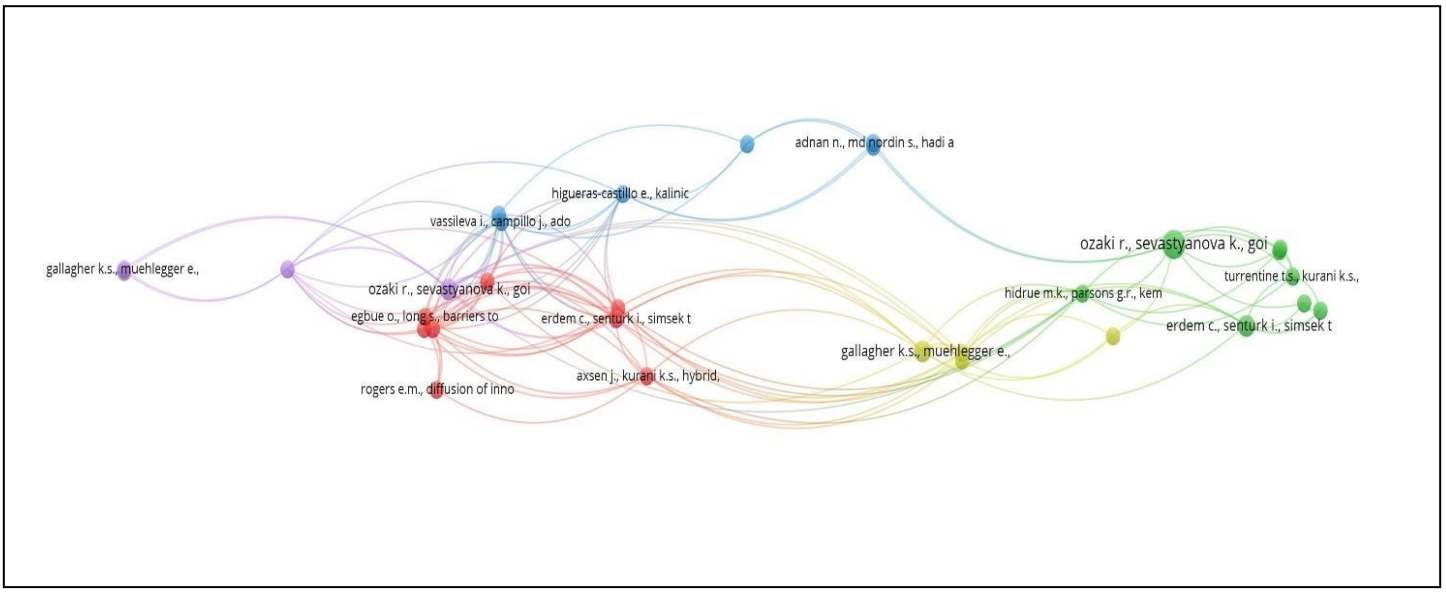


Fig.1.1 Hybrid Car Co-citation Analysis, VOS viewer

Electric car (Co-citation Analysis)

Cluster: 1

The collection of studies investigates various facets of electric and hybrid vehicle adoption, focusing on factors that influence consumer choices, the effectiveness of government policies and incentives, and obstacles hindering widespread adoption.

Government Incentives in the US: Diamond (2009) in cluster 1 represented by red colour scrutinizes how government variables impact the adoption of hybrid & electric vehicles across US states. Using hybrid registration data, the study analyzes the relationship between HEV adoption and policy variables, highlighting the significance of upfront payment incentives.

Barriers to EV Adoption: Egbue and Long (2012) in cluster 1 represented by red colour whichis identified socio-technical hurdles that impede consumer acceptance of electric vehicles (EVs) and assess whether sustainability concerns influence purchase decisions. The research provides insightful information into consumer attitudes and tastes, offering guidance for policymakers and engineers in crafting effective energy and transportation policies.

Impact of Local Policies in Sweden: Egner and Trosvik (2018) in cluster 1 represented by redcolour which empirically examines how local policy instruments affect EV adoption in Sweden. Their findings underscore the positive influence of increased public charging points and EV procurement on adoption rates, emphasizing the need for tailored municipal-level policies.

Cluster: 2

The main area of exploration that appeared from this cluster was Identifying Theory of Planned Behavior (TPB): Ajzen's seminal work (1991) in cluster 2 represented by green colour which lays the groundwork for comprehending consumer behavior toward EVs based on the TPB. This theory posits that attitudes, subjective requirements, and perceivedbehavioral intentions, ultimately shape actual behavior.

Consumer Stated Intent to Purchase EVs: Carley et al. (2013) delve into initial impressions andstated intent to purchase connect-to-electric vehicles among consumers in major US cities. They identify factors influencing interest in EV adoption, including education level, prior hybrid ownership, environmental concerns, and technological perceptions.

Factors Affecting EV Adoption: Coffman et al. (2017) assess factors influencing EV adoption,highlighting government incentives, public charging infrastructure, and consumer perceptions of environmental performance, price value, and range confidence.

Cluster: 3

The main area of exploration that appeared from this cluster was Identifying Impact of Fiscal Incentives on EV Market Entry: Levay et al. (2017) in cluster 3 represented by blue colour which analyzes how fiscal incentives affect the market penetration of EVs by comparing the total value of ownership between EVs and internal combustion engine (ICE) vehicles. Their findings underscore a negative correlation between TCO and EV sales, which varies based on car segments and country contexts, highlighting the significance of fiscal incentives in lowering TCO and enhancing EV adoption rates.

Charging Behavior and Infrastructure Planning: Morrissey et al. (2016) examine the chargingpatterns of existing EV users in Ireland to understand their preferences regarding charging locations, energy requirements, duration, and preferred charging methods. Their study sheds light on the usage patterns of public charging infrastructure, suggesting the potential viability of fast charging facilities in the near to medium term.

Barriers and Experiences of Early Adopters: Vassileva and Campillo (2017) in cluster 4 represented by blue color which is investigates the obstacles to EV adoption based on insightsfrom early adopters in Sweden.

Their analysis of socio-demographic profiles, motivations for selecting EVs, charging habits, and driving preferences among private EV owners offers valuable insights into promoting the sustainable and widespread adoption of EVs.

Cluster: 4

The main areas of exploration that appeared from this cluster were Identifying Impact of Policy Incentives on EV Adoption: Langbroek et al. (2016) in cluster 4 represented by yellow colourwhich investigates how policy benefits influence the adoption of EVs. They utilize the Trans-theoretical model of change and the protection motivation theory to assess the effect of various policy benefits on the likelihood of individuals stating their intention to adopt EVs. The study reveals that the contingency of charging adoption increases when policy benefits are offered, with preferences for specific incentives varying among different demographic groups. For instance, incentives like free parking or access to bus lanes emerge as attractive alternatives to costly subsidies.

Comparison of Power Device Technologies: Siemieniec and Mente (2021) delve into the comparison of power device technologies aimed at enhancing the efficiency of power supplies.Their analysis focuses on a range of devices used in Switched Mode Power Supplies (SMPS),including Cool MOS Super junction (SJ) devices, Cool Sic Silicon-Carbide MOSFETs, and CoolGaN E-mode Gan power transistors. The study investigates how the unique propertiesof each technology impact application performance and the selection of topology, particularlyin the context of AC-DC conversion for power supplies.

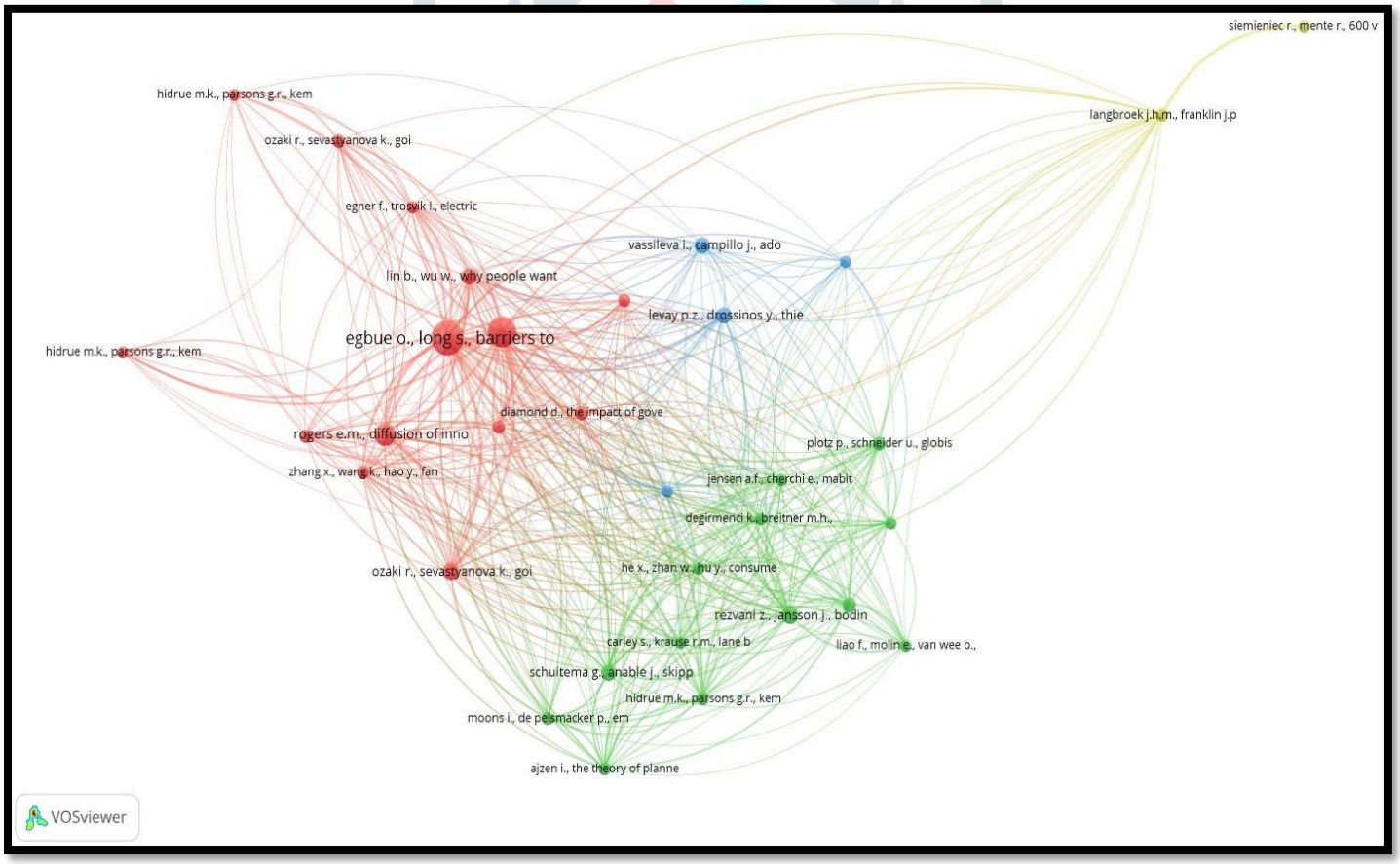


Fig.1.2 Electric Car Co-citation Analysis, VOS viewer

Analysis of Co-occurrence:

Using a bibliometric tool, such as the VOS viewer, co-word analysis helps in identifying an intrinsic relationship between 2 or more keywords from a specific exploration area that appears in the same article. The objective of this relationship can be represented by the number of times these words have co-occurred in the articles that were considered for the bibliometric analysis.

Electric Car (co-occurrence analysis)

Cluster 1

The main areas of Cluster 1 represented by red colour highlight key research areas thatappeared from this cluster were provided encompass a broad spectrum of topics related to electric vehicles (EVs), renewable energy, and climate change. Easwaran Narasimhan and Caley Johnson (2018) surveyed the role of demand-side benefits and charging equipment on connecting to electric adoption in cluster 1 represented by red colour showing the effects of incentives and infrastructure on EV adoption, the potential of Contactless Power Transfer (CPT) systems for charging EVs while in motion, the impacts of EV charging on the electricity grid, the ethical considerations surrounding climate change, and the technological developments and market outlook for EVs.

This overview synthesizes various research areas. It begins with a study that assesses the effectof state and local incentives on the acquiring of plug-in vehicles (PEVs) in the US, focusing on the role of tax benefits and public charging equipment in influencingconsumer behavior.

Cluster 2

The main areas of cluster 2 represented by blue colour explored from this cluster highlight diverse sources of competitive advantages, Simon Caney (2018) with this paper proposing that a combination of Voice and Exit behavioural models can enhance the competitive edge of car manufacturers. Battery Electric Vehicles (BEVs) are a promising solution to environmental concerns and play a pivotal role in smart transportation.

EVs can potentially replace Internal Combustion Engine Vehicles (ICEVs) for last-miledeliveries in e-commerce, providing economic benefits and environmental superiority. The development of the EV industry in China is crucial for energy development, and lithium-ion secondary batteries have played a critical role in advancing battery technology. An examination of attitudes toward surveys found that attitudes are related to exposure to surveying, and the adoption of BEVs is influenced by consumer acceptance.

Cluster 3

The main areas of exploration from cluster 3 are represented by blue colour. This cluster depicts rechargeable batteries, eliminating the necessity for fossil fuels or internal combustionengines.

Hanna Ehrnrooth, Christian Gronroos (2013**)** Subsequent advancements have led to contemporary BEVs like the Tesla Roadster, capable of traveling over 320 kilometers per charge. BEVs consist of various components, such as batteries, electric motors, and power electronics controllers. Despite their environmental advantages and reduced operating costs, BEVs encounter challenges such as the availability of charging stations and high initial expenses.

Overcoming these challenges necessitates understanding consumer behaviour and addressing technological and infrastructural limitations. Efforts are being made to enhance charging demand models,

explore the economics of EVs, and incorporate renewable energy sources intoEV charging.

The influencing factors were classified into demographic, situational, and psychologicalcategories. The study highlighted the necessity of addressing these factors to stimulate higher BEV adoption rates. Furthermore, it emphasized the importance of considering consumer behaviour and preferences when developing and promoting BEVs.

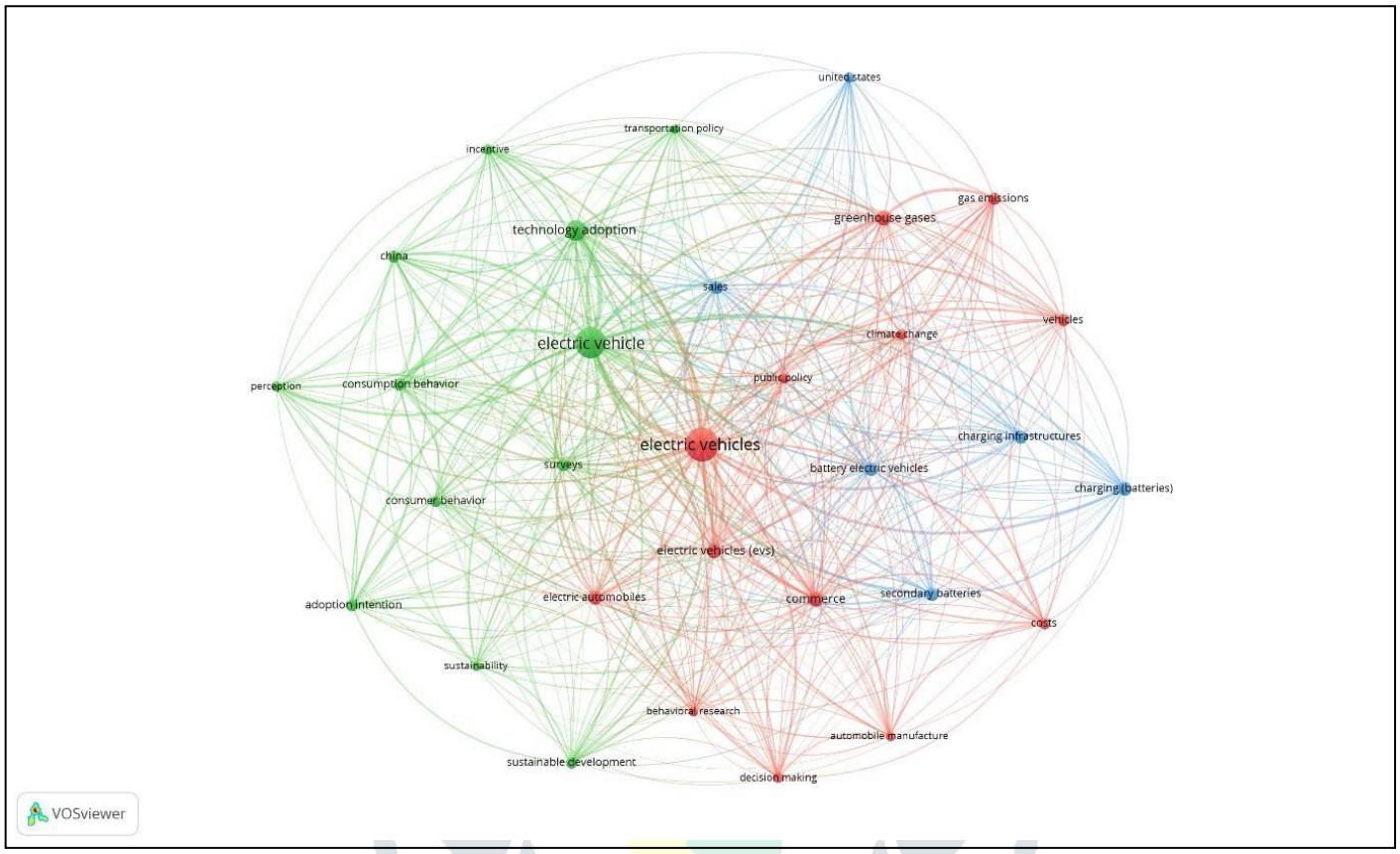


Fig 2.1: - Electric Car Co-Occurrence Analysis (Vos viewer)

Hybrid Car (Co-occurrence Analysis)

Cluster 1

The main areas of research that comes out from cluster 1 were represented by red colour highlighting key research area that appears from this cluster a systematic approach to evaluatinghybrid car adoption by Thomas Waldmann, Margret Wohlfahrt-Mehrens (2021). which includes sorting system variables into groups and developing a hierarchical model of the partnership's stages using Interpretive Structure Modelling (ISM).

Analytic Hierarchical Processes are then used to assess the hybrid vehicle adoption based on 20 system variables, determining the most significant variables quantitatively, such as management strength and power.

This examines the fundamentals of physiochemistry of various mixtures of materials, identifying lithium transport within the electrodes function as a step that restricts the pace of rapid charging. Lithium diffusion and concentration polarization within the active materials and electrolyte phase limit the charging rate, with both effects causing lithium plating on graphite anodes.

Cluster 2

The main areas of exploration appeared from cluster 2 was represented by a blue color that delves into the complex interplay of factors influencing consumer adoption of hybrid cars in the context of promoting greener, more eco-conscious behavior.

Martin Weiss, Andreas Zerfass, Eckard Helmers (2018) by drawing on insights from consumer behavior theory & cultural dimensions theory, research aims to understand the diverse, segmentation of the market.

Perceptions of risk across various cultures, the study focuses on Australian, South Korean, and Japanese consumers, aiming to fill the gap in cross-cultural research on environmental vehicles. Through a comprehensive survey of 817 respondents, the study evaluates the influence of 5 types of risks(social, psychological, time, finance externalities & network externalities) and three key purchasing drivers (item benefits, product glow or attraction, and superiority of the good) on consumers' perceptions of hybrid cars.

Cluster 3

The main areas of research explored from this cluster 3 was represented by a blue colour that delves into the influence of individual values and attitudes on the purchase intention of green products in a developing country, employing the Theory of Reasoned Action (TRA) as its theoretical foundation. Utilizing Structural Equation Modelling (SEM) on data from 257 working respondents, the studies reveal that individual consequences concerning effort and convenience negatively affect the intention to purchase green products under Bernhard Hauler, Andreas Wild, Ulrich S. Schubert (2015), The studies highlight recent advancements in this area and provide insights into the working principles and structural designs of differentcarbonyl materials, along with an evaluation of the impact of conductive additives and binderson cell performance for each material category.

Determinants of Hybrid Vehicle Purchase Intentions in Malaysia Hamzah et al. (2021) explorethe factors impacting Malaysians' intentions to buy eco vehicles by integrating the

Norm Activation Model (NAM) and TPB. Their findings indicate that perceived green value, perceived behavioral control, subjective norm, and environmental knowledge positively impact green purchase intentions.

Cluster 4

The main areas of exploration from this cluster was technology overview investigation of the drivers behind the development of HEVs and categorizing them based on the arrangement of their internal combustion engines and electric motors for traction. It also discusses the kinds of batteries needed and the use of electrical power converters in hybridized electric vehicle for effective power processing and usage drives. Furthermore, the overview evaluatesthe merits and demerits of various types of modified electrical engines for traction drives inHEVs.

Evaluation of Structural Equation Models by Fornell and Larcker (1981) scrutinizes the statistical tests employed in analyzing equation models with unobservable variablesand errors. They identify limitations in commonly used tests and propose an alternative testing framework based on shared variance measures within the structural models and measurement models to evaluate a model's explanatory capacity.

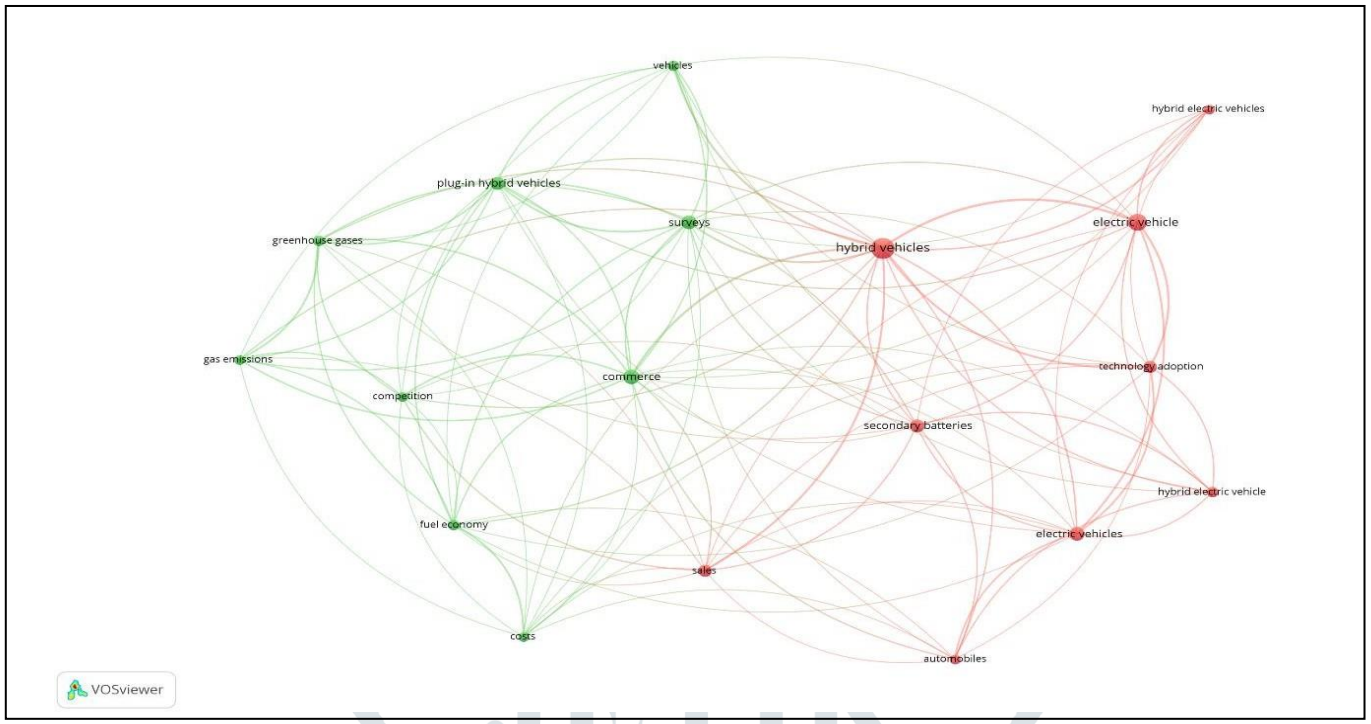


Fig 2.2: - Hybrid Car Co-Occurrence Analysis (Vos Viewer)

Bibliographic Coupling Analysis:

Derived from the premise that works with numerous shared references likely cover similar topics, bibliographic coupling is a science mapping technique. This method proves most beneficial when employed within a limited timeframe, concentrating on categorizing publications into thematic clusters according to their common references. Unlike co-citation analysis, bibliographic coupling directs attention toward recent and specialized publications byclustering them based on their citing sources. Hence, it is particularly advantageous for business researchers seeking insights into the latest developments spanning diverse subject areas.

Bibliographic Coupling (Electric Car Adoption)

Cluster1:

The key areas of research cluster1 represented by red color in Fig.3.1 highlight key research areas that appeared from this cluster and were investigated by wang and Vasseliva (2017) conduct a survey revealing a multifaceted landscape of challenges, policy mechanisms, and behavioral factors influencing consumers' decisions.

Adoption barriers such as pricing, range anxiety, and charging infrastructure pose significant hurdles, while policy incentives and psychological factors like environmental concern play pivotal roles. Shifting the focus from cost reduction to convenience could enhance adoption rates. The significance of charging infrastructure, high-speed chargers, cannot be overstated inovercoming range limitations. Insights into early adopters' profiles and charging behaviors offer valuable insights for promoting sustainable EV adoption.

Cluster2:

The main areas of research explored from this cluster was represented and linked with bothred and green colors in Fig.3.1 investigated by Helveston and Haddadian (2015) related to electric vehicle

(EV) adoption, including barriers, policy incentives, market dynamics, and demographic influences.

They reveal common challenges like consumer skepticism about EV performance and concernsover battery costs and charging infrastructure. Policy incentives are shown to shape consumerpreferences, with diverse impacts across different incentives. The studies also analyze marketdiffusion patterns, individual driving behaviors, and demographic factors affecting adoption rates. Moreover, they highlight the function of fleet managers in influencing EV adopting decisions.

Cluster3:

The main areas of research explored from this cluster were represented with blue color in Fig.3.1 and investigated by Bockarjovoc (2014) and Coffman (2017) collectively examined various factors impacting the adoption of electric vehicles (EVs), encompassing consumer perceptions, environmental considerations, and policy implications.

They delve into the significance of personal values, green self-identity, and symbolic attributesin shaping individuals' intentions to embrace EVs, offering insights into effective marketing strategies and policy interventions.

Cluster4:

The main areas of research explored from this cluster were represented with blue color in Fig.3.1 and investigated by Jansson (2017) and Bakker (2013) with a collection of papers thatdelve into the intricacies of electric vehicle (EV) adoption, exploring various factors that influence individuals' decisions to embrace this technology.

Through investigations into perceived risks, benefits, interpersonal influence, and attitudinal factors, these studies shed light on the complexities surrounding EV adoption. Additionally, they propose a range of policy measures aimed at promoting EV uptake, including supportive initiatives, infrastructure development, regulatory actions, and intergovernmental collaboration.

Cluster5:

The main areas of research explored from this cluster were represented in yellow color in Fig.3.1 and investigated by Avci and Lim (2015) with various aspects affecting the adoptionof electric vehicles (EVs) and suggested strategies to mitigate barriers.

These include examining optimal subsidy schemes for enhancing EV uptake in different market settings, tackling issues related to range anxiety and battery costs, and analyzing the influenceof range and resale concerns on adoption patterns and business models.

Cluster6:

The main areas of research explored from this cluster are represented in red color in Fig. 3.1 investigated two main areas by authors He (2018) and Welch (2000) for consumer perceptions of electric vehicles (EVs) in China and the potential benefits of hybrid electric vehicle (HEV) technology for global energy sustainability.

One study delves into the factors influencing EV purchase intention among Chinese consumers, shedding light on the roles of perception and personality traits, and offering guidance for policymakers and manufacturers. Another paper underscores the significance of HEVs in enhancing car efficiency and extending the longevity of petroleum reserves, advocating for their widespread adoption as a strategic global energy policy.

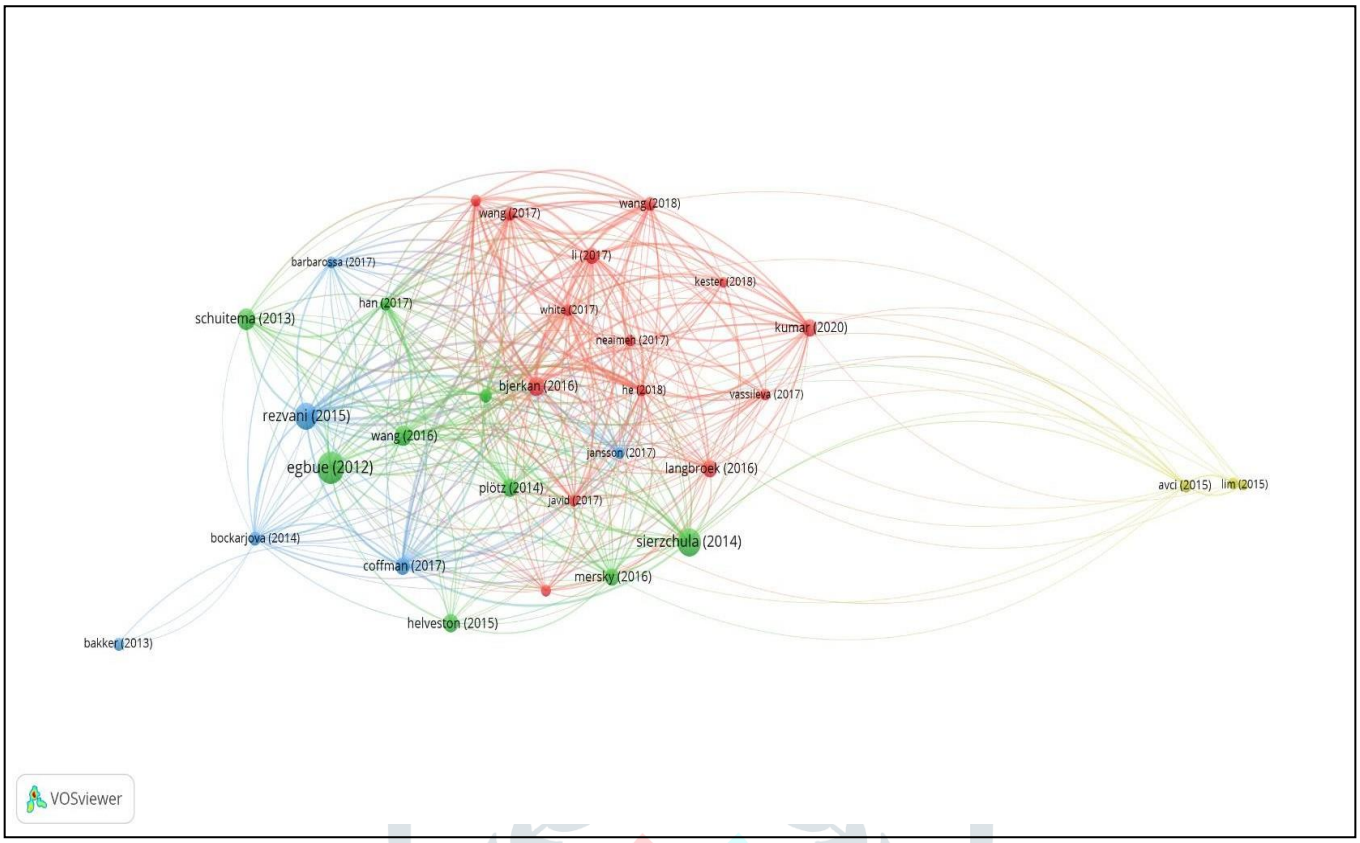


Fig.3.1 – Electric Car Bibliographic Coupling Analysis, (VOS viewer)

Bibliographic Coupling (Hybrid Car Adoption)

Cluster1:

The main areas of research explored from this cluster were represent in red color in Fig.3.2 and investigated by Gallagher (2011) and Heutel (2015) explored various facets of hybrid-electric vehicle adoption and the effects of policy interventions such as vehicle ownership and usage patterns, incentives for adoption, product quality and adoption, technology adoption life cycle, and government policy impact.

These studies collectively contribute to comprehending customer behavior, policies effectiveness, and ecofriendly ramifications concerning the adoption of hybrid-electric vehicles.

Cluster2:

The main areas of research explored from this cluster were represent in green color in Fig.3.2 and investigated by McLeay (2018) and Jeon (2012). The collection of studies that explored diverse factors influencing the adoption of hybrid-electric vehicles (HEVs) across different regions. They delve into consumer motivations and risks associated with hybrid car purchases, analyzing various market segments in Australia, South Korea, and Japan.

Additionally, research in Malaysia examines the factors shaping consumers' intentions to buy hybrid cars, including price sensitivity and perceived behavioral control. Studies conducted inSpain explore the determinants of customer willingness to embrace electro-mobility (EM) options, focusing on emotional considerations, pricing, and technical attributes.

Cluster3:

The main areas of research explored from this cluster were represented with blue color in Fig.3.2 and investigating various aspects of sustainable transportation, particularly focusing onthe acquiring of electric and hybrid vehicles, as well mobility services by the authors Jin (2020) and Khattak (2023).

One study delves into the factors influencing the uptake of battery electric vehicle (BEV) sharing services, considering attitudes, service quality, and vehicle restriction policies. Anotherexamines the role of alternative fuel vehicles (AFVs) in mobility services, analyzing travel preferences and shared mobility patterns.

Cluster4:

The main areas of research explored from this cluster were represented with yellow color and investigating various facets of hybrid electric vehicle (HEV) adoption and its consequencesby Krupa (2012) and Saarenpaa (2013).

Utilizing data mining methods, one paper uncovers regions more conducive to HEV uptake based on socio-demographic data. Another study employs a Genetic Algorithm to forecast consumer acceptance of connection to Hybrid Electric Vehicles. Spatial analysis is conducted to understand the geographical patterns of HEV adoption and its correlation with demographic factors.

Cluster5:

The main areas of research explored from this cluster were representing with purple color inFig.3.2 and investigated by Liu (2017) and Zhu (2013) which delves into hybrid electric vehicle(HEV) technology from diverse angles.

One paper delves into refining HEV performance through sophisticated modeling and control methods. Another introduces an innovative control strategy tailored for unmanned underwater vehicles. Lastly, a study investigates the influence of transport policies, such as the exemptionof HEVs from the London Congestion Charge, on vehicle registration patterns.

Cluster6:

The main areas of research explored from this cluster were represented with light blue colorin Fig.3.2 and investigated by Wang (2016) and Alzahrani (2019) that delve into the potentialupdating of hybrid electric automobiles within Saudi Arabia & China.

In Saudi Arabia, where energy efficiency programs are imperative, the research utilizes the reasoned action theory to explore the factors impacting citizens' inclination towardadopting HEVs.

Meanwhile, in China, a prominent energy-consuming nation, another study employs anextended version of the planning behavior theory to investigate HEV adoption intentions.

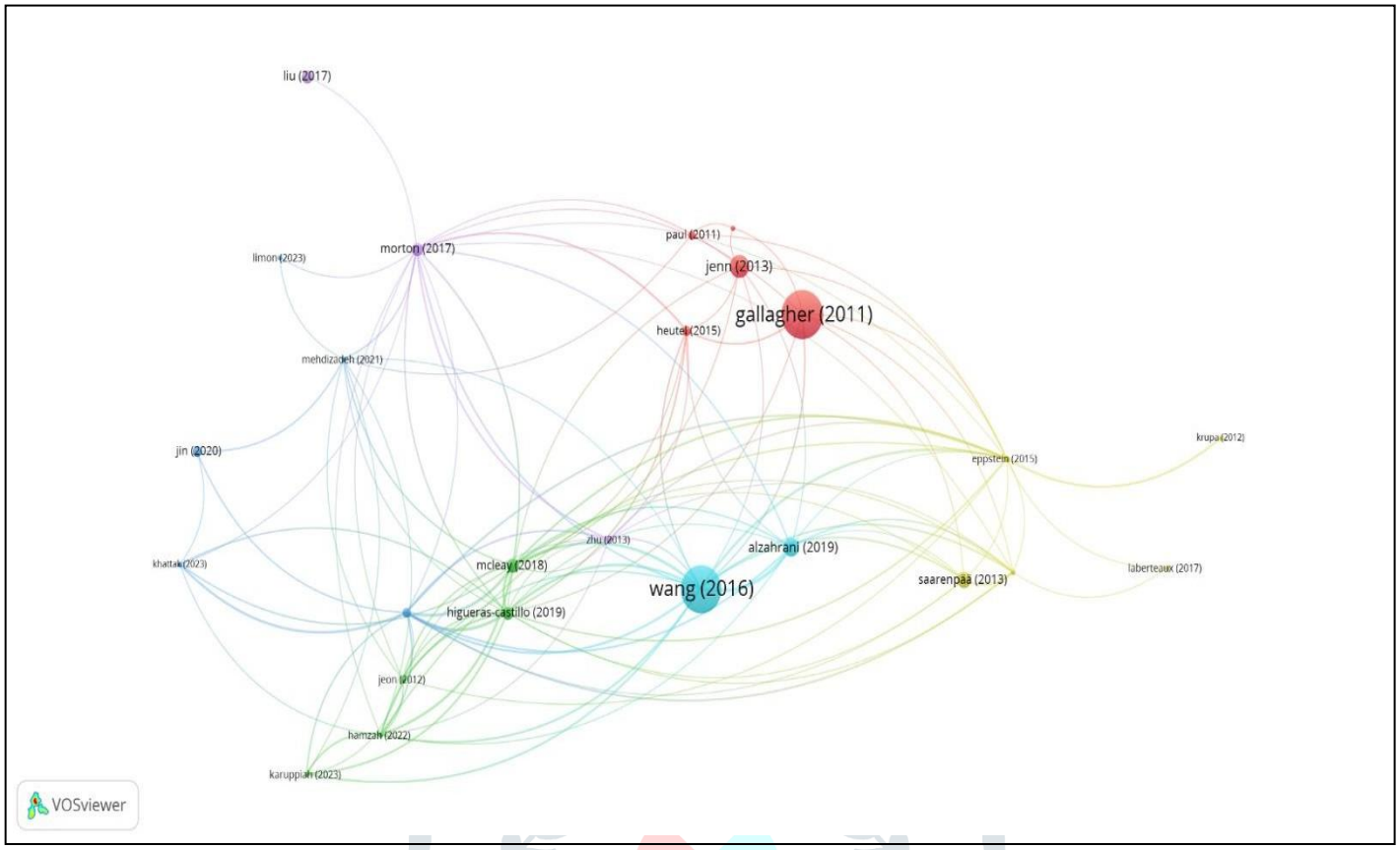


Fig.3.2 – Hybrid Car Bibliographic Coupling Analysis, VOS viewer

Conclusion:

The comprehensive science mapping analysis conducted on the adoption of electric and low-combustion vehicles offers a nuanced perspective on the multifaceted landscape of sustainable transportation research. Through methodologies such as co-citation analysis, co-occurrence analysis, and bibliographic coupling, the scholarly discourse surrounding this pivotal topic is systematically examined. Key findings from this analysis reveal significant clusters of researchfocusing on pivotal themes including consumer behavior, government policies, technological advancements, and socio-economic factors influencing adoption patterns. This granular understanding of the interconnectedness of research topics provides valuable insights for policymakers, industry stakeholders, and researchers alike. By delineating the complex dynamics shaping electric and hybrid vehicle adoption, Detailed strategy and informed choice-making are based on this analysis. aimed at accelerating the transition to sustainable mobility solutions. In sum, this professional analysis contributes to the broader discourse on sustainable transportation, facilitating evidence-based interventions and fosteringinnovation in the pursuit of a greener and more resilient automotive industry.

Through co-citation analysis, which examines the interconnectedness of research documents based on shared citations, key clusters emerge, focusing on diverse aspects such as consumer behavior, government incentives, and socio-technical barriers. These clusters represent focal points where scholars delve into the intricate dynamics shaping the adoption of electric and hybrid vehicles, offering insights into factors influencing consumer preferences and decision-making processes. Additionally, co-occurrence analysis uncovers the inherent relationships between keywords, elucidating critical research areas like EV charging infrastructure, battery technology, and environmental considerations. This analysis underscores the multidimensionalnature of the discourse surrounding electric and hybrid car adoption, highlighting the interconnectedness of various themes within the broader context of sustainable mobility. Furthermore, bibliographic coupling further refines our understanding by categorizing publications into thematic clusters, providing nuanced insights into consumer behavior, policyefficacy, and technological advancements driving adoption rates. Collectively, these methodologies contribute to an extensive awareness of possibilities and obstacles in transitioning towards electric and hybrid vehicles, ultimately paving the way for a more environmentally responsible and viable conscious forwardness or updating of transportation

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