Rich Picture and Data Model for: Website to store and analyze data on Greenhouse Gas Emission

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1 INTRODUCTION

1.1

When it comes to environmental sustainability, the role of Database Management Systems (DBMS) has become increasingly vital, offering innovative solutions to address complex challenges. This collection of literature reviews encompasses a diverse array of research papers, each delving into the intricate relationship between database management and the pressing global concern of greenhouse gas emissions. These reviews span a spectrum of topics, from the estimation and reduction of emissions in various sectors to the utilization of cutting-edge technologies like Blockchain, Internet of Things (IoT), and Geoinformation systems.

The first set of reviews explores the estimation and reduction of greenhouse gas emissions in the industrial sector, specifically focusing on cement manufacturing processes, residential buildings, data centers, and the agricultural sector. These reviews illuminate the intricate web of factors influencing emissions, presenting insights into how advanced technologies and systems such as Blockchain, SSL, and cyber-physical monitoring can contribute to more sustainable practices.

Moving beyond traditional industrial domains, the literature reviews extend to the realm of urban environments, investigating the carbon footprints of constructed wetlands and examining the role of cities in contributing to overall climate change. The interdisciplinary nature of these studies integrates web applications, GIS tools, and IoT advancements to assess and manage greenhouse gas emissions in diverse settings, emphasizing the need for holistic solutions.

Moreover, the reviews explores the intersection of technology and energy consumption in buildings, shedding light on how controlling electricity storage can not only balance costs but also minimize greenhouse gas emissions. The exploration of photovoltaic nanogrids, battery and thermal storage reservoirs, and real-time monitoring systems highlights the potential for integrated solutions in mitigating environmental impact.

These reviews also venture into the global context, studying greenhouse gas emissions in various countries, including a detailed analysis of Hungary and a broader overview of emissions from global cities. Furthermore, they tackle the life-cycle analysis of greenhouse gas emissions, emphasizing the importance of considering human health trade-offs in organic waste management strategies.

2 Paper 1: Estimation of Greenhouse Gas Emissions in Cement Manufacturing Process Through Blockchain and SSL Based IoT Data Analysis

Journal/Conference Rank: Q1
Publication Year: 2020
Reference: Truong, N.B., Sun, K., Lee, G.M., Guo, Y.: GDPR-compliant personal data management: a blockchain-based solution. IEEE Trans. Inf. Forensics Secur. 5(15), 1746–1761 (2020)

2.1 Summary

The development of a comprehensive management platform that combines Secure Socket Layer (SSL) and blockchain technology to ensure data integrity and reliability in the cement manufacturing process is a significant step towards enhancing security and reducing the resource-intensive verification process. The Internet of Things (IoT) has gained prominence for its ability to support various human activities with real-world data. However, the system's behavior relies heavily on this data, making it vulnerable to manipulation by potential attackers. Recognizing the critical importance of data integrity, researchers have explored data management platforms with advanced security technologies to safeguard IoT-generated data. In the proposed platform, particular attention is given to the pre-manufacturing phase of the cement manufacturing process. Here, data reliability is assured through the use of blockchain technology. A distributed ledger on the blockchain is employed to record and verify the data generated in this phase. During the manufacturing phase, SSL (Secure Socket Layer) or digital certificates are utilized to establish secure, encrypted connections between users' devices (such as browsers or computers) and the server or website. SSL ensures that sensitive data exchanged during each session is protected from unauthorized interference. The central goal of this platform is to create a management system that can effectively verify the integrity of stored data, both through SSL and blockchain. This dual-layer security approach ensures that data remains unaltered and trustworthy throughout its lifecycle. Testers in the system continuously collect real-time data, particularly focusing on carbon emissions calculations. This real-time data offers assurance and accuracy in tracking emissions, which is vital for regulatory compliance and environmental sustainability efforts. One of the significant advantages of this platform is its ability to significantly reduce the manpower and time resources required for the verification process. By automating and securing data at the source, the need for labor-intensive first and second stages of verification is minimized.

2.2 Software Architecture

The software architecture for estimating greenhouse gas emissions in the cement manufacturing process through blockchain and SSL-based IoT data analysis should be designed to ensure data accuracy, security, and real-time analysis. Here's a high-level overview of the software architecture for such a system:

Data Collection Layer:

IoT Sensors: IoT sensors are deployed throughout the cement manufacturing plant to collect real-time data on various parameters, including temperature, pressure, fuel

consumption, and operational metrics. Data Preprocessing: Raw data from sensors is preprocessed to clean and format it for further analysis. Data Transmission Layer:

Secure Communication (SSL): Data from IoT sensors is securely transmitted to the central database using SSL encryption to protect the data during transmission. Data Storage Layer:

Blockchain Ledger: Data is stored on a blockchain ledger. Each validated data point is recorded as a transaction in the blockchain, ensuring immutability and transparency. Relational Database: In addition to the blockchain, a relational database may be used to store metadata, user information, and other relevant data. Data Processing Layer:

Emissions Calculation: This layer includes algorithms for calculating greenhouse gas emissions based on the collected data, emissions factors, and process-specific models. Smart Contracts: Smart contracts on the blockchain are employed to automate emissions calculations, validation, and reporting. These contracts can trigger alerts or actions if emissions exceed predefined limits. Data Analysis and Visualization Layer:

Real-time Monitoring: Real-time monitoring tools provide visualizations and dashboards for stakeholders to track emissions, operational data, and other relevant information. Historical Data Analysis: Historical data is analyzed to identify trends, patterns, and opportunities for emissions reduction. Security and Authentication Layer:

User Authentication: Users, such as plant operators and environmental regulators, are authenticated and authorized to access different levels of data and functionality. Data Integrity Checks: Data integrity is maintained through hash functions and cryptographic checks. Regulatory Compliance and Reporting Layer:

Compliance Check: The system checks emissions data against regulatory standards and provides alerts if emissions exceed permitted levels. Emissions Reporting: Automated emissions reports are generated and can be submitted to regulatory authorities. External Data Integration:

Weather and Environmental Data: Integration with external sources for weather and environmental data helps account for external factors affecting emissions. Notification and Alerting Layer:

Alerts: The system sends alerts and notifications to relevant parties (e.g., plant managers, regulators) in case of abnormal emissions levels or potential security breaches. User Interface Layer:

Web and Mobile Interfaces: User-friendly web and mobile interfaces provide access to real-time data, analytics, and reporting. Stakeholders can interact with the system through intuitive dashboards. Blockchain Network:

The blockchain network, which can be a public or private blockchain, facilitates secure and transparent data storage and validation. Cloud-Based Infrastructure:

Cloud services may be utilized for scalability, data redundancy, and accessibility from anywhere. Scalability and Redundancy:

The architecture should be designed to scale with the increasing volume of data and provide redundancy to ensure data availability. The software architecture outlined here combines the strengths of IoT data collection, SSL encryption, blockchain for data integrity, and real-time analysis to estimate and manage greenhouse gas emissions in the cement manufacturing process effectively. It enhances data security, transparency, and regulatory compliance while providing actionable insights for reducing emissions.

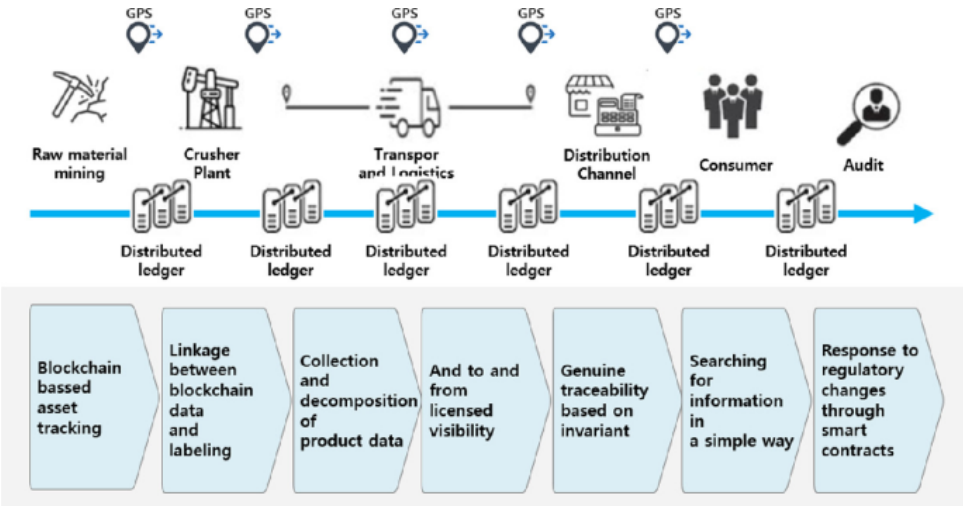

Figure 1: Software architecture diagram for Paper 1.

2.3 Data Parameters

Estimating greenhouse gas emissions in the cement manufacturing process through blockchain and SSL-based IoT data analysis requires the consideration of various data parameters and factors. These data parameters play a crucial role in accurately calculating and monitoring emissions. Here are some of the key data parameters involved in this process:

Emissions Factors: Emissions factors represent the amount of greenhouse gases (e.g., carbon dioxide, methane) produced per unit of activity in the cement manufacturing process. These factors are specific to various process stages, such as limestone calcination, clinker production, and fuel combustion.

Raw Material Inputs: Data related to the type and quantity of raw materials used in cement production. This includes information about limestone, clay, iron ore, and other materials.

Fuel Usage: Detailed data on the type of fuels used (e.g., coal, natural gas, alternative fuels) and the quantity consumed. Fuel data is critical for assessing emissions from the combustion process.

Energy Consumption: Data on energy consumption within the cement plant, including electricity usage, heat energy, and other forms of energy. This data helps in estimating indirect emissions associated with energy use.

Production Output: Information about the quantity and type of cement produced during a specific time frame. This parameter is necessary to calculate emissions on a per-unit basis (e.g., emissions per ton of cement produced).

Operational Parameters: Parameters related to the operation of various equipment and processes, such as kiln temperatures, pressure levels, and flow rates. These parameters impact emissions and are monitored through IoT sensors.

Weather and Environmental Data: Data on external conditions, including temperature, humidity, wind speed, and other environmental factors, which can influence emissions. Weather data helps account for variations in emissions.

Blockchain Records: Data stored on the blockchain ledger, including emissions calculations, historical data, and verification records. These records ensure data integrity and transparency.

SSL Encrypted Data: Data collected through Secure Socket Layer (SSL) encryption,

which secures the transmission of sensitive data from IoT sensors to the central database. This dataset contains records of secure communications.

Regulatory Standards: Information on emissions standards and regulations relevant to the region or country where the cement plant operates. Compliance with these standards is critical.

Historical Emissions Data: A historical dataset of emissions data over time, including any records of past emissions calculations and reports. This provides a baseline for comparison and tracking progress.

Geospatial Data: Geographic data that helps in mapping the location of the cement plant and potential environmental impacts, as well as in assessing transportation-related emissions.

Operational Logs: Records of day-to-day operational activities, such as production schedules, equipment usage, and maintenance activities.

By integrating and analyzing these data parameters, a robust system can accurately estimate greenhouse gas emissions in the cement manufacturing process, track emissions over time, ensure regulatory compliance, and make informed decisions to reduce the environmental impact of cement production. The use of blockchain and SSL-based security measures enhances data integrity and transparency, making the estimation process more reliable and secure.

2.4 Datasets Used

Estimating greenhouse gas emissions in the cement manufacturing process through blockchain and SSL-based IoT data analysis typically relies on a variety of datasets to provide comprehensive and accurate insights. Some of the key datasets used in this process may include:

IoT Sensor Data: Data collected from IoT sensors installed at various points in the cement manufacturing plant. This data includes information on temperature, pressure, energy consumption, fuel usage, and other operational parameters.

Energy Usage Data: Detailed data on the energy sources and consumption within the cement plant. This includes data on electricity usage, as well as the type and quantity of fossil fuels used for heating and power generation.

Raw Material Data: Information regarding the raw materials used in the cement manufacturing process, including the types of raw materials, quantities, and their carbon content.

Production Data: Data related to the quantity and type of cement produced during a specific timeframe.

Emissions Factors Data: Emissions factors are values that represent the amount of greenhouse gases released per unit of raw material processed or cement produced. These factors are essential for estimating emissions accurately.

Blockchain Data: Data stored on the blockchain, which includes details of emissions calculations, historical emissions data, and verification records. This dataset ensures data integrity, transparency, and traceability.

SSL Encrypted Data: Data collected through Secure Socket Layer (SSL) encryption, which secures the transmission of sensitive data from IoT sensors to the central database. This dataset contains records of secure communications.

Weather and Environmental Data: Weather conditions and other environmental variables can influence emissions. Access to climate data can help account for external factors

impacting emissions.

Regulatory Emissions Standards: Data related to emissions standards and regulations in the region or country where the cement plant operates. This information is crucial for compliance and reporting.

Historical Emissions Data: A historical dataset of emissions over time, including any records of past emissions calculations and reports.

Geospatial Data: Geospatial data can help in mapping the location of the cement plant and potential environmental impacts, as well as in assessing transportation-related emissions.

Operational Logs: Records of the day-to-day operational activities at the cement plant, such as production schedules, equipment usage, and maintenance activities.

The combination of these datasets allows for a comprehensive analysis of the greenhouse gas emissions in the cement manufacturing process. By integrating IoT sensor data with blockchain and SSL security measures, it becomes possible to accurately estimate, track, and report emissions, ensuring transparency, compliance with regulations, and the reduction of environmental impact.

2.4.1 Paper Link

Access the full paper at: https://link.springer.com/chapter/10.1007/978-3-030-58802-$1_4 6 Abs 1$.

3 Paper 2: WEB APPLICATION SUPPORT FOR CARBON FOOTPRINT MANAGEMENT OF PETROL STATIONS IN THAILAND

Journal/Conference Rank: A*
Publication Year: 2017
Reference: Department of energy business. Number of petrol stations in Thailand [Internet]. 2017 [cited 2019 Apr 21] [?]

3.1 Summary

In Thailand, a "petrol station" is considered an "organization" that not only sells fuels and engine lubricants for motor vehicles but also includes many other facilities provided to satisfy the modern lifestyle of customers. In other words, a petrol station in Thailand comprises a large complex service center offering a wide range of services that contribute greenhouse gas emissions to the atmosphere. This paper aimed to present a specific web application tool developed to estimate the carbon footprint for petrol stations in Thailand. The application system comprises three core components: 1) a web-based user interface; 2) a processing system, incorporating the carbon footprint of the organization (CFO) framework and the calculated model and 3) a database. The site-specific input data or activity data provided by the user was primarily required for the data entry in the system. The processing system will then quantify the amount of greenhouse gas emissions by multiplying the activity data by the emission factor (EF). A database was also created containing default EFs readily used for the calculation, but users can change these values at any time when a more appropriate one is indicated. Finally, the CF calculation results

can be evaluated in various functional units: monthly or yearly, per fuel sold, or per area of the petrol station, and visualized in graphs. In addition, the results can be reported by categorizing the emission sources according to the scope of the CFO and the GHGs reporting guidelines

3.2 Software Architecture

Designing the software architecture for a web application that supports carbon footprint management for petrol stations in Thailand involves multiple components and considerations. Below is a high-level overview of the architecture, which may include various modules and technologies.

Front-end Application: The front-end is the user interface through which users interact with the application. It includes web pages, forms, and dashboards.

User Interface: HTML, CSS, JavaScript, and a modern front-end framework such as React or Angular. User Experience: Design the UI/UX for ease of use and accessibility. Back-end Application: The back-end handles business logic, data processing, and server-side operations.

Web Server: Node.js, Ruby on Rails, or Python with frameworks like Django or Flask. APIs: Develop RESTful or GraphQL APIs for communication between the front-end and back-end. Authentication: Implement secure user authentication, possibly using OAuth or JWT. Authorization: Define user roles and permissions for data access. Database: Store data related to petrol stations and carbon footprint. PostgreSQL, MySQL, or a NoSQL database like MongoDB may be suitable. Middleware: Implement middleware for request handling, logging, and error management. Data Collection and Integration: Gather and integrate data from various sources, including petrol stations and environmental data.

Data Sources: Collect data from petrol station management systems, environmental sensors, and government agencies. Data Integration: Develop ETL (Extract, Transform, Load) processes to clean and process data before storing it in the database. Real-time Data: Implement real-time data integration if necessary. Carbon Footprint Calculation: Calculate the carbon footprint of petrol stations based on various factors like fuel consumption, emissions, and more.

Algorithms: Develop or use existing algorithms to calculate carbon emissions. Environmental Data: Integrate environmental data such as emission factors, weather conditions, and traffic patterns. Reporting and Analytics: Provide tools for users to generate reports and perform analytics.

Reporting Engine: Implement reporting features using tools like Power BI, Tableau, or custom reporting solutions. Data Visualization: Create interactive charts and graphs for data analysis. Geospatial Information: Incorporate geospatial data to map and locate petrol stations.

Geospatial Database: Use GIS (Geographic Information System) databases like PostGIS. Mapping Libraries: Leverage mapping libraries like Leaflet or Google Maps for visualization. User Management and Security: Ensure data security, user management, and role-based access control.

User Management: Handle user registration, authentication, and password management. Security: Implement security best practices, including encryption and secure API endpoints. Scalability and Performance: Design the architecture to be scalable as the application grows.

Load Balancing: Distribute incoming traffic across multiple servers. Caching: Implement caching mechanisms to improve performance. Scalable Infrastructure: Use cloud services like AWS, Azure, or Google Cloud for scalability. DevOps and Deployment: Implement a robust DevOps process for continuous integration and continuous deployment (CI/CD).

Containerization: Use Docker for containerization. Orchestration: Utilize Kubernetes for container orchestration. Monitoring and Logging: Set up monitoring and logging tools to track application performance. Compliance and Regulations: Ensure the application adheres to relevant environmental regulations and data protection laws.

Compliance Checks: Regularly update the application to comply with changing regulations. Data Privacy: Implement data privacy features to protect user and environmental data. Maintenance and Support: Plan for ongoing maintenance, bug fixes, and user support. Support Team: Have a dedicated support team to handle user inquiries and issues. Version Control: Use version control systems for code management. Testing and Quality Assurance: Implement a robust testing strategy, including unit tests, integration tests, and user acceptance testing.

Documentation: Maintain comprehensive documentation for the application's architecture, APIs, and user guides.

This software architecture should serve as a solid foundation for developing a web application that helps manage the carbon footprint of petrol stations in Thailand. It's important to continually iterate, improve, and adapt the architecture as requirements and technologies evolve.

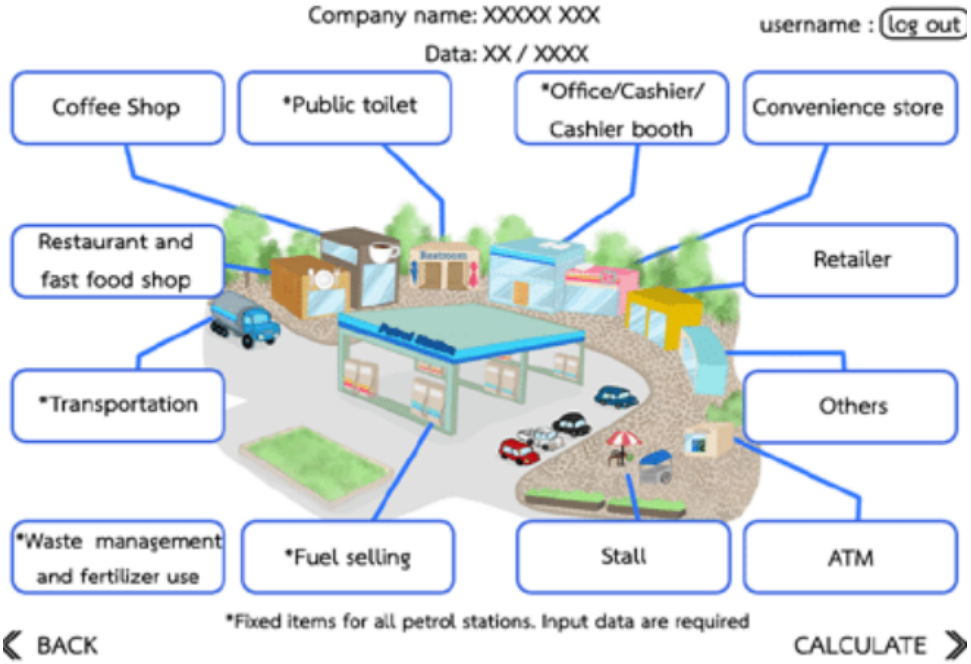

Figure 2: Software architecture diagram for Paper 2.

3.3 Data Parameters

To build a web application for carbon footprint management of petrol stations in Thailand, you will need to work with various data parameters and parameters to collect,

process, and display relevant information. Here are some key data parameters and data sources that would be essential for such an application:

1. Petrol Station Data: -Station Information: Details about each petrol station, including name, location, contact information, and ownership. - Fuel Types: Information about the types of fuels sold at the station (e.g., gasoline, diesel, natural gas). - Fuel Consumption: Data on the volume of fuel sold and consumed at the station over time. - Emission Factors: Data on the carbon emission factors for each type of fuel sold at the station.

2. Environmental Data: - Weather Data: Information about weather conditions (e.g., temperature, humidity, wind speed) that can affect fuel combustion and emissions. - Air Quality Data: Data on air quality, including levels of pollutants like CO2, NOx, and particulate matter, in the vicinity of the petrol stations. - Traffic Data: Data on traffic patterns and congestion around the stations, which can impact emissions.

3. User Data: - User Profiles: User-specific information, including login credentials, contact details, and user roles. - User Preferences: User-defined settings and preferences related to carbon footprint management.

4. Emission Data: - Emission Calculation Results: Calculated carbon emissions for each petrol station based on fuel consumption and emission factors. - Emission Trends: Historical emission data to track changes over time. - Comparative Emission Data: Data that allows users to compare emissions between different petrol stations.

5. Geospatial Data: - Geolocation Data: Geographic coordinates (latitude and longitude) of each petrol station for mapping and visualization. - Geographic Boundaries: Geospatial boundaries and regions relevant to carbon footprint management.

6. Regulatory Data: - Environmental Regulations: Information about relevant environmental regulations and emissions standards in Thailand. - Compliance Data: Data on whether each petrol station is complying with environmental regulations.

7. Reporting and Analytics Data: - Generated Reports: Data used to generate carbon footprint reports for each petrol station. - Analytics Data: Aggregated data for statistical analysis and visualization.

8. Security and Audit Data: - Access Logs: Records of user interactions with the system, including logins and data changes. - Security Event Data: Records of security-related events, such as failed login attempts.

9. Maintenance and Support Data: -Issue Tracking: Data related to bug reports, feature requests, and support tickets. - Version Control Data: Information about software versions, updates, and patches.

10. Compliance and Regulatory Reporting Data: -Regulatory Reports: Data required for submitting regulatory reports to government agencies.

11. Machine Learning Data (Optional) - Training Data: If machine learning is used for predictive modeling or anomaly detection, you'll need historical data for model training. -Predictive Data: Real-time or near-real-time data used as input to machine learning models.

12. Billing and Financial Data (if applicable): Billing Information: Data for invoicing petrol stations for carbon footprint management services. - Payment Data: Data related to payments and financial transactions.

13. User Interaction Data: - User Actions: Records of user interactions with the application, such as data entry and report generation.

14. Data Privacy and Consent Data: - User Consent Records: Information about user consent for data processing and privacy policies.

15. Third-Party Data Sources: - Data from third-party providers, such as government agencies or environmental monitoring organizations, for supplementary environmental data.

To effectively manage these data parameters, you'll need a robust data storage and management system, such as a relational database for structured data and possibly NoSQL databases for semi-structured or unstructured data. Additionally, data integration, transformation, and real-time processing capabilities will be crucial for ensuring data accuracy and relevancy in your carbon footprint management application.

3.4 Datasets Used

Developing a web application for carbon footprint management of petrol stations in Thailand would require access to various datasets to gather the necessary information for calculations, reporting, and decision-making. While I cannot provide specific, up-to-date datasets, I can suggest the types of datasets that would be useful for such an application:

1. Petrol Station Data: - Information about each petrol station, including location, fuel types, and contact details.

2. Fuel Consumption Data: - Historical data on the volume and type of fuel sold and consumed at each petrol station.

3. Emission Factors Data: - Data on carbon emission factors for different types of fuels and combustion processes.

4. Environmental Data: - Weather data, including temperature, humidity, wind speed, and precipitation, which can affect fuel combustion and emissions. - Air quality data, including measurements of pollutants such as CO2, NOx, SOx, and particulate matter.

5. Traffic Data: - Data on traffic patterns and congestion around petrol stations, which can influence emissions.

6. Geospatial Data: - Geographic coordinates (latitude and longitude) for mapping and visualization of petrol stations and their surroundings. - Geospatial boundaries and regions relevant to carbon footprint management.

7. Regulatory Data: - Information about relevant environmental regulations and emissions standards in Thailand. - Compliance data indicating whether each petrol station is meeting regulatory requirements.

8. Reporting and Analytics Data: - Historical data used for generating carbon footprint reports for each petrol station. - Aggregated data for statistical analysis and visualization.

9. Security and Audit Data: - Access logs and security event data to monitor user interactions and system security.

10. Maintenance and Support Data: - Data related to bug reports, feature requests, and support tickets for application maintenance and user support.

11. Compliance and Regulatory Reporting Data: - Data needed for submitting regulatory reports to government agencies.

12. Machine Learning Data (if applicable): - Historical data for training machine learning models if used for predictive modeling or anomaly detection.

13. Billing and Financial Data (if applicable): - Data related to invoicing petrol stations for carbon footprint management services and financial transactions.

14. User Interaction Data: - Records of user interactions with the application, including data entry and report generation.

15. Data Privacy and Consent Data: - Records of user consent for data processing and privacy policies.

16. Third-Party Data Sources: - Data from third-party providers, such as government agencies or environmental monitoring organizations, for supplementary environmental data.

It's important to ensure that the data you use is up-to-date, accurate, and relevant to the specific context of carbon footprint management for petrol stations in Thailand. Depending on the availability of such data, you may need to collaborate with government agencies, environmental organizations, and petrol station operators to gather the necessary datasets for your application. Data integration and data cleaning processes will also be essential to ensure data quality.

3.4.1 Paper Link

Access the full paper athttps://www.researchgate.net/publication/341481126$_{W}EB_{A}PPLICATION_{S}U$

4 Paper 3: A scenario of comparatively high greenhouse gas emissions

Journal/Conference Rank: A*
Publication Year: 2011
Reference: Amann M, Bertok I, Borken J, Chambers A, Cofala J, Dentener F, Heyes C, Kejun J, Klimont K, Makowski M, Matur R, Purohit P, Rafaj P, Sandler R, Schöpp W, Wagner F, Winiwarter W (2008a) GAINS-Asia. A tool to combat air pollution and climate change simultaneously. International Institute for Applied Systems Analysis (IIASA), Laxenburg [?]

4.1 Summary

RCP 8.5, part of the set of Representative Concentration Pathways (RCPs), represents a climate scenario characterized by exceptionally high greenhouse gas emissions throughout the 21st century. This scenario, often referred to as the "business as usual" or "worst-case" scenario, paints a sobering picture of a future world where human activities continue to release substantial amounts of carbon dioxide (CO2) and other greenhouse gases into the atmosphere. Under RCP 8.5, greenhouse gas emissions increase significantly, leading to a doubling of atmospheric CO2 concentrations by the year 2100. This unprecedented level of emissions results from a multitude of factors, including a heavy reliance on fossil fuels, limited efforts to mitigate emissions, and continued population and economic growth. The consequences of the RCP 8.5 scenario are substantial and alarming. The Earth experiences a rapid and significant increase in global temperatures, with potential consequences including more frequent and severe heatwaves, rising sea levels, altered precipitation patterns, and a heightened risk of extreme weather events. These changes have far-reaching implications for ecosystems, human societies, and economies. The RCP 8.5 scenario serves as a critical tool for climate scientists and policymakers, allowing them to model and understand the potential impacts of unabated greenhouse gas emissions. It highlights the urgency of global efforts to reduce emissions, transition to renewable energy sources, and implement climate mitigation strategies to avoid the most severe

consequences of climate change. While RCP 8.5 represents a bleak outlook, it underscores the importance of proactive measures to address the climate crisis and secure a more sustainable future.

4.2 Software Architecture

RCP 8.5—A scenario of comparatively high greenhouse gas emissions," the concept of software architecture doesn't apply directly. Instead, I'll provide an outline of the key elements that would be involved in the development and analysis of scenarios like RCP 8.5:

Climate Modeling Framework:

Climate models form the backbone of scenario development. These models simulate how greenhouse gas emissions, atmospheric processes, oceanic circulation, and other factors interact to produce climate outcomes. Emission Data and Scenarios:

Datasets and scenarios for greenhouse gas emissions are used to define the future trajectory of emissions in the scenario. This often involves assumptions about economic growth, energy use, and policy actions. Climate Data and Parameters:

Climate data, including historical climate records and model parameters, are essential for initializing and calibrating climate models. These data sources are crucial for understanding how changes in emissions impact the climate. Scenario Generation:

Software tools and models are used to generate RCP scenarios, including RCP 8.5. These tools simulate emissions, energy use, land use, and other relevant factors over time. Data Analysis and Visualization:

Data analysis tools and software are used to interpret the results of climate model simulations. Visualization tools help convey the data to researchers, policymakers, and the public. Scientific Collaboration Tools:

Collaboration software and platforms facilitate the work of scientists and researchers in different locations who contribute to the development and analysis of scenarios like RCP 8.5. Documentation and Reporting:

Software may be used to create reports and documentation that explain the methodology, assumptions, and results of the scenario, making the information accessible to a wide audience. Policy and Decision Support Tools:

Tools may be developed to assist policymakers and decision-makers in understanding the implications of RCP 8.5 and other scenarios, helping them make informed choices related to climate policy. Communication and Outreach:

Software can support outreach efforts to communicate the findings of the scenario to the public, stakeholders, and other researchers. This may involve websites, social media, and multimedia presentations. While the above elements aren't part of a single software architecture, they encompass the software and data-related components that support the development and analysis of climate scenarios like RCP 8.5. Climate modeling and scenario analysis are complex, interdisciplinary efforts that require various tools and software systems to generate, analyze, and communicate findings.

4.3 Data Parameters

Data parameters are critical for understanding and characterizing this scenario. Here are some key data parameters related to RCP 8.5:

Greenhouse Gas Emissions Data:

figure.png

Figure 3: Software architecture diagram for Paper 3.

Historical and projected data on greenhouse gas emissions, including carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). This data parameter provides the foundation for the scenario. Emissions Scenarios:

Projections of future greenhouse gas emissions, which are typically based on assumptions about economic growth, energy use, land use, and policy actions. Emissions scenarios help define the trajectory of RCP 8.5. Global Temperature Data:

Historical and projected data on global temperatures, which are influenced by the greenhouse gas emissions. This data parameter is used to understand the temperature outcomes of RCP 8.5. Atmospheric CO2 Concentrations:

Data on atmospheric CO2 concentrations over time, reflecting the buildup of carbon dioxide in the atmosphere. This parameter is a key driver of climate change in the scenario. Climate Models and Parameters:

Data related to the climate models used in the scenario, including their parameters and configurations. These models simulate the interactions between emissions and the climate system. Economic and Population Data:

Assumptions about economic growth, population growth, and technological development that underpin emissions scenarios. These data parameters provide context for the scenario. Energy Consumption Data:

Data related to energy production and consumption, including the use of fossil fuels, renewable energy sources, and energy efficiency. These parameters influence emissions.

Land Use and Land Cover Data:

Data on land use changes, deforestation, afforestation, and land management practices, which can affect emissions and the climate. Policy Scenarios:

Data parameters related to policy assumptions, including climate policies, international agreements, and regulatory actions. These data parameters shape emissions trajectories. Historical Emissions Data:

Historical records of greenhouse gas emissions are used to calibrate and validate the emissions scenarios. These data parameters help ensure the accuracy of the scenario. Sea-Level Rise Data:

Projections of sea-level rise, which are a consequence of warming temperatures and melting ice. Sea-level rise data is important for assessing the impact of RCP 8.5 on coastal areas. Climate Impact Parameters:

Data parameters that describe the impacts of the scenario, such as changes in precipitation patterns, extreme weather events, and other climate-related effects. Emission Reduction Technologies and Strategies:

Data related to the availability and adoption of technologies and strategies for reducing greenhouse gas emissions, which can influence the trajectory of emissions in the scenario. These data parameters are essential for developing, analyzing, and communicating the implications of RCP 8.5, a scenario that represents a high greenhouse gas emissions trajectory and its potential consequences for the Earth's climate. They provide the foundation for climate modeling and scenario analysis.

4.4 Datasets Used

The development and analysis of the Representative Concentration Pathway 8.5 (RCP 8.5) scenario, which represents a future with high greenhouse gas emissions, rely on various datasets to understand and model the impact of these emissions. While I can't provide a specific list of datasets used in the abstract, I can mention the types of datasets commonly employed in such climate modeling efforts:

Historical Emissions Data:

Datasets detailing historical greenhouse gas emissions, such as CO2, CH4, and N2O, are essential to understand past trends and to calibrate models. Future Emissions Scenarios:

Projections of future emissions, including economic growth, energy consumption, land use changes, and policy assumptions. These datasets form the basis of RCP scenarios. Climate Data:

Historical and present-day climate data, including temperature records, precipitation data, and climate model outputs, are used to understand the baseline climate conditions and variability. Climate Model Parameters:

Data parameters that define the configurations and parameters of climate models, which are instrumental in projecting the impacts of emissions scenarios. Economic and Population Data:

Datasets that provide information about economic growth, population projections, technological development, and related factors that influence emissions. Energy Consumption Data:

Information on energy production and consumption, including the use of fossil fuels, renewable energy sources, and energy efficiency data. Land Use and Land Cover Data:

Data on land use changes, deforestation, afforestation, land management practices, and land cover, as changes in land use can affect emissions and the climate. Policy Scenarios:

Datasets describing policy assumptions, including climate policies, international agreements, and regulatory actions, which shape emissions trajectories. Sea-Level Rise Data:

Projections of sea-level rise data, which are critical for assessing the impact of RCP 8.5 on coastal areas and infrastructure. Climate Impact Parameters:

Data parameters that describe the potential impacts of the scenario, such as changes in precipitation patterns, extreme weather events, and other climate-related effects. Emission Reduction Technologies and Strategies:

Data related to the availability and adoption of technologies and strategies for reducing greenhouse gas emissions, which can influence the trajectory of emissions in the scenario. The specific datasets used can vary depending on the research institution, modeling tools, and research objectives. Researchers often use data from various sources, including government agencies, international organizations, research institutions, and specialized climate and emissions datasets. These datasets collectively support the development and analysis of scenarios like RCP 8.5, aiding in understanding the potential consequences of high greenhouse gas emissions.

4.4.1 Paper Link

Access the full paper at https://link.springer.com/article/10.1007/s10584-011-0149-y.

5 Paper 4: Greenhouse gas emission reduction in residential buildings

Journal/Conference Rank: A*
Publication Year: 2022
Reference: Al-ShahriO.A. et al. Solar photovoltaic energy optimization methods, challenges and issues: A comprehensive review J. Cleaner Prod. (2021) [**?**]

5.1 Summary

Electricity produced and used in the residential sector is responsible for approximately 30 percents of the greenhouse gas emissions (GHGE). Insulating houses and integrating renewable energy and storage resources are key for reducing such emissions. However, it is not only a matter of installing renewable energy technologies but also of optimizing the charging/discharging of the storage units. A number of optimization models have been proposed lately to address this problem. However, they are often limited in several respects: (i) they often focus only on electricity bill reduction, placing GHGE reduction on the backburner; (ii) they rarely propose hybrid-energy storage optimization strategies considering thermal and storage heater units; (iii) they are often designed using Linear Programming (LP) or metaheuristic techniques that are computational intensive, hampering their deployment on edge devices; and (iv) they rarely evaluate how the model impacts on the battery lifespan. Given this state-of-affairs, the present article compares

two approaches, the first one proposing an innovative sliding grid carbon intensity threshold algorithm developed as part of a European project named RED WoLF, the second one proposing an algorithm designed based on LP. The comparison analysis is carried out based on two distinct real-life scenarios in France and UK. Results show that both algorithms contribute to reduce GHGE compared to a solution without optimization logic (between 10 to 25 percent), with a slight advantage for the LP algorithm. However, RED WoLF makes it possible to reduce significantly the computational time.

5.2 Software Architecture

The software architecture for greenhouse gas emission reduction in residential buildings typically involves a combination of technologies and systems to monitor, control, and optimize energy usage. Here's a high-level overview of the software architecture:

1. Data Acquisition and Sensing: Sensor Integration: Various sensors are placed within the residential building to collect data on temperature, humidity, occupancy, and energy usage. IoT Devices: Internet of Things (IoT) devices, including smart thermostats, smart meters, and occupancy sensors, are integrated to monitor and control various systems.

2. Data Processing and Analytics: Data Ingestion: Collected data is ingested into a central database or cloud platform. Data Processing: Data is processed and analyzed to identify patterns and anomalies. Machine Learning: Machine learning algorithms can be employed for predictive analytics and anomaly detection.

3. Building Energy Management System (BEMS): BEMS Integration: The software interfaces with a Building Energy Management System to control heating, cooling, lighting, and other energy-consuming systems. Optimization Algorithms: Energy optimization algorithms within the BEMS make real-time adjustments based on data analysis.

4. User Interface: Resident Dashboard: An interface is provided to homeowners or residents, allowing them to view energy usage, set preferences, and monitor the system's performance. Mobile Applications: Mobile apps enable remote monitoring and control.

5. Energy Storage Integration: Battery Management: If energy storage solutions like batteries are present, the architecture includes software for managing their charging and discharging based on energy demand and cost considerations.

6. Renewable Energy Integration: Solar and Wind Integration: The system can interface with solar panels, wind turbines, or other renewable energy sources to optimize energy generation and consumption.

7. Real-time Monitoring and Alerts: Alerting System: Alerts and notifications are generated for residents or maintenance personnel in case of energy wastage or system malfunctions. Real-time Dashboards: Provide real-time insights into energy consumption, production, and savings.

8. Data Storage and Security: Database: Data is stored securely in a database or cloud platform. Data Encryption: Strong encryption is used to protect sensitive data. User Authentication: Secure user authentication ensures data access is limited to authorized users.

9. Reporting and Analysis: Energy Reports: The system generates periodic energy consumption and cost reports for homeowners. Energy Efficiency Recommendations: Based on historical data and patterns, the system can provide recommendations for further energy efficiency improvements.

10. Integration with Utility Providers: - Integration with utility providers allows for

real-time energy pricing data and grid demand information, enabling cost-effective energy usage.

11. Regulatory Compliance: Ensure the system complies with relevant energy efficiency and emissions reduction regulations and standards.

12. Machine-to-Machine (M2M) Communication: M2M communication capabilities enable devices and systems to interact and make automated decisions to optimize energy usage.

13. Cloud-based Solutions: Cloud platforms may be used for scalability, remote access, and data storage.

The software architecture for greenhouse gas emission reduction in residential buildings focuses on data acquisition, processing, control, and optimization. It aims to empower residents with real-time insights and control over their energy consumption, ultimately reducing emissions and contributing to a more sustainable living environment. The specific architecture and technologies used can vary depending on the complexity and scale of the residential building and its energy systems.

5.3 Data Parameters

Data parameters play a crucial role in greenhouse gas emission reduction efforts in residential buildings. These parameters are essential for monitoring and optimizing energy usage and assessing the effectiveness of emission reduction strategies. Here are some key data parameters for such initiatives:

1. Energy Consumption Data: Data on electricity and natural gas consumption, including usage patterns, peak demand, and seasonal variations.

2. Energy Efficiency Metrics: Metrics related to the energy performance of the building, such as Energy Use Intensity (EUI), heating degree days (HDD), and cooling degree days (CDD).

3. Weather Data: Information on weather conditions, including temperature, humidity, and solar radiation, which affect heating and cooling needs.

4. Occupancy Data: Data on the number of occupants, their daily routines, and occupancy patterns, which influence energy use.

5. Appliance and Equipment Data: Data on the types and efficiency of appliances, lighting, and HVAC systems in the building.

6. Renewable Energy Generation Data: Information on energy generation from renewable sources like solar panels or wind turbines, including output and efficiency.

7. Smart Meter Data: Data from smart meters, providing detailed information on electricity and gas consumption at short intervals.

8. Behavioral Data: Information on residents' energy-saving behaviors, such as adjusting thermostats, turning off lights, and reducing water usage.

9. Cost and Billing Data: - Data on energy costs and billing, including rates, tariffs, and utility bills.

10. Emission Factors: - Emission factors for the local energy grid, indicating the amount of greenhouse gas emissions associated with energy consumption.

11. Carbon Footprint Data: Data on the building's carbon footprint, which includes emissions from energy use, transportation, and waste.

12. Renewable Energy Certificates (RECs) Data: Information on the purchase and use of RECs to offset carbon emissions associated with energy use.

13. Indoor Air Quality Data: Data on indoor air quality, as poor indoor air quality can lead to increased energy use due to heating or cooling.

14. Cost Savings Data: Data on cost savings resulting from energy efficiency measures, such as lower utility bills or reduced maintenance costs.

15. Emissions Reduction Targets and Reporting Data: Information on emissions reduction targets, goals, and progress tracking to assess the effectiveness of emission reduction strategies.

16. Utility Rate Structures: Details of utility rate structures, including time-of-use rates and peak demand charges, which can impact energy consumption.

17. Maintenance and Equipment Performance Data: Data on the maintenance of energy systems and the performance of HVAC equipment and appliances.

18. Grid Electricity Data: Data on the electricity supplied by the grid, its source (e.g., coal, natural gas, renewables), and associated emissions.

19. Cost-Benefit Analysis Data: Data used for conducting cost-benefit analyses of energy efficiency and emission reduction measures.

These data parameters are crucial for tracking, analyzing, and optimizing energy usage and emissions reduction in residential buildings. They support informed decision-making, help identify areas for improvement, and measure progress toward reducing greenhouse gas emissions in the residential sector.

5.4 Datasets Used

The successful implementation of greenhouse gas emission reduction strategies in residential buildings relies on a variety of datasets to monitor, assess, and optimize energy consumption and emissions. While the specific datasets used may vary depending on the project's scope and objectives, here are some common datasets and sources:

1. Energy Consumption Data: Utility bills and historical energy consumption records from electricity and gas providers.

2. Weather Data: Local weather data, including temperature, humidity, wind speed, and solar radiation, obtained from meteorological agencies or online sources.

3. Smart Meter Data: Data from smart meters, which provide granular information on electricity and gas usage in real time. This data is often obtained directly from utility providers.

4. Renewable Energy Generation Data: Data on the energy generated from renewable sources within the residential building, such as solar panels or wind turbines.

5. Building Energy Efficiency Data: Information on the energy efficiency of building components, insulation, windows, and HVAC systems. This data can be obtained through energy audits and assessments.

6. Occupancy Data: Data on occupancy patterns, schedules, and behavior, which can be collected through surveys, occupancy sensors, or smart home systems.

7. Energy Pricing Data: Information on energy prices and tariff structures, which can affect residents' energy consumption patterns. This data is often provided by utility companies.

8. Appliance and Equipment Data: - Data on the types, models, and efficiency ratings of appliances and equipment within the building, which can be collected through surveys or home automation systems.

9. Carbon Intensity Data: Data on the carbon intensity of the electricity grid, which indicates the emissions associated with electricity generation. This data can be obtained

from utility companies or government agencies.

10. Emission Factors Data: Emission factors for various energy sources, including electricity, natural gas, and other fuels, provided by environmental agencies or industry sources.

11. Renewable Energy Certificates (RECs) Data: Data on the purchase and use of RECs to offset carbon emissions associated with energy consumption.

12. Indoor Air Quality Data: Indoor air quality monitoring data to assess the impact of energy-efficient ventilation systems and their effect on air quality.

13. Carbon Footprint Data: Data on the carbon footprint of the residential building, which includes emissions from energy use, transportation, and waste.

14. Cost Savings Data: Data on cost savings resulting from energy efficiency measures, including reduced utility bills and maintenance costs.

15. Emissions Reduction Targets and Reporting Data: Information related to emissions reduction targets, goals, and progress tracking to evaluate the effectiveness of emission reduction strategies.

16. Grid Electricity Data: Data on the source of grid electricity, including the proportion of renewable and non-renewable energy sources used in the grid.

17. Energy Efficiency Program Data: Data from energy efficiency programs or initiatives, which may include incentives, rebates, and program-specific metrics.

18. User Behavior Data: Data on user behavior, including energy-saving practices and engagement with energy efficiency measures.

19. Cost-Benefit Analysis Data: Data used to conduct cost-benefit analyses of energy efficiency and emission reduction measures, including initial investment and long-term savings.

These datasets collectively support the design, implementation, and evaluation of greenhouse gas emission reduction strategies in residential buildings. They are crucial for identifying opportunities for improvement, tracking progress, and promoting sustainable living practices.

5.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/abs/pii/S0959652622026816prev section-references.

6 Paper 5: Greenhouse gas emission reduction system in photovoltaic nanogrid with battery and thermal storage reservoirs

Journal/Conference Rank: A*
Publication Year: 2021‘
Reference: S. Adams et al. Reducing carbon dioxide emissions; Does renewable energy matter? Sci. Total Environ. (2019) [?]

6.1 Summary

The residential sector accounts for a further 1/4 of EU final energy consumption, and for 30of the total green house gas emissions. Within this context, the development of green

energies in Europe comes with technological advances, cost decreases, process industrialisation, and efficiency improvement. Having said that, there is still work left to optimize the use of technologies such as PV, storage units (e.g., batteries) and so forth. This is the objective of the on going Interreg NWE RED.

6.2 Software Architecture

The software architecture for a greenhouse gas emission reduction system in a photovoltaic nanogrid with battery and thermal storage reservoirs involves complex control, monitoring, and optimization of various components. This architecture aims to maximize the utilization of renewable energy sources while minimizing the reliance on non-renewable energy. Here is an overview of the key components and their interactions:

1. Data Acquisition and Sensing Layer: - This layer collects real-time data from various sources, including: Photovoltaic Panels: Solar power generation data, including current and voltage. Battery Systems: Battery charge and discharge status. Thermal Storage Reservoirs: Temperature and heat storage level. Weather Data: Solar irradiance, temperature, humidity, and weather forecasts. Grid Electricity Data: Information about grid electricity prices and availability.

2. Control and Decision-Making Layer: - This layer processes data, makes decisions, and sends control signals to various components. It includes the following modules: Energy Management System (EMS): Controls the operation of the photovoltaic system, battery storage, and thermal storage based on real-time data and user preferences. Load Management: Manages the distribution of renewable energy to meet the electrical and thermal load demands of the building. Battery Management: Optimizes battery charging and discharging cycles for load balancing and grid interaction. Thermal Management: Controls the charging and discharging of thermal storage reservoirs for space heating and cooling. Grid Interaction: Determines when to export surplus energy to the grid or import energy based on grid conditions and pricing.

3. Monitoring and Reporting Layer: This layer provides real-time monitoring and reporting capabilities, enabling users to track system performance, energy consumption, and emissions reduction. It includes: User Interfaces: Web or mobile applications for users to monitor system status, set preferences, and receive notifications. Data Logging and Analytics: Collects and stores historical data for performance analysis and reporting. Alerts and Notifications: Sends alerts to users or system administrators in the event of system issues or unusual conditions.

4. Communication Layer: - Facilitates communication between the various system components, including: Communication Protocols: Use standard communication protocols like MQTT, REST APIs, or Modbus to enable data exchange. Grid Interaction: Interfaces with utility providers and grid operators to manage grid interactions and billing.

5. Security and Privacy Layer: - Ensures the security and privacy of data and system operations: User Authentication: Implements user authentication and access control to protect user data. Data Encryption: Secures data transmission between components. Cybersecurity Measures: Protects the system from cyber threats and intrusions.

6. Optimization Algorithms: - Advanced optimization algorithms are employed to: Schedule energy generation, storage, and consumption to minimize grid reliance and maximize the use of renewable energy. Optimize battery charging and discharging patterns for cost savings and emissions reduction. Manage thermal storage reservoirs for efficient heating and cooling. Determine the optimal times for grid interactions, such as selling

surplus energy to the grid during peak demand.

7. Emissions Tracking and Reporting: The system tracks and reports on greenhouse gas emissions reductions achieved by using renewable energy sources and optimizing energy usage.

This software architecture enables the photovoltaic nanogrid system to efficiently generate, store, and use renewable energy while minimizing its carbon footprint. It combines real-time data acquisition, intelligent decision-making, user-friendly interfaces, and robust security measures to achieve greenhouse gas emission reduction goals in a residential or small-scale commercial setting.

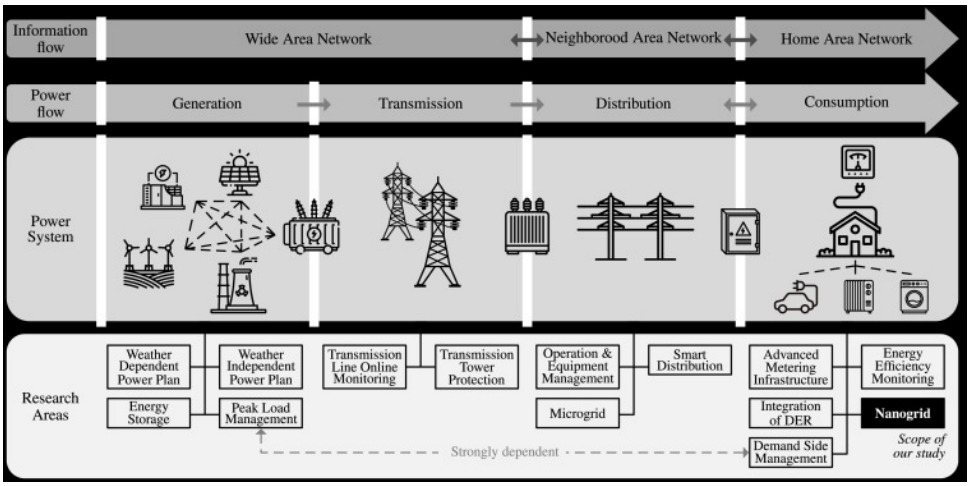

Figure 4: Software architecture diagram for Paper 5.

6.3 Data Parameters

Data parameters are essential for monitoring, controlling, and optimizing a greenhouse gas emission reduction system in a photovoltaic nanogrid with battery and thermal storage reservoirs. These parameters provide the necessary information to manage the system effectively. Here are key data parameters for such a system:

1. Photovoltaic (PV) System Data: Solar panel output data, including: - Solar irradiance (W/m^2). - PV array current (A). - PV array voltage (V). - PV array temperature (°C).

2. Battery System Data: Battery charge and discharge status, including: - State of charge (SoC). - State of health (SoH). - Charge and discharge rates. - Battery voltage and current.

3. Thermal Storage Reservoir Data: Data related to thermal storage reservoirs, including: - Reservoir temperature (°C). - Heat storage level. - Heat transfer rates.

4. Weather Data: Real-time and forecasted weather data, such as: - Solar irradiance (incoming sunlight). - Ambient temperature (°C). - Relative humidity (- Wind speed and direction.

5. Load Data: Information on the electrical and thermal loads, including: - Electrical load power (kW). - Heating or cooling demand (kW or BTUs).

6. Grid Data: - Information on grid electricity, such as: - Grid electricity prices (per kWh). - Grid reliability and availability.

7. User Preferences and Settings: - User-defined settings and preferences, which may include: - Energy usage priorities (e.g., cost or emissions minimization). - Comfort temperature settings. - Battery use preferences (e.g., maximize self-consumption).

8. Energy Conversion Efficiencies: - Conversion efficiencies for energy storage and conversion components, such as: - PV system efficiency. - Battery charging and discharging efficiency.

9. Emission Factors: - Emission factors for electricity generation from the grid, indicating the carbon emissions associated with grid electricity.

10. System State Parameters: - Current operating state of the system, including: - Charging or discharging status of the battery. - Heating or cooling status of thermal storage.

11. Performance Metrics: - Metrics for system performance evaluation, such as: - Energy utilization ratio. - Carbon emissions savings.

12. Historical Data: Historical records of system performance, including energy generation, consumption, and carbon emissions.

13. Control Setpoints: Setpoints for controlling system components, like charge/discharge thresholds for the battery or temperature setpoints for thermal storage.

14. Real-Time Sensor Data: Data from sensors monitoring parameters like temperature, voltage, current, and humidity.

15. Energy Pricing: Real-time or forecasted energy pricing data, which influences decision-making for grid interactions.

These data parameters enable the system to make informed decisions about how to generate, store, and utilize energy efficiently, considering both user preferences and environmental goals. They also facilitate real-time monitoring and reporting of system performance and greenhouse gas emission reductions.

6.4 Datasets Used

Implementing a greenhouse gas emission reduction system in a photovoltaic nanogrid with battery and thermal storage reservoirs may involve the use of various datasets to monitor and optimize the system's performance. While the specific datasets may vary based on the project's requirements and goals, here are some common types of datasets used in such a system:

1. Solar Irradiance Data: - Historical and real-time solar irradiance data for the specific geographic location where the PV panels are installed. This data is essential for understanding solar power generation potential.

2. Weather Data: - Data on weather conditions, including temperature, humidity, wind speed, and cloud cover. Weather forecasts can also be valuable for predicting energy generation.

3. Energy Generation Data: - Data on the actual energy generation of the PV panels, including current, voltage, and power output. This data helps assess the efficiency of the PV system.

4. Battery Performance Data: - Information on the performance of the battery storage system, including state of charge (SoC), state of health (SoH), charge/discharge rates, and voltage.

5. Thermal Storage Data: - Data related to the thermal storage reservoirs, including reservoir temperature, heat storage levels, and heat transfer rates.

6. Grid Electricity Data: - Information on grid electricity prices, grid reliability, and grid demand. This data helps determine when to interact with the grid.

7. Load Data: - Data on the electrical and thermal loads of the building, including load profiles, power requirements, and heating or cooling demands.

8. User Preferences and Settings: - User-defined preferences, such as comfort temperature settings, energy usage priorities, and battery use preferences.

9. Carbon Emission Factors: - Emission factors for grid electricity generation, indicating the carbon emissions associated with grid electricity. This data is crucial for assessing emissions reductions.

10. Historical Performance Data: - Historical records of the system's performance, including energy generation, consumption, storage, and emissions reduction. This data is used for analysis and reporting.

11. Energy Conversion Efficiencies: - Data on the efficiency of energy conversion processes within the system, such as PV system efficiency and battery charging/discharging efficiency.

12. Real-time Sensor Data: - Data from sensors monitoring parameters like temperature, voltage, current, and humidity within the system.

13. Grid Interaction Data: - Data related to interactions with the grid, such as grid import/export records and grid electricity pricing data.

14. Performance Metrics: - Metrics for evaluating the system's performance, such as energy utilization ratio, cost savings, and emissions reductions.

15. Energy Pricing Data: - Real-time or forecasted energy pricing data, which influences decisions regarding when to buy, sell, or store energy.

These datasets collectively support the system's ability to make informed decisions about energy generation, storage, and consumption, with the overarching goal of reducing greenhouse gas emissions and optimizing the use of renewable energy sources. The specific datasets used may vary depending on the system's complexity and objectives.

6.4.1 Paper Link

Access the full paper at: https://www.sciencedirect.com/science/article/abs/pii/S0959652621015663pre section-references.

7 Paper 1:Operations of data centers with onsite renewables considering greenhouse gas emissions

Journal/Conference Rank: Q1
Publication Year: 2023
Reference: BilalK. et al. A taxonomy and survey on green data center networks Future Gener. Comput. Syst. (2014) HuangS. et al. Congestion control in high-speed lossless data center networks: A survey Future Gener. Comput. Syst. (2018)

7.1 Summary

The paper looks at the significant energy consumption and environmental impacts of data centers in a technology dependent society. It emphasizes the importance of transitioning data centers to green data centers (GDCs) powered by renewable energy sources (RES)

and integrating them with the grid. In order to take account of the intermittency of renewable energy sources, the paper proposes an operational system involving a network of shared gigawatts and focuses on best job migration, scheduling, energy management and effective optimisation. A new approach combining geographic and time flexibility, comprising demand side management policies, GHG emission reduction strategies as well as uncertainty in RES is a key contribution to the paper. The economic and environmental benefits of the proposed scheme, taking account of a variety of configuration and sensitivity analyses, have been demonstrated in this case study. The study highlights the need for the service sector, in particular data centers, to switch to cleaner energy sources as a key step towards achieving the GHG reduction targets. In order to contribute to the worldwide efforts aimed at minimizing environmental impacts of data centers and reducing operating costs, this paper introduces a coherent framework for optimizing GDFs' operation.

7.2 Software Architecture

The paper doesn't provide a detailed description of the software architecture used in the proposed system for optimizing the operation of interconnected green data centers (GDCs). However, based on the information provided,

7.3 Data Parameters

Several data parameters and elements were included in the research, according to the report:

1.Usage of internet and traffic data, obtained from the World Bank and other appropriate sources: Data related to Internet user growth in recent years.

2.Data Centre Energy Consumption: information on global data center energy consumption, including statistics relating to total energy usage and trends, which is often cited in reports such as Masanet et al.

3.Energy Efficiency trends: Data concerning the development of energy efficiency in data centers, including how energy consumption has changed as a result of increasing computational power and services

4.Green Data Centres: information on the concept of green data centers, where they use Renewable Energy sources and energy storage systems in order to minimize their carbon footprint.

5.Renewable Energy Sources (RES): Data regarding the utilization of renewable energy sources like solar PV and wind turbines in data centers, often highlighting initiatives by major companies like Google, Apple, etc.

6.Demand-Side Management (DSM) Data: Information about DSM policies implemented by utility operators, such as Time-of-Use (TOU) and Time-and-Level-of-Use (TLOU) programs, which influence data center energy demand curves.

7.4 Datasets Used

The use of specific data sets is not explicitly mentioned in the paper. However, the focus of this study is to develop a model and methodology for optimizing the operation

of interconnected Green Data Centres powered by renewable energy resources RES or electricity grids. In this context, factors such as: are likely to have an impact on the significance of the data.

1.Renewable energy availability: Data from the geographic regions where GOCs are situated regarding the availability and variability of renewables, for instance Solar and Wind. The data are vital in the planning of batch jobs based on periods of high energy availability for renewables. 2.Grid energy price data: information on grid electricity prices, including Time of Use or TOMU and different pricing schemes which could affect the cost of power generation from the grid.

3.Geographical information: due to this the availability of renewable power and grid energy prices, particularly as part of a network of interlinked grids can be affected by geographical location data for GDCs. 4 Energy Storage System Data: Information on the capacity and efficiency of energy storage systems used to mitigate intermittency for renewable sources.

7.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/abs/pii/S2210537923000586?fbc
93oSb9Zn9IiP71mZrRjW8f-LTscan-BDeNGu0Rs-OSA.

8 Paper 2:Energy consumption and greenhouse gas emissions by buildings: A multi-scale perspective

Journal/Conference Rank: A*
Publication Year: 2019
Reference:J. Hong et al. A multi-regional structural path analysis of the energy supply chain in China's construction industry Energy Policy (2016) Z Liu et al. Embodied energy use in China's industrial sectors Energy Policy (2012)

8.1 Summary

The paper is from the multiscale perspective and concerns the impact of infrastructure construction for buildings in Beijing on the environment. The study includes the quantification of embodied energy consumption and greenhouse gas emissions at city, regional or global level by means of input output analysis and process analysis. The main findings are as follows:

1. The construction of buildings in Beijing has a significant impact on energy consumption and greenhouse gas emissions, with an important economic impact for cities, states and economies around the world. 2. According to the study, there are different supply chains for different building materials, with basic materials such as metals and petroleum, which are mainly imported from around the world, and synthetic materials such as paints and rubber, which are typically reprocessed and transported in China. 3. In Beijing, energy consumption and greenhouse gas emissions per unit area of buildings vary significantly from one scale to another, with global impacts relatively low compared to urban and national levels.

3. The paper emphasizes the interconnectedness of global supply chains and underlines the importance of taking into account internal consumption and greenhouse gas emissions

originating from products and services through both national and international trade. In order to assess energy consumption and emissions 5. The study uses a method combining process analysis with input hybrid output analysis which allows an overall assessment of environmental impacts associated with construction.

Finally, this research gives a comprehensive analysis of energy consumption and greenhouse gas emissions associated with construction projects in Beijing which shed light on multiannual impacts and underlined the necessity for coordinated efforts to reduce total consumption and GHG emissions from a holistic perspective.

8.2 Software Architecture

8.3 Data Parameters

The paper you provided appears to be a scientific research paper in the field of environmental impact assessment and energy consumption analysis, specifically focusing on the construction industry in Beijing. It uses a hybrid approach that combines input-output analysis and process analysis to calculate the embodied energy consumption and greenhouse gas emissions of case buildings in Beijing at multiple scales - urban, national, and global. Here's a breakdown of the key components of the paper:

1.Importance of Infrastructure Building: The reports highlight the important role played by building infrastructure in local development and its influence on energy consumption and greenhouse gas emissions.

2.Urbanization and Globalization: The factors influencing the construction sector and its environmental impact are highlighted as the increasing urbanisation and globalization trends.

3.Accounting Method: In assessing energy consumption and greenhouse gas emissions in construction, the papers present a range of accounting methods, including process analysis, inputs output analysis as well as hybrid approaches.

8.4 Datasets Used

In order to carry out a multiscale analysis of embodied energy consumption and greenhouse gas emissions from the construction of buildings in Beijing, the paper uses different data parameters. A list of and brief description of the essential data parameters used is given below:

1.Primary inputs: The study considers over 100 main inputs, which are the sources, materials, services and labor needed for construction. Among the other inputs are steel, cement, lime and metal products. 2.Urban scale intensity databases: These databases provide information on embodied energy consumption and greenhouse gas emissions associated with construction activities at the urban scale in Beijing. Local impact analysis is enabled by these data.

3.National intensity databases: The national intensity database provides data related to energy consumption and greenhouse gas emissions associated with construction projects in China, as well as information from urban scale databases.

4. Energy Consumption per unit area: for buildings in Beijing, with values at national, regional and global level, the paper provides data on energy consumption per unit area. The GJ7/m2 data are shown here.

5.GHG emissions per unit area: For buildings on the scale of cities, states or global regions listed in t CO2eq M2, GHG emissions per unit area have also been reported by this paper.

A research paper conclusion should summarize the main points of the paper and help readers contextualize the information. Although conclusions don't normally present new information that wasn't mentioned in the article, they often reframe the issues or offer a new perspective on the topic.

8.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/abs/pii/S0360132318306917?fbc
Q.

9 Paper 3:Controlling electricity storage to balance electricity costs and greenhouse gas emissions in buildings

Journal/Conference Rank: Q1
Publication Year: 2022
Reference: AEMO (2022a) Data dashboard [cited 2022 February]; Available from: https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem

AEMO (2022b) Negative electricity demand in South Australia [cited 2022 June]; Available from: https://aemo.com.au/newsroom/news-updates/negative-electricity-demand-in-south-australia.

9.1 Summary

The authors of this research examine effective electricity management in buildings, paying particular attention to cutting down on both costs and greenhouse gas emissions. The study develops a real-time model to calculate the electrical grid's carbon emissions against the backdrop of the Australian National Energy Market. Surprisingly, the research reveals that the way power is now priced doesn't effectively encourage users to use electricity at times when there are less emissions. The following section of the essay investigates the applications by looking at a case study featuring a business office building with a battery storage system. There is a difficult balance that must be struck because reducing emissions could result in increased operating expenses even though cost-saving system optimization may not be compatible with reducing emissions. This finding emphasizes how crucial it is to weigh economic as well as environmental considerations when deciding how to manage a building's energy systems.

9.2 Software Architecture

9.3 Data Parameters

The writers of this work examine a wide range of significant issues to determine how to manage power in buildings more effectively. The following are the main things they are

examining:

1. Electricity grid emissions: are just one. They monitor the amount of carbon emissions generated when power is generated. Consider it knowing how "green" the energy you reconsuming is.

2. Electricity Tariffs: This is comparable to being aware of the price of power at various hours.They are curious in when something is affordable and when it is a little more pricey.

3. Battery Storage System: These systems are used in buildings to store electricity. The goal of the study is to determine how managing this system might assist balance emissions and expenses.

4. Operating Costs: The expense of keeping things running. They are looking for a balance between cost and environmental impact to locate this sweet spot.So, to put it simply, they're figuring out how to manage electricity in buildings wisely in order to save money and protect the environment.

9.4 Datasets Used

The researchers collected data on a few critical issues, including:

1. Electricity emissions: They monitored how much carbon is emitted during the production of power. It's similar to determining whether the electricity we use is green.

2. Prices of electricity: They examined when electricity is inexpensive and when it is a little more expensive. It's comparable to receiving discounts while buying electricity.

3. Battery System Data: Extra electricity is stored in a system in buildings. The researchers looked into the financial and environmental benefits of controlling this system.

4. Operating expenses: They looked into the total cost of operation. It's important to strike a balance between expense and environmental impact.

9.4.1 Paper Link

Access the full paper at https://energyinformatics.springeropen.com/articles/10.1186/s42162-022-00216-5?fbclid=IwAR0tPQdUCTIZwEHxcm0hW5RbROOLyaP6Py$_R4RuiCx2oXCtAbByvrMOn$

10 Paper 4:Contemporary changes of greenhouse gases emission from the agricultural sector in the EU-27

Journal/Conference Rank: A*
Publication Year: 2019
Reference: Arora, N. K., Fatima, T., Mishra, I., Verma, M., Mishra, J., Mishra, V. (2018). Environmental sustainability: Challenges and viable solutions. Environmental Sustainability, 1(4), 309–340. [Crossref], [Google Scholar] Burney, J. A., Davis, S. J., Lobell, D. B. (2010). Greenhouse gas mitigation by agricultural intensification. Proceedings of the National Academy of Sciences, 107(26), 12052–12057. [Crossref] [PubMed] [Web of Science ®], [Google Scholar]

10.1 Summary

The article delves into the subject of agricultural greenhouse gas emissions in the EU-27 nations from 1990 to 2016. To identify trends on a country-by-country basis, they employed a method known as the Simple Linear Regression Model. The exciting part? During this time, the majority of these nations were able to drastically reduce their emissions. Salutations to Germany, France, and the United Kingdom for setting the pace! But the story takes a turn. Similar to the rebels in the greenhouse gas reduction saga, Iceland and Spain did not follow the same pattern. The study emphasizes how these emissions are impacted by national legislation. The study emphasizes the significance of using data and statistics to address significant challenges like climate change, even though it doesn't go into detail on the software employed.

10.2 Software Architecture

The paper does not provide detailed information about the software architecture used for data analysis. However, it does mention the use of the Simple Linear Regression Model (SLRM) for estimating the trend in greenhouse gas (GHG) emissions from the agricultural sector in the EU-27 between 1990 and 2016.

10.3 Data Parameters

The paper doesn't explicitly list the specific data parameters used, but it mentions that data was collected from these Organization:

1. Greenhouse Gas (GHG) Emissions: Data related to emissions of greenhouse gases, including but not limited to carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O).
2. Country-Specific Data: Information on GHG emissions from the agricultural sector for each of the EU-27 countries.
3. Time Period: Data spans the years 1990 to 2016, indicating a temporal dimension to track changes over time.
4. Organization for Economic Co-operation and Development (OECD) Data: The source of data collection, implying reliance on OECD datasets for relevant information.
5. Simple Linear Regression Model (SLRM): Parameters associated with the application of SLRM, such as coefficients (and) and variables (Y and X).
6. Statistical Analysis: Parameters related to statistical measures, including mean, standard deviation, coefficient of variation, skewness, and kurtosis.
7. Emission Reduction Trends: Parameters describing trends in GHG emission reductions for individual countries.

10.4 Datasets Used

The Organization for Economic Co-operation and Development (OECD) website is where the article gets its data. The tracking of greenhouse gas (GHG) emissions from the agriculture sector in the EU-27 between 1990 and 2016 depends on these datasets. Their significance stems from their function as the study's analytical framework. The datasets offer a rich supply of data that enables the researchers to analyze trends and modifications in GHG emissions at the level of individual nations. The use of such data makes it possible

to assess the success of emission reduction initiatives throughout the given time period in various EU member states.

10.4.1 Paper Link

Access the full paper at https://www.tandfonline.com/doi/full/10.1080/24749508.2019.1694129?fbclid=

11 Paper 5:Cyber-physical system-based real-time monitoring and visualization of greenhouse gas emissions of prefabricated construction

Journal/Conference Rank: Q1
Publication Year: 2020
Reference: A.A. Acquaye et al. Input-output analysis of Irish construction sector greenhouse gas emissions Build. Environ. (2010) L. Aye et al. Life cycle greenhouse gas emissions and energy analysis of prefabricated reusable building modules Energy Build. (2012)

11.1 Summary

The need of reducing greenhouse gas (GHG) emissions in real-time during the prefabricated building construction process is emphasized in the article. It proposes an intelligent tracking system based on cyber-physical systems (CPS), utilizing recent technology breakthroughs. The emphasis is on the energy consumption of machinery, which is broken down into sections for electricity, gasoline, and diesel.The method used incorporates a thorough quantitative model that breaks down all of the variables affecting GHG emissions, such as running time and emission factors. The authors go into the creation of the CPS-based configuration, with a focus on its use in the building sector.Even though the study offers a viable method, it recognizes the need for additional validation via actual construction projects. During this testing phase, the system's long-term stability will be ensured, and a thorough GHG emission record will be created. The ultimate objective is to provide a dependable and real-time GHG emission monitoring system to support sustainable construction practices.

11.2 Software Architecture

The paper outlines the development of a cyber-physical system (CPS)-based real-time monitoring and visualization system for greenhouse gas (GHG) emissions from prefabricated construction sites. The software architecture used in this system involves data collection, processing, storage, and visualization. Here is an overview of the software architecture:

Sensing Layer: The sensing layer is responsible for collecting data from various sensors and devices. In this system, it includes:

Acceleration sensors to monitor the operational status of tower cranes. Barometric sensors to monitor the running state of construction elevators. A Global Positioning System (GPS) module to record the travel time of on-site transfer vehicles. Data Transmission: The collected data from these sensors are transmitted to a remote server. The

paper mentions the use of a preinstalled Wi-Fi or General Packet Radio Service (GPRS) module for data transmission. This data transmission involves real-time communication between the construction site and the remote server.

Remote Server: The remote server is a crucial component in the architecture. It receives data from the construction site, processes it, and calculates GHG emissions in real-time. The server stores data in a database, including information about the model number, quantity, and power of each construction machinery, as well as GHG emission factors.

Quantitative Model: The paper discusses the development of a quantitative model for calculating GHG emissions. This model is likely implemented in the remote server to process the collected data, perform calculations, and estimate GHG emissions based on the model parameters.

Database: The system includes a database to store information about construction machinery, GHG emission factors, and real-time GHG emission data. It allows for easy retrieval and management of GHG-related information.

Visualization Layer: The visualization layer is responsible for displaying GHG emission data. The paper mentions that GHG emission data can be displayed using visual models and 2D charts on fixed and mobile devices. This implies the use of software for data visualization and presentation.

11.3 Data Parameters

The research assesses greenhouse gas (GHG) emissions during the prefabricated building construction phase using a variety of data metrics. Here are some significant data points:

1. Electricity Usage:

Definition: Determines how much electricity is consumed during construction.

Purpose: To comprehend how electrical energy use affects greenhouse gas emissions.

2. Consumption of gasoline

Definition: Calculates the amount of gas that machinery uses.

Purpose: To determine how much gasoline contributes to total GHG emissions in the building industry.

3. Diesel Consumption:

Definition: Monitors the amount of diesel fuel that construction equipment uses.

Purpose: Assessing the contribution of diesel fuel to the production of GHG emissions.

4. Running Time of Machinery:

Definition: The amount of time construction equipment is in use.

Purpose: In order to help with the calculation of GHG emissions, this purpose links operating time to energy usage.

5. GHG Emission Factors:

Definition: Elements that translate energy use into greenhouse gas emissions.

Purpose: Makes it possible to convert the energy used by machinery into measurable GHG emissions.

The quantitative model is built on these data characteristics, which enables the researchers to assess and compute GHG emissions based on the energy consumption patterns of various machinery types utilized in the construction industry. The breakdown of these variables offers a thorough comprehension of the sources and amounts of emissions, which helps in the creation of an extensive real-time monitoring system.

11.4 Datasets Used

The publication describes the different types of data that were taken into consideration for the study but does not specifically name any datasets. The following are essential components.

1. Machinery Energy Consumption Data: For determining the environmental impact and estimating GHG emissions, this information offers insights into the energy consumption trends of construction equipment.

2. Running Time Data: It's crucial to understand how long machinery runs. It makes it easier to match energy use to real running time, which allows for more precise GHG emission estimations.

3. GHG Emission Factors: These variables serve as conversion parameters that convert energy use into calculable GHG emissions. They are essential for precisely determining how construction operations affect the environment.

The importance is found in the thorough knowledge of the energy dynamics and emissions related to construction equipment. The researchers hope to create a quantitative model for real-time monitoring of GHG emissions during the prefabricated house construction phase by merging these datasets. Designing sustainable construction methods, maximizing energy use, and supporting environmental conservation efforts all depend on this information.

11.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/abs/pii/S0959652619339290?fbc

12 Paper 1: WEB-GIS-TOOL: ESTIMATION OF GREENHOUSE GAS SAVINGS DUE TIMBER USE IN THE URBAN BUILT ENVIRONMENT

Journal/Conference Rank: Q1
Publication Year: 2023
Reference:Büchner H.: Rechtliche Grundlagen kommunaler Selbstverwaltung. München. 2020 [?]

12.1 Summary

This paper introduces the Holzbau-GIS system, a web-GIS tool that calculates the potential greenhouse gas reductions and carbon storage benefits of using timber in new construction and refurbishment projects in urban areas. The tool is designed to help decision-makers make informed choices that benefit both the environment and the economy. The paper provides information on the different elements and methods that characterize the refurbishment scenario, including geospatial data, building geometry, and building use. The paper also highlights the importance of valid extrapolation to generate an initial estimation of potential GHG reductions at the municipal level and the role of urban land use planning in supporting decision-making processes or planning measures for climate protection in urban areas. Overall, the paper aims to serve as a representative

calculation to demonstrate the potential of timber construction to the decision-makers of a municipality..

12.2 Software Architecture

Describe the software architecture used in the paper.

12.3 Data Parameters

The dashboard view displayed by Holzbau-GIS's web interface is tailored to the user's specific needs and the data being displayed. A map view, two charts, and the aggregate sum of one chosen output parameter are all included in the dashboard. A part of the scenario for new building can be seen in Figure 6. A case study approach was used to provide extensive representations of quantitative GHG reduction potentials and temporary carbon storage for new building initiatives, as well as to acquire a thorough understanding of the influence of material selections. In this section of the new construction scenario, five case studies that represent recent construction in Menden, Switzerland, are briefly discussed. The approved land uses, building kinds, and further information on permitted building attributes are all included in development plans. Regarding land usage and building types, the five case studies' development plans diverge. The case study number 221 is shown in Figure 6. According to Development Plan No. 221, the map view displays the locations of the upcoming construction sites. Single-family homes (SFH) were allowed in eight construction sites under Development Plan No. 221

12.4 Datasets Used

The paper describes how different municipal geodata, such as building footprints, 3D building models, historical satellite images, etc. are used in the Holzbau-GIS system to set up fundamental data and provide a reliable foundation for the GHG-Calculation by the research partner Environmental Engineering+Ecology (eE+E). The database is maintained by the disy Cadenza platform, according to the report, and the data is saved in a PostgreSQL DBMS with the PostGIS extension for storing spatial data. A complete list of all the datasets used in the Holzbau-GIS system is not included in the study, though.

12.4.1 Paper Link

Access the full paper at https://www.researchgate.net/publication/371546945$_{W}EB-GIS{-}TOOL_{E}stimation_{o}f_{g}reenhouse_{g}as_{s}avings_{d}ue_{t}imber_{u}se_{i}n_{t}he_{u}rban_{b}uilt_{e}nvironment.$

13 Paper 2: Analysis of Specific Greenhouse Gas Emissions Savings from Biogas Production Based on Agricultural Residues and Industrial By-Products

Journal/Conference Rank: A*
Publication Year: 2023
Reference: Parralejo, A.I.; Royano, L.; González, J.; González, J.F. Small scale biogas

production with animal excrement and agriculturalresidues. Ind. Crops Prod. 2019,131, 307–314. [CrossRef] [**?**]

13.1 Summary

The analysis of particular greenhouse gas emissions savings from biogas production based on agricultural waste and industrial byproducts is presented in this research. The study looks at how biogas can replace fossil fuels in the future and emphasizes the need for more feedstocks for which default and typical values are available. The study finds that the premise that studied feedstocks can achieve 80 percent GHG savings in the case of a travel distance up to 50 km is untrue for municipal biowaste, unbaled wheat, and barley straw. Along with a list of acronyms and references, the study also goes over the research's funding and methods. Overall, the article offers insightful information about the potential of biogas production and its function. Along with a list of acronyms and references, the study also goes over the research's funding and methods. Overall, the report offers insightful information about the possibilities of producing biogas and its contribution to lowering greenhouse gas emissions.

13.2 Software Architecture

13.3 Data Parameters

The study includes a number of data parameters pertaining to the production of biogas from industrial waste and agricultural residues. These consist of: Types of feedstocks: The study looks at the possibility of producing biogas from municipal garbage, unbaled wheat and barley straw, and commercial by-products such glycerol and crude glycerin. Next, GHG savings: Based on the various feedstocks and transit distances, the report examines the precise greenhouse gas emissions savings from biogas production. The findings indicate that, for transport distances of up to 50 km, the evaluated feedstocks are unable to achieve 80 percent GHG savings. Also, Data on the transport and distribution values of the various feedstocks is provided in the study, including information on the bulk density of residues, truck load capacity, and transport distances. The article looks at the biogas potential of various feedstocks and gives information on the methane content and biogas yield. Moreover, Methane lower heating value: The study also gives information on this crucial factor in estimating the energy value of biogas. Overall, the study offers useful data factors linked to the generation of biogas and its potential as a sustainable fuel substitute.

13.4 Datasets Used

The study is based on a review of the literature and earlier research on the generation of biogas. The analysis of greenhouse gas emissions and particular greenhouse gas emissions savings from biogas production utilizing various feedstocks, as described in Directive 2018/2001, are presented in this document. The study looks at methane concentration, reduced heating value, biogas yield, transport and distribution costs, and potential biogas from various feedstocks. The findings demonstrate that greenhouse gas emission reductions as a result of transportation and distribution emissions have a significant impact on overall emissions. Overall, the study offers useful data factors linked to the generation of biogas and its potential as a sustainable fuel substitute.

13.4.1 Paper Link

Access the full paper at https://www.researchgate.net/publication/370358221$_Analysis_of_Specific_Green$
$Products.$

14 Paper 3: Analysis of agricultural greenhouse gas emissions using the STIRPAT model: a case study of Bangladesh

Journal/Conference Rank: Q1
Publication Year: 2022
Reference:Alam MM, Khan MI, Saha CK, Rahman A, Bhuyian MG. Manufacturing of agricultural machinery in Bangladesh: Opportunities and constraints. Agricultural Engineering International: THe CIGR e-Journal. 2020;19(1):122–13
[**?**]

14.1 Summary

This article examines Bangladesh's agricultural greenhouse gas emissions. According to the study, carbon intensity, wealth, population, energy intensity, and urbanization are the factors that have the greatest effects on carbon dioxide emissions, followed by rural population. The intensity of fertilizer has the biggest impact on nitrous oxide emissions. The amount of rice that is grown, the cultivated land area, and crop yield have the most impacts on methane emissions.

14.2 Software Architecture

14.3 Data Parameters

The CO2, CH4, and N2O emissions from agriculture are the study's dependent data parameters. the following independent data variables: Population, both urban and rural, Affluence of urban areas, (real GDP per capita), Energy intensity in terms of carbon intensity, area of land used for agriculture, Amount of land irrigated, Amount of rice that is grown, yield of crops on the land, use of nitrogen, fertilizers in quantity, Nitrogen fertilizer usage intensity. Agrarian emissions may be influenced by socioeconomic conditions, which are represented by the independent data parameters. Population, for instance, is a measure of how many people depend on agricultural production, while the rural population is a measure of how many people work in the agricultural industry. Because a decline in rural population results in a greater reliance on mechanization, which might raise emissions, urbanization is included. Since people with higher incomes typically consume more products and services that require energy to generate, affluence is included since it is believed to have a positive link with emissions. Because it is a gauge of how clean the energy utilized in agriculture is, the carbon intensity of energy is included. Considering that the energy intensity is a gauge of The World Bank, the International Energy Agency, the Food and Agriculture Organization, and the Emissions Database for Global Atmospheric Research are just a few of the organizations from which the study's data was compiled.

14.4 Datasets Used

The study's data set spans a 25-year period from 1990 to 2014. The information was gathered from a number of sources, including the Eora multiregional input output (MRIO) tables, the International Energy Agency (IEA), the PRIMAP database, the Bangladesh country database of the World Bank, the Emissions Database for Global Atmospheric Research (EDGAR) database, and the Food and Agriculture Organization database (FAOSTAT). The information in the data comprises the following agricultural industry output, Energy use in the industry, emissions of CO2,both the energy and carbon intensities Population, rural population, rates of urbanization, GDP per person, cereal yield, and area under cultivation of cereals Utilization of nitrogen fertilizer in agriculture, its intensity, the cultivation of rice, and the area irrigated emissions of CH4 and N2O.

14.4.1 Paper Link

Access the full paper at https://pubmed.ncbi.nlm.nih.gov/35880193/.

15 Paper 4: Blaming cities for climate change? An analysis of urban greenhouse gas emissions inventories

Journal/Conference Rank: Q1
Publication Year: 2009
Reference:Air Quality Division (2005), District of Columbia Greenhouse Gas Emissions Inventories and Preliminary Projections, District of Columbia Department of Health, Air Quality Division. [?]

15.1 Summary

The article examines inventories of greenhouse gas emissions from various cities and nations around the world. It concludes that, for the most part, city per capita emissions are below the national average for the nations in which they are located. In contrast to rural areas, cities frequently have denser populations and more effective transportation infrastructures. The report also discusses the effects of various methodological strategies for creating emissions inventories. According to its findings, an inventory's outcomes might vary greatly depending on the techniques employed to gather and examine the data. The key causes of high levels of greenhouse gas emission in cities are then identified by the article. These include things like energy use, travel, and waste management.The final section of the report looks at cities' potential and involvement in lowering global greenhouse gas emissions. It makes the case that cities are essential to lowering emissions and that there are several things they can do to do this, including spending money on renewable energy, enhancing public transit, and cutting waste..

15.2 Software Architecture

15.3 Data Parameters

Energy supply, transportation, agriculture, forestry, industry, waste and wastewater, and residential and commercial construction make up the majority of the cities' sources of greenhouse gas emissions. Depending on the economic foundation, urban morphology, and level of wealth of the city, different sectors of the economy contribute a different amount of emissions. It's vital to remember that these numbers only represent proportions and do not say whether or not the emissions levels are sustainable. Even though it generates income and jobs, industrial activity is a significant source of greenhouse gas emissions in many cities.

15.4 Datasets Used

The approach chosen to calculate greenhouse gas emissions has ramifications for both moral and practical reasons. A production-based economy morally deflects attention and responsibility away from high consumption habits that are the cause of unsustainable levels of greenhouse gas emissions. This system, in practice, fails to identify the regions where interventions are needed to cut emissions since it only pays attention to one link in a complicated web of commodity chains. On the analysis of consumption patterns, alternative mechanisms for creating emissions inventories can be built. The ecological footprint methodology, which assigns the consumer responsibility for the ecological effects of a specific economic process, is the foundation of a totally consumer-focused strategy. In theory, this type of accounting system should encourage consumers in high-income countries to take responsibility for picking the best strategies and policies to reduce emissions, resulting in a lower level of greenhouse gas emissions to low- and middle-income countries (with a likely substantial reduction in the greenhouse gas emissions allocated to China and Chinese cities).

15.4.1 Paper Link

Access the full paper at https://www.semanticscholar.org/paper/Blaming-cities-for-climate-change-An-analysis-of-Dodman/f3904c35a01fc036d0acbd51f350f9d4da3fb65d.

16 Paper 5: Controlling electricity storage to balance electricity costs and greenhouse gas emissions in buildings

Journal/Conference Rank: Q1
Publication Year: 2022
Reference:AEMO (2022a) Data dashboard [cited 2022 February]; Available from: https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/data-nem/data-dashboard-nem [?]

16.1 Summary

In order to reduce both power prices and carbon emissions, the article looks into managing variable loads and generation sources in buildings. The authors start by employing a power-flow tracing method to create a real-time emission intensity model of the Australian National Energy Market. This model shows that at the moment, power price signals do not encourage users to use electricity during periods of lower emissions. While the 30-min wholesale electricity price in each region has no discernible relationship with the emissions intensity of electricity consumed in that region, the mean and peak emissions intensity during low electricity tariff periods are, for example, equal to or slightly higher than those during high electricity tariff periods. The authors next examine how much managing a battery can be done using the emissions model. The study's findings suggest that power tariffs should be created to incentivize users to utilize electricity during periods when emissions are at their lowest. The authors advise facilities looking to cut emissions to think about the cost-benefit ratios involved.

16.2 Software Architecture

16.3 Data Parameters

This section provides an overview of the research technique used to construct a consumption-based NEM emission model and how to use that model in an MPC framework. Fig. 1 depicts the modelling framework schematically. To reduce costs and emissions, a scheduler was fed historical site electricity usage and gird emission intensity data to simulate control of battery charge/discharge actions. Receding Horizon Control, another name for MPC, is the foundation of the proposed scheduler. Through this method, the scheduler analyzes the battery's present and projected states as well as the predicted PV generation to find the best course of action for minimizing the cost of electricity and emissions for the microgrid over a given time horizon. After

16.4 Datasets Used

Even though the entire historical data is available in this modelled scenario evaluation framework, only data two days in the future (the prediction horizon) was sent to the scheduler at each time-step. This enables a realistic update of the demand charge due to the battery charging solution (without knowing the future). The following goals were looked into: 1. The potential savings from employing a PV-battery system on electricity and pollution costs. 2. The cost and carbon savings impact of time of use versus wholesale-based prices. 3. The savings' sensitivity to rising carbon prices.

16.4.1 Paper Link

Access the full paper at https://energyinformatics.springeropen.com/articles/10.1186/s42162-022-00216-5Sec2.

17 Paper 1: Comparative evaluation of data requirements and level of decision support provided by decision support tools for reducing livestock-related greenhouse gas emissions

Journal/Conference Rank: Q1
Publication Year: 2022
Reference:https://www.sciencedirect.com/science/article/pii/S0264837714001148 [**?**]

17.1 Summary

The authors emphasize the global importance of identifying and mitigating greenhouse gas (GHG) emissions from the livestock sector due to its significant impact on climate change in this research. They explore the complexities of estimating these emissions and highlight the availability of several tools, each with its own set of limitations in terms of accessibility, methodology, and scope. The research examines open-access decision-support tools (DSTs) for calculating farm-level GHG emissions, noting that the vast majority are based on IPCC Tier 2 criteria, with only a few tools acceptable for all geographic areas. While some systems provide static advice, others do not provide concrete guidelines for designing effective mitigation solutions. To address these shortcomings and improve climate-related livestock decision-making processes, the authors suggest a high-level framework for Data-driven Decision Support Tools (DDSTs). The paper is organized in such a way that it provides an overview of extant DSTs, assesses their features, gives a framework for evaluation, analyzes existing tools, proposes a data-driven decision support system, and finishes with insights.

17.2 Software Architecture

Describe the software architecture used in the paper.

17.3 Data Parameters

Data Requirements: This dimension evaluates the quantity and type of data required for the tools to perform properly. It could comprise farm-specific information, animal gross energy, feed composition, dry matter intake, waste management data, and so forth.

Level of Decision Support: This factor assesses how well the tools aid in decision-making processes linked to GHG emissions reduction. It could include the capacity of the tools to provide recommendations and suggestions depending on the data input.

Presented Output Features: This dimension investigates the type of output provided by the tools. It could contain the results' format, such as numerical data, graphs, visualisations, or detailed reports.

User Friendliness: This factor evaluates the tools' usability and accessibility. It takes into account things like user interface design, simplicity of data input, and overall user experience.

17.4 Datasets Used

Datasets Used in the Paper:

Livestock GHG Emissions Data Decision Support Tools (DSTs) Information, Life Cycle Assessment (LCA) Data, Farm-Specific Data, Emission Mitigation Strategies and Their Effectiveness Data.

Significance of the Datasets:

Comparison of DSTs, Identification of Data Gaps, Supporting Sustainable Farming Practices,

17.4.1

Access the full paper at

https://www.sciencedirect.com/science/article/abs/pii/S0959652622034564?fbclid=IwAR2ow1b$_N A$

18 Paper 2: A web application to estimate the carbon footprint of constructed wetlands

Journal/Conference Rank: A*
Publication Year: 2021
Reference:https://www.sciencedirect.com/science/article/pii/S0306261920302658
[?]

18.1 Summary

The research describes a web application for estimating direct and indirect greenhouse gas (GHG) emissions from built wetlands (CWs), a sustainable wastewater treatment method. CWs, as opposed to traditional wastewater treatment plants, use natural processes for treatment and emit less GHG. The report emphasizes the lack of comprehensive tools for analyzing CW emissions and explores the limitations associated with LCA approaches. The web tool incorporates reported data from scientific literature, allowing users to compute GHG emissions in CWs, facilitating greater access and understanding of the environmental impact of CWs in wastewater treatment

18.2 Software Architecture

Describe the software architecture used in the paper.

18.3 Data Parameters

Wastewater Characteristics:

Organic Load, Flow Rate Constructed Wetland Design and Configuration:

Surface Area, Depth, Plant Species, Hydraulic Loading Rate, Wetland Performance:

Removal Efficienc, Water Quality Parameters, Methane Emission, Energy Consumption and Carbon Emissions:

Energy Use, Carbon Emissions from Energy Use, Construction and Maintenance:

Construction Materials, Transportation Emissions, Maintenance Activities Life Cycle Assessment (LCA) Data:

Data Inputs for LCA, Geographical Data:
Location, Economic Data:
Cost Data, Database Sources:
Literature Review, Environmental Databases,

18.4 Datasets Used

Wastewater Characteristics:

Organic matter content: Nutrient levels: Pollutant concentrations: Constructed Wetland Design and Operation:

Surface area: Hydraulic loading rate: Plant species and density: Retention time: Wetland Performance Data:

Pollutant removal efficiency: Water quality parameters: Methane emissions: Energy Consumption and Carbon Emissions:

Energy usage: Carbon emissions from energy use: Construction and Maintenance:

Construction materials: Maintenance activities: Life Cycle Assessment (LCA) Data:

Raw material production: Transportation emissions: End-of-life disposal emissions: Geographical and Climate Data:

Location:

18.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/abs/pii/S1364815220309555?fbc PY7M-PE7KQXqRo0iKCTgTWKa$_H NU$.

19 Greenhouse gas emission reduction system in photovoltaic nanogrid with battery and thermal storage reservoirs

Journal/Conference Rank: Q1
Publication Year: 2021
Reference:https://www.sciencedirect.com/science/article/pii/S0048969719332073
[**?**]

19.1 Summary

The research presents a novel greenhouse gas emission (GHGE) reduction system at the house (nanogrid) level to address Europe's large GHGE from the residential sector. Energy flows are optimized between on-site power generation systems (e.g., photovoltaics), loads, and storage units (battery and thermal storage) in the proposed system. It employs a unique CO2-based progressive threshold technique, as well as battery and thermal storage reservoirs, and functions in real-time using data collected on-site and projected. Based on real-world data from the UK and France, the system outperforms typical residential energy infrastructures in terms of reducing non-carbon-free energy use, maximizing local green energy utilization, and lowering overall power prices.

19.2 Software Architecture

Describe the software architecture used in the paper.

19.3 Data Parameters

Data on Energy Consumption:

Energy usage data from IoT devices and networks.

IoT device energy efficiency metrics.

Data on energy consumption compared between regular IoT devices and green IoT devices.

Data on Carbon Emissions:

Data on emissions linked with the manufacture and use of IoT devices.

Carbon footprint comparison of traditional IoT systems versus green IoT solutions.

Data on Resource Utilisation:

Data on the usage of rare earth metals and other resources in the manufacture of IoT devices.

Rates of recycling and reusing IoT devices and components.

Data on the Environmental Impact:

Environmental assessments of IoT technology, taking into account variables like as water usage, pollution, and habitat damage.

Data on the effects of Internet of Things technologies on wildlife and ecosystems.

Integration of Renewable Energy:Information about the incorporation of renewable energy sources into IoT networks. Efficiency measures and rates of adoption of solar, wind, and other renewable energy options for powering IoT devices. Data on Waste Management:

Electronic garbage (e-waste) data created by IoT devices. Rates of recycling and disposal of IoT devices and electronic components. IoT Device Durability:

Data about the average lifespan of Internet of Things devices. Rates of planned obsolescence and solutions for extending the life of IoT equipment. Data on Sustainable Manufacturing:

Data on IoT device makers' use of sustainable manufacturing practises. Environmentally friendly manufacturing procedures are indicated by certification data (such as ecolabels). User Awareness and Behaviour:

User behaviour data influencing IoT energy use. Green IoT practises have a high level of public awareness and adoption. Regulation and policy:

Policy, regulation, and standard data promoting green IoT practises. Environmental regulation compliance rates and industry adherence.

19.4 Datasets Used

Describe the datasets used in the paper and their significance.

19.4.1 Paper Link

Access the full paper at http://www.example.com/jse/vol15/issue3/paper1.pdf.

20 Paper 4:Green IoT: Advancements and Sustainability with Environment by 2050

Journal/Conference Rank: A*
Publication Year: 2020
Reference:https://ieeexplore.ieee.org/abstract/document/9197796/referencesreferences [?]

20.1 Summary

The article investigates the environmental impact of Internet of Things (IoT) technology, which connects billions of smart devices via the Internet, resulting in a rise in carbon footprint and greenhouse gas emissions. The authors emphasize the rapid proliferation of IoT devices and the resulting increase in environmental degradation, emphasizing the need for long-term solutions. The article suggests "Green IoT" as an environmentally beneficial alternative to standard IoT, with a focus on reducing carbon footprints and greenhouse gas emissions. The study's goal is to examine the environmental sustainability of smart gadgets and provide solutions to lessen their environmental impact. Furthermore, the study examines the use of Deep Learning and Data Mining approaches to improve Life Cycle Assessment (LCA) models for smart devices, so ensuring more efficient and eco-friendly outcomes.

20.2 Software Architecture

Describe the software architecture used in the paper.

20.3 Data Parameters

Environmental Sensor Data: This could involve data from various sensors measuring parameters like air quality, water quality, temperature, humidity, pollution levels, etc.

Energy Consumption Data: Data related to energy usage, both in the IoT devices themselves and in the systems they are monitoring or controlling.

Network Traffic Data: Information about the data traffic between IoT devices, which is vital for understanding communication patterns and optimizing energy use.

Geospatial Data: Data related to the geographic location of IoT devices and the environmental features around them.

User Behavior Data: If applicable, data regarding how users interact with IoT devices and systems, which could include user preferences, usage patterns, etc.

Lifecycle Assessment Data: Data about the manufacturing, usage, and disposal of IoT devices, which is crucial for assessing their overall environmental impact.

Predictive Models: Data parameters used in predictive models, which could include historical environmental data, weather patterns, and other relevant variables.

20.4 Datasets Used

Climate Data: Climate datasets include information about temperature, precipitation, humidity, and other climate-related variables. Researchers use climate data to analyze long-term climate patterns and predict future climate changes.

Environmental Pollution Data: Datasets related to environmental pollutants such as air quality indices, water pollution levels, and soil contamination data are crucial for understanding the impact of pollution on the environment and human health.

Energy Consumption Data: Energy consumption datasets provide information about the usage of energy resources in different sectors. This data is vital for analyzing energy consumption patterns and identifying areas for improvement and energy conservation.

IoT Sensor Data: Internet of Things (IoT) devices equipped with sensors can collect data on various environmental parameters such as air quality, water quality, and energy usage. This real-time data is valuable for monitoring environmental conditions and making necessary adjustments for sustainability.

Biodiversity Datasets: Researchers studying the impact of climate change and environmental degradation on biodiversity use datasets that contain information about different species, their habitats, population sizes, and distribution patterns.

Geospatial Data: Geospatial datasets, including satellite imagery and geographic information system (GIS) data, are used to study land use, deforestation, urbanization, and other geographical factors affecting the environment.

Social and Economic Data: Socio-economic datasets help researchers understand the relationship between human activities, economic development, and their impact on the environment. This information is crucial for formulating sustainable policies and practices.

20.4.1 Paper Link

Access the full paper at https://ieeexplore.ieee.org/abstract/document/9197796/referencesreferences.

21 Paper 5: Towards Efficient Mapping of Greenhouse Gas Emissions: A Case Study of the Port of Tallinn

Journal/Conference Rank: Q1
Publication Year: 202
Reference:https://doi.org/10.3390/su15129520

21.1 Summary

Due to the global challenge of climate change, the article discusses the urgent need to minimize greenhouse gas (GHG) emissions in ports. It emphasizes the significance of identifying the major sources of emissions in ports as a critical first step toward mitigation. The study examines the current state of GHG emission assessment procedures in ports, to identify effective and efficient approaches. It emphasizes the quick advancements in this field and includes a case study conducted in the Port of Tallinn to evaluate the practical application of these approaches. The report assesses the benefits and drawbacks of present approaches and makes significant recommendations for future strategies for decreasing GHG emissions at ports.

21.2 Software Architecture

Describe the software architecture used in the paper.

21.3 Data Parameters

Types of Greenhouse Gases (GHGs): This includes gases such as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and fluorinated gases. Different GHGs have different global warming potentials, so it's important to specify which gases are being measured.

Emission Sources: Identifying and categorizing the sources of greenhouse gas emissions is crucial. In the context of a port, sources might include ships, trucks, cargo handling equipment, and port facilities.

Activity Data: This involves the data related to the activities that produce emissions. For a port, it could include data on the number and types of ships docking, the amount of cargo being handled, the number of vehicles entering and exiting the port, and the energy consumption of port facilities.

Emission Factors: Emission factors are used to calculate the amount of greenhouse gas emissions produced per unit of activity. For example, the emission factor for a specific type of ship engine might be used to calculate emissions based on the amount of fuel consumed.

Time Period: The study should specify the time period for which the data is collected. Emissions can vary seasonally or annually, so it's important to capture data over an appropriate timeframe.

Spatial Data: Geographic information about the port and its facilities, such as layout, area, and proximity to populated areas, can be important for understanding the dispersion and impact of emissions.

Data Collection Methods: Specify the methods used to collect the data. This could include direct measurements, remote sensing technologies, interviews, surveys, or data obtained from monitoring equipment.

Uncertainty Analysis: It's important to assess the uncertainties associated with the data and the methods used for estimation. Uncertainty analysis helps in understanding the reliability of the results.

21.4 Datasets Used

21.4.1 Paper Link

Access the full paper at https://scholar.google.com/scholar$_{u}rl?url = https://www.mdpi.com/1996-1073/14/16/4854/pdfhl = ensa = Xei = a8wqZcSDMoWH6rQP2aKAoQ4scisig = AFWwaea5oIEk7MaO2HmoQ_{1}1HmO8oi = scholarr.$

22 Paper 1: Agricultural opportunities to mitigate greenhouse gas emissions

Journal/Conference Rank: Q1
Publication Year: 2007
Reference: [?] Aerts, R., 1997. Climate, leaf litter chemistry and leaf decomposition in terrestrial ecosystems e a triangular relationship. Oikos 79, 439e449. Arrhenius, S.,

1896. On the influence of carbonic acid in the air upon the temperature of the ground. Philosophical Magazine 41, 237e276.

22.1 Summary

Agriculture is a major source of greenhouse gas emissions, accounting for about 10 percent of global emissions. The three main GHGs emitted from agriculture are carbon dioxide , methane and nitrous oxide . Agriculture can also be a sink for CO2 through carbon sequestration in biomass products and soil organic matter.

This paper reviews the literature on GHG emissions and C sequestration in agriculture, with a focus on how agriculture can reduce its GHG burden and how it can help to mitigate GHG emissions through conservation measures.

22.2 Software Architecture

A software architecture for agriculture greenhouse gas emissions consists of the following components:

1)Data collection: This component would collect data on agricultural practices and systems, such as crop type, livestock numbers. Data could be collected from a variety of sources, including farm sensors, and government databases.

2)Data processing: This component would process the collected data to estimate GHG emissions . This could be done using a variety of methods, such as statistical modeling.

3)Scenario analysis: This component would allow users to run scenarios to assess the impact of different agricultural practices on GHG emissions and C sequestration.

4)Visualization : This component would provide users with tools to visualize and report on the results of the analysis. This could include maps, charts, and tables that show GHG emissions and C sequestration by region, crop type.

22.3 Data Parameters

1)Greenhouse gas emissions: The paper reviews the literature on GHG emissions from agriculture, including CO2, CH4, and N2O. The authors discuss the impacts of different agricultural practices and systems on GHG emissions.

2)Carbon dioxide sequestration: The paper reviews the literature on CO2 sequestration in agricultural systems. The authors discuss the role of biomass products and soil organic matter in CO2 sequestration.

3)Agricultural practices and systems: The paper discusses a wide range of agricultural practices and systems that can impact GHG emissions and CO2 sequestration. These include:

1)Conservation practices: Conservation practices that help prevent soil erosion, such as cover cropping and no-till farming, can also sequester soil C and enhance CH4 consumption.

2)Nitrogen management: Managing nitrogen to match crop needs can reduce N2O emissions and avoid adverse impacts on water quality.

3)Animal diet and manure management: Manipulating animal diet and manure management can reduce CH4 and N2O emissions from animal agriculture.

22.4 Datasets Used

The database used in the paper is not exactly mentioned. However, it is likely that the authors used a combination of datasets from different sources to compile their review. Some possible sources of data include:

FAOSTAT: The faostat database provides statistics on agriculture, forestry, fisheries, and food security from over 200 countries and territories. It includes data on crop production, livestock production, land use, and environmental indicators, such as greenhouse gas emissions.

National inventories: Many countries produce national inventories of their GHG emissions. These inventories are typically submitted to the UNFCCC on an annual basis.

Peer-reviewed literature: The peer-reviewed literature is a rich source of data on GHG emissions from agriculture and other topics.

The authors may also have used other datasets, such as those from research projects and industry organizations..

22.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/abs/pii/S0269749107003016.

23 Paper 2: An overview of greenhouse gases emissions in Hungary

Journal/Conference Rank: A*
Publication Year: 2009
Reference: [**?**] Baccini, P.; Brunner, P. H.Metabolism of the Anthroposphere;Springer-Verlag: Berlin, 1991.(3) Odum, H. T.Systems Ecology: An Introduction; Wiley: New York

23.1 Summary

The paper examines the changes in greenhouse gas emissions from different sectors in Hungary between 1985 and 2018, as well as the relationship between GHG emissions and economic growth. The authors find that the industrial sector is the main source of CO2 emissions in Hungary, accounting for 72

The Mann-Kendall test results show that total CO2 emissions decreased significantly at a rate of 1001 thousand tonnes per year between 1985 and 2018. Total N2O emissions also decreased significantly at a rate of 0.31 thousand tonnes per year.

The EKC results show that there is a long-run positive significant relationship between income growth and GHG emissions in Hungary. However, the negative significance of the squared term of income growth indicates that the EKC exists for CO2, CH4, and N2O in Hungary. This means that GHG emissions will increase at a decreasing rate with economic growth in Hungary.

The authors conclude that Hungary has been successful in reducing its GHG emissions in recent years. However, they also caution that the EKC relationship is long-run, and that Hungary needs to continue to invest in low-carbon technologies in order to meet its emissions targets.

The authors' findings are useful for policymakers in Hungary, as they provide insights into the trends in GHG emissions from different sectors and the relationship between GHG emissions and economic growth. This information can be used to develop more effective policies to reduce GHG emissions and mitigate climate change.

23.2 Software Architecture

The software architecture for the research paper could be as follows:

1)Data collection and preparation: The first step would be to collect and prepare the data on GHG emissions from different sectors in Hungary between 1985 and 2018. This data could be collected from a variety of sources, such as government agencies and research institutions. Once the data is collected, it would need to be cleaned and preprocessed to ensure that it is in a consistent format and can be easily analyzed.

2)Data analysis: The next step would be to analyze the data using the Mann-Kendall test and the environmental Kuznets curve (EKC) model. The EKC model is a theoretical relationship between economic growth and environmental quality.

3)Visualization: The results of the data analysis could be visualized using charts and graphs to make them easier to understand.

3)Reporting: The final step would be to write a report that summarizes the findings of the research. The report should include a description of the data collection and analysis methods, as well as a discussion of the results and their implications.

23.3 Data Parameters

The paper focuses on an analysis of greenhouse gas emissions in Hungary from 1985 to 2018, with an emphasis on the interaction between these emissions and economic growth. The data parameters used in this research are as follows:

GHG Emissions Data: The primary dataset consists of GHG emissions data, including carbon dioxide , methane , and nitrous oxide . These emissions data are likely collected from national records, international databases.

Sector-Specific Emission Data: The GHG emissions data are segmented by various sectors, such as the industrial sector, waste sector, and agricultural sector.

Mann-Kendall Test (M-K Test): The Mann-Kendall test is applied to the GHG emissions data to assess the trends over time. This statistical test helps determine if there are significant changes in GHG emissions during the study period.

Environmental Kuznets Curve (EKC): The EKC concept is used to explore the relationship between GHG emissions and economic growth in Hungary. This involves examining how GHG emissions change concerning Gross Domestic Product (GDP) and its square, and whether this change follows the EKC hypothesis.

Economic Data: GDP data for Hungary over the same period, from 1985 to 2018, is used to study the connection between economic growth and GHG emissions. Economic data is crucial in the analysis of the EKC.

Temporal Scope: The study focuses on the period from 1985 to 2018. This extended time frame allows for the evaluation of long-term trends in GHG emissions and their relationship with economic factors.

Spatial Scope: The research specifically pertains to Hungary, with all data parameters concentrated on the country's GHG emissions and economic conditions.

Statistical Significance: The paper employs statistical significance measures, such as "p ¡ 0.05," to determine the significance of observed trends or relationships in the data.

23.4 Datasets Used

. The paper is structured to address the following questions related to environmental dimensions of GHG emissions and their economic implications. The key datasets and summaries are as follows:

GHG Emissions Data (CO2, CH4, N2O): The paper utilizes historical GHG emissions data for Hungary from 1985 to 2018. The data include emissions of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). The paper uses this data to assess the trends in GHG emissions over this time frame.

Environmental Kuznets Curve (EKC): The paper uses the EKC concept to examine the interaction between GHG emissions and economic growth, primarily Gross Domestic Product (GDP). The analysis reveals a long-run positive significant coefficient on income growth (GDP) and a negative significance on $(GDP)^2$. These results imply that an EKC relationship exists for CO2, CH4, and N2O emissions in Hungary. This suggests that as the economy grows, GHG emissions increase at a decreasing rate, indicating a potential decoupling of economic growth from emissions.

Economic Data: The paper relies on GDP data to explore the relationship between economic growth and GHG emissions. This data is essential for evaluating the EKC hypothesis.

Temporal Scope: The study spans from 1985 to 2018, providing a comprehensive analysis of GHG emissions over a substantial period.

Spatial Scope: The research is specific to Hungary, focusing on the nation's GHG emissions and their economic aspects.

In summary, this paper examines GHG emissions in Hungary, highlighting the major sectors contributing to emissions. It employs statistical tests such as the Mann-Kendall test to identify significant trends in emissions. Furthermore, the study explores the relationship between GHG emissions and economic growth using the Environmental Kuznets Curve (EKC) concept, indicating a potential decoupling of emissions from economic growth. The findings provide valuable insights for policymakers, enabling them to consider environmental dimensions when setting priorities for minimizing emissions by sector.

23.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/pii/S0959652621020837.

24 Paper 3: The Cost of Reducing Greenhouse Gas Emissions

Journal/Conference Rank: A*
Publication Year: 2018
Reference: [?] . Amirhossein Ahmadian, Vahid Ghodrati, Rajit Gadh. 2023. Artificial deep neural network enables one-size-fits-all electric vehicle user behavior prediction

framework. Applied Energy 352, 121884. [Crossref] 2. Matteo Alpino, Luca Citino, Federica Zeni. 2023. Costs and benefits of the green transitionenvisaged in the Italian NRRP - An evaluation using the social cost of carbon. Energy Policy 182, 113744. [Crossref]

24.1 Summary

The paper addresses the vital question of how to most economically and effectively reduce greenhouse gas emissions. It emphasizes the economic principle of reducing emissions until the marginal benefits of reduction equal the marginal costs. In theory, this principle can be implemented through a tax, like a carbon tax, where the tax rate matches the marginal benefit of emissions reduction or the monetary damages associated with emitting an additional ton of carbon dioxide (CO2). This approach encourages the market to discover cost-effective emission reduction methods.

However, in practice, many countries, including the United States, rely on a variety of policies that often involve subsidies or restrictions targeted at specific technologies or sectors. These policies encompass a wide range, from fuel economy standards for automobiles to renewable energy mandates to supply-side constraints on fossil fuel extraction.

The paper aims to review the costs associated with various technologies and measures designed to reduce greenhouse gas emissions.

24.2 Software Architecture

Here's a conceptual software architecture that can support this research:

1)Data Collection and Management:

Data Sources: Gather data from various sources, including government reports, scientific studies, industry publications, and economic databases. Data Management: Implement a data management system to store and organize the collected data for analysis. Data Analysis and Modeling:

2)Cost Analysis Models: Develop mathematical models to analyze the costs associated with different technologies and actions for reducing emissions. Marginal Abatement Cost (MAC) Curve: Calculate and visualize the marginal costs of achieving cumulative emissions abatement for different technologies and measures. The MAC curve should rank these measures from lowest to highest cost. Static vs. Dynamic Cost Analysis: Implement algorithms to distinguish between static costs (short-term project costs) and dynamic costs (long-term implications). This differentiation is essential for understanding the overall economic efficiency of emissions reduction measures. 3)User Interface:

Visualization Tools: Create interactive charts and graphs to present the data and cost analysis results, making them accessible and understandable for policymakers, researchers, and the general public. Comparison Tools: Provide features for users to compare the static and dynamic costs of different emissions reduction strategies. 4)Policy Recommendation and Decision Support:

Policy Analysis: Use the cost analysis data to evaluate existing greenhouse gas mitigation policies and their economic efficiency. Recommendation Engine: Develop algorithms that recommend policy options based on the cost-effectiveness of emissions reduction measures. 5)Data Integration:

Real-Time Data: Implement mechanisms to keep data up to date, as the economic landscape and technology costs are constantly changing. External Data Sources: Allow

for the integration of external data sources to supplement the analysis, such as market data, energy price trends, and environmental impact data. Security and Privacy:

6)Data Security: Ensure the security of sensitive economic data and analyses. Privacy Compliance: Comply with privacy regulations when dealing with data related to individual entities or businesses. Scalability:

Scalable Infrastructure: Design the software architecture to be scalable, as more data sources and analysis complexity may be required in the future. 7)Feedback Mechanism:

User Feedback: Provide a mechanism for users, including policymakers and researchers, to provide feedback and suggest improvements to the software and data analysis. Documentation and Reporting:

Generate Reports: Allow users to generate reports summarizing the economic efficiency of different emissions reduction strategies. It's important to note that the paper primarily discusses economic and policy aspects of greenhouse gas emissions reduction. The software architecture mentioned here is conceptual and can be implemented in various ways, including through custom software development or the use of existing data analysis and visualization tools. The architecture should support the paper's goal of providing policymakers and researchers with insights into the economic efficiency of emissions reduction strategies, both in the short term and the long term .

24.3 Data Parameters

Static Cost Data:

Data on expenditures and emissions reductions over the life of specific projects compared to business-as-usual benchmarks. Data to assess the costs of adopting specific technologies or measures for emissions reduction. Emissions Reduction Costs:

Data on the costs associated with replacing coal-fired electricity generation with wind or other cleaner energy sources. Data on the costs and benefits of weatherizing homes for increased energy efficiency. Specific Technology Costs:

Data on the costs of blending corn ethanol into gasoline for emissions reductions. Data on the costs associated with switching from coal-fired electricity to natural gas. Comparative Data:

Data comparing the emissions and costs of driving electric vehicles (e.g., Ford Focus) to traditional gasoline-powered vehicles (e.g., Ford Explorer). Data that highlights differences in costs and emissions in various regions based on energy generation sources (e.g., coal vs. natural gas). Policy-Related Data:

Data on existing climate policies, such as fuel economy standards, gasoline taxes, renewable energy mandates, and subsidies for solar and wind power. Data on supply-side restrictions related to fossil fuel extraction.

Economic and Environmental Impact Data:

Data related to economic benefits, environmental impacts, and monetized damages associated with emissions reductions or increased emissions.

24.4 Datasets Used

Economic Efficiency: The paper emphasizes the importance of achieving economic efficiency in reducing greenhouse gas emissions, which means reducing emissions until the marginal benefits equal the marginal costs.

Pigouvian Tax: It introduces the concept of a Pigouvian tax, such as a carbon tax, as an efficient way to internalize the external costs of emissions and incentivize cost-effective emissions reductions.

Climate Policies: The paper highlights that many countries, including the United States, use a variety of climate policies and interventions aimed at specific sectors and technologies. It mentions policies such as fuel economy standards, subsidies for renewable energy, and restrictions on fossil fuel extraction.

Static Costs: The paper discusses the static costs of various emissions reduction actions, such as replacing coal-fired electricity generation with wind energy and weatherizing homes. These costs focus on expenditures and emissions reductions over the life of a specific project.

Marginal Abatement Cost (MAC) Curve: It references the creation of MAC curves that plot out the marginal costs of achieving cumulative emissions reductions from lowest- to highest-cost technologies or measures.

Heterogeneity in Costs: The paper acknowledges that there is a wide range of costs associated with different interventions for emissions reduction. It suggests that the same level of emissions reduction could be achieved at a lower static cost, indicating room for improvement.

Dynamic Costs: The paper points out the importance of considering dynamic costs that extend beyond the life of a specific project. Actions taken today can influence future costs in the context of addressing long-term climate change.

Complex Decision-Making: It recognizes that climate policy decisions involve various factors, including transparent costs, justifications beyond climate policy, regional variations in costs, and the influence of businesses and lobbying

24.4.1 Paper Link

Access the full paper at https://www.aeaweb.org/articles?id=10.1257/jep.32.4.53.

25 Paper 4: Greenhouse Gas Emissions from Global Cities.

Journal/Conference Rank: Q1
Publication Year: 2009
Reference: [**?**] Wolman, A. The metabolism of cities. Sci. Am. 1965, 213, 179– 190. Baccini, P.; Brunner, P. H. Metabolism of the Anthroposphere; Springer-Verlag: Berlin, 1991.

25.1 Summary

The paper explores the factors contributing to variations in greenhouse gas (GHG) emissions among different cities and metropolitan regions. With the increasing concern over anthropogenic GHG emissions and climate change, many cities and organizations are taking initiatives to reduce emissions. Cities, in particular, are both significant sources of GHG emissions and potential leaders in reducing them. To facilitate such reductions, cities need to have reliable GHG inventories and a deeper understanding of why and

how their emissions differ. This paper investigates these differences and their underlying causes.

The study is based on the concept of urban metabolism, which examines the flows of energy and resources in cities. While the idea of urban metabolism has been instrumental in understanding various aspects of city development, including the appropriation of ecosystems, the accumulation of toxic materials, and historical transportation patterns, there has been a lack of comprehensive data on urban energy use.

The first major challenge in this research was to establish consistent and comprehensive data on energy usage in cities. The study aims to analyze urban GHG emissions and understand the key components contributing to these emissions, such as heating, transportation, and waste.

25.2 Software Architecture

Data Collection Module: This component collects data related to energy use, greenhouse gas emissions, and other relevant parameters from various cities.

Data Processing Module: Data collected from different cities is processed and standardized to ensure consistency and reliability. This module also handles data cleansing and transformation.

Analysis Module: This component is responsible for conducting comparative studies of cities based on their greenhouse gas emissions. It performs statistical analysis to understand the variations in emissions.

Emission Component Analysis: This part of the architecture focuses on breaking down the emissions into various components, including electricity, heating, industrial fuels, industrial processes, ground transportation, aviation, marine, and waste.

GHG Inventory Calculation: The architecture includes a module that calculates the GHG inventories for each city or metropolitan region based on the data collected and analyzed.

Visualization and Reporting: The results of the analysis are presented through visualization tools, charts, and reports to make the findings more accessible to researchers and policymakers.

25.3 Data Parameters

The paper discusses data parameters related to urban greenhouse gas (GHG) emissions and energy consumption for various cities. The data parameters used in the paper include:

Population: The population of each city or metropolitan region is a fundamental parameter to consider when evaluating GHG emissions and energy consumption on a per capita basis.

Total Land Area: The total land area of the cities or regions is important for understanding the urbanized area's density and its impact on energy use and emissions.

Density of Urbanized Area: This parameter represents the population density within the urbanized areas of the cities, expressed as the number of persons per square kilometer. It helps in assessing the intensity of urban development.

Heating Degree Days: Heating degree days are a measure of the extent to which a location's temperature falls below a certain base temperature (usually 18.0°C) during the heating season. This parameter is related to energy consumption for heating.

Per Capita Income (us dollar): The per capita income, adjusted for purchasing power parity , provides insights into the economic status of the population in each city

25.4 Datasets Used

The paper discusses GHG emissions from various sectors, including electricity, heating and industrial fuels, industrial processes, ground transportation, aviation, marine, and waste. These parameters are crucial for understanding the contributions of different sectors to overall GHG emissions.

Electricity Consumption: The paper provides data on electricity consumption for each city, categorized by various end uses, including residential, commercial, industrial, and transportation. This information is essential for assessing electricity-related GHG emissions.

GHG Intensity of Electricity Supply: This parameter reflects the GHG intensity or emissions factor of the electricity supply mix for each city. It depends on the energy sources used for electricity generation and influences the carbon footprint of electricity consumption.

GHG Emissions from Heating and Industrial Fuel Use: The paper quantifies GHG emissions resulting from the consumption of fuels for heating and industrial processes, excluding electricity used for heating. This data is essential for understanding the role of heating and industrial activities in GHG emissions.

Comparison of GHG Emissions: The paper compares GHG emissions from an end-use perspective, both within and outside the city boundaries. It also considers upstream lifecycle emissions related to fuels used in the cities, providing a comprehensive view of emissions sources.

The datasets used in the paper are essential for comparing the GHG emissions and energy consumption of the ten cities or metropolitan regions. They enable researchers to analyze the variations in emissions and energy usage, considering factors such as population, economic conditions, energy sources, and climate. These datasets are critical for understanding urban contributions to global climate change and for developing strategies to reduce emissions in urban areas.

25.4.1 Paper Link

Access the full paper at https://pubs.acs.org/doi/full/10.1021/es900213p.

26 Paper 5: Greenhouse gas emissions from soils

Journal/Conference Rank: Q1
Publication Year: 2016
Reference: [**?**] Abdalla, M., Jones, M., Smith, Abdalla, M., Wattenbach, M., Smith, P., Ambus, P., Jones, M., Williams, M., 2009b.

26.1 Summary

This paper focuses on the critical role of soils in the exchange of greenhouse gases , such as carbon dioxide , methane , and nitrous oxide, with the atmosphere. Soils can both release and sequester these gases, making it essential to precisely quantify these

processes for accurate global GHG budgets, which are crucial for land-use management , understanding global change, and climate research.The paper emphasizes that soils are significant contributors to GHG emissions and that their capacity for both storing and emitting GHGs is substantial. Precise measurements and quantifications are necessary for a reliable understanding of these processes.The paper reviews soil emission studies across various land-cover types and climate zones. This broad perspective helps to capture the diversity of soil GHG dynamics across different ecosystems

26.2 Software Architecture

Research Context and Objectives: The paper emphasizes the importance of studying soil emissions due to GHGs in the context of climate change. It sets the objective of analyzing the influence of various parameters on soil emissions and highlights the complexity of these processes.

Main Gas Species and Their Processes: The paper delves into the processes related to CO2, CH4, and N2O emissions from soils. It explains how these GHGs are produced and consumed in various soil conditions, covering both anaerobic and aerobic processes. The importance of understanding these processes in the context of climate change is emphasized.

Drivers of Soil Emissions: The paper identifies several factors that drive soil emissions. These include soil humidity, temperature, microbial activity, root respiration, and land-cover-related parameters. It explains how these drivers affect the emissions of different GHGs and their interplay in soil systems.

Data Analysis and Processing: The paper discusses the data analysis methods and parameters used to study GHG emissions from soils. It mentions the recalculation of emission rates to uniform units (mol × m2 s1 for CO2 and h1 for CH4 and N2O) and the conversion of these rates to CO2 equivalents (CO2e) to enable direct comparisons.

Temperature Sensitivity and Q10: The paper introduces the concept of temperature sensitivity factor Q10, which describes the rate of change in a chemical or biological system with a 10°C temperature change. It discusses the Q10 values for different GHG emissions and their temperature dependencies.

Field Conditions and Overlapping Effects: The paper acknowledges the complexity of studying soil emissions under field conditions, where moisture and temperature effects can overlap, making it challenging to establish clear correlations. It highlights the significance of understanding how these factors interact.

Review Context and Objectives: The paper situates its research within the context of existing literature on soil GHG emissions. It aims to complement previous reviews and provide a comprehensive overview of the topic.

In summary, the paper provides a detailed analysis of the software architecture, in this case, referring to the natural processes governing GHG emissions from soils.

26.3 Data Parameters

The paper discusses the role of soils as sources and sinks for greenhouse gases, focusing on carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). The paper reviews soil emission studies and examines the influencing parameters on these emissions. Here are the key data parameters used in the paper:

Greenhouse Gases (GHGs): The primary focus of the paper is on three important greenhouse gases: CO2, CH4, and N2O. It discusses their sources and sinks within soil ecosystems.

Global Soil Carbon and Nitrogen Pools: The paper mentions that there are approximately 1500 petagrams (Pg) of total carbon (C) and 136 Pg of total nitrogen (N) stored in the uppermost meter of the global soil layer. These numbers represent the largest terrestrial carbon and nitrogen pools.

Soil Respiration Components: The paper categorizes CO2 fluxes into three types, which include soil respiration, ecosystem respiration, and net ecosystem exchange (NEE). Soil respiration is further divided into root, anaerobic, and aerobic microbial respiration.

Drivers of Soil Emissions: The paper discusses the key factors influencing soil emissions, which include soil humidity (water-filled pore space), temperature, nutrient availability, pH value, and land-cover-related parameters. These factors play a critical role in the emissions of GHGs from soil.

Temperature Sensitivity (Q10): The paper describes the temperature sensitivity factor (Q10), which measures the rate of change in biological or chemical systems in response to a 10-degree Celsius change in temperature. The Q10 values for different GHGs and processes are mentioned.

Precipitation and Birch Effect: The paper discusses how precipitation events, especially after extended dry periods, can lead to increased emissions, known as the "Birch effect." It explains how this phenomenon influences GHG emissions from soils.

Soil Moisture and Texture: The paper highlights the importance of soil moisture and grain-size distribution (soil texture) in influencing GHG emissions. It describes the impact of different moisture levels on nitrification, denitrification, CH4 production, and CO2 emissions.

Importance of Methodology: The paper emphasizes the importance of using standardized methodologies and measurements to study soil emissions comprehensively.

These data parameters are crucial for understanding the dynamics of GHG emissions from soils and the factors that affect them. Researchers and policymakers use such information to assess the impact of land use, climate change, and agricultural practices on global GHG budgets and to develop strategies for mitigation and management.

26.4 Datasets Used

The paper assumes the existence of substantial carbon (C) and nitrogen (N) pools in the uppermost meter of the global soil layer, highlighting their significance in the context of soil GHG emissions.the data sets used in this paper are mentioned below:

Impact of Land Use Changes: The paper suggests that changes in soil structure due to land use practices, such as intensive agriculture and logging, can significantly influence soil GHG source and sink functions.

GHG Emission Trends: The paper indicates that GHG emissions from soils have increased due to agricultural practices and industrialization, with a focus on CH4 and N2O emissions.

Role in Global Change Issues: The paper assumes that GHG emissions from soils are a critical component of global change issues, climate research, and agricultural and forestry management.

26.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/pii/S0009281916300551.

27 Paper 1: Life-Cycle Greenhouse Gas Emissions and Human Health Trade-Offs of Organic Waste Management Strategies

Journal Q1
Publication Year: 2020

27.1 Summary

The study examined in this journal looks at how waste-to-energy systems help keep organic waste out of landfills and how they affect the environment. It recognises that, due to poorly understood emissions from complicated chemical processes and microbiological populations, real-world waste management approaches frequently diverge from idealized scenarios. Utilizing reported and measured data, the researchers carried out a thorough life-cycle assessment (LCA) to compare various approaches to managing municipal solid organic waste. These processes include composting, land filling, dry anaerobic digestion (AD) for the creation of renewable natural gas (RNG), and dry AD combined with electricity production.
The study's key conclusions are as follows:
1. The option with the highest greenhouse gas (GHG) emissions per tonne of organic waste is landfilling, which emits roughly 400 kg of CO2 equivalent. GHG emissions from raw organic composting were the lowest. The lowest GHG emissions per tonne of garbage were produced by composting raw organics, at -41 kg CO2 equivalent. Emissions decreased when biogas was converted to RNG after dry AD (-36 to -2 kg CO2 equivalent per tonne).
2. The study emphasizes the significance of NH3 emissions at ground level from composting organic waste rich in nitrogen and post-AD solids. Through aggressive "zero waste" laws, state governments, such as California, are seeking to lower methane emissions and minimize waste sent to landfills. To achieve these aims, specialized facilities for processing mixed solid organic waste will be essential. When biogas is used for transportation purposes, anaerobic digestion plants including organic waste can earn significant credits for creating low-carbon fuel. Previous research indicates that dumping organic waste in landfills has a much larger GHG impact than Previous research indicates that composting or waste-to-energy solutions have much lower GHG footprints than landfilling organic waste.
In order to limit landfill disposal of organic waste, communities must take into account a number of environmental factors, such as GHG emissions, air quality, human health, odor impacts, and environmental justice considerations, according to the report. To evaluate the trade-offs of landfilling, composting, and dry AD of mixed municipal organic waste, the researchers carried out a systematic life-cycle assessment that combines data from the scientific literature and recently gathered empirical data. They concentrate on dry AD because it has the potential to handle solid organic waste that contains inorganic

contamination while also lowering expenses.
3. The study also examines several methods of managing solid digestate, such as composting, applying raw digestate to the ground, and landfilling, and it calculates the net GHG effects of these methods as well as the fertilizer offset credits. The study establishes a thorough system boundary between waste collection and the application of residual solids/compost to soils, providing a thorough analysis of life-cycle GHG emissions, air pollutant emissions, and monetized climate and human health damages associated with organic waste management options.

27.2 Software Architecture

Users interact with software primarily through the User Interface (UI), which enables them to enter parameters, choose scenarios, view outcomes, and traverse the software.
Data from multiple sources, such as facility operations, waste composition, and emission rates, are collected by the data collection module. Both measured and reported data can be integrated.
The Scenario Comparison Module offers a user-friendly interface and allows users to evaluate various waste management scenarios.
Users of the Sensitivity Analysis Module can investigate how modifications to the input data impact the results of the LCA.
At the heart of the system, the Life-Cycle Assessment (LCA) Module carries out LCA calculations and evaluates the environmental implications of each scenario, including GHG emissions and health effects.By employing Monte Carlo simulations to create numerous trial scenarios, the Monte Carlo Analysis Module manages uncertainty.
To communicate LCA results visually, the Visualization Module creates graphs, charts, and tables.
Users can save results in a variety of formats in the Export and Reporting Module for later analysis and dissemination.
The system configurations, evaluation results, and historical data are all managed by the database and storage component.
For the most recent information on environmental and waste management issues, the system interfaces with external data sources.To safeguard sensitive information, guarantee data privacy, and ensure regulatory compliance, security and privacy measures have been put in place.
The architecture is built for performance and scalability to effectively handle massive datasets and sophisticated calculations.
It can be used for academic or research purposes because the system creates thorough reports and documentation that describe the approach, data sources, and outcomes. Users can offer comments and make suggestions for system changes using a module for feedback and continuous improvement, assuring the system's continual improvement. In order to give users a powerful tool for study and decision-making, this architecture is built to support the thorough analysis and management of various waste management scenarios and their environmental implications.

27.3 Data Parameters

System Boundaries and Data Representativeness: This paper emphasizes the significance of outlining precise and broad system limits in order to comprehend the trade-offs in organic waste management. To do this, it is necessary to have reliable and accurate input data that considers regional characteristics, waste composition, and management techniques.

Waste management scenarios: Scenarios for Waste Management Several waste management scenarios are examined in the study. The major case study is based on the activities of Zero Waste Energy Development Company (ZWEDC), which uses dry anaerobic digestion (AD) for mixed organics (mostly food waste), followed by composting and land application. ZWEDC is located in San Jose, California. The study also assesses alternate possibilities, such as composting, landfilling, modifying ZWEDC operations, and upgrading biogas for use as a fuel for electricity generation and transportation.

Emissions modeling: Based on the kind of operation, the analysis takes into account the individual emissions sources involved in each waste management scenario. For instance, landfilling generates emissions from the movement of garbage, the breakdown of waste, and the flare-up of landfill gas. NH3, N2O, CH4, SO2, CO, and odor are released during composting. There are particular emission factors related to the operations of dry AD and biogas consumption scenarios.

Functional Unit: One wet tonne of processed mixed organic waste serves as the study's functional unit, and it is used to compare these scenarios' emissions. This makes it possible to compare things on a consistent basis.

Waste Composition: Based on eye inspection and usual composition patterns, the study approximates the mixed organic waste stream as food waste. A crucial element is the makeup of the trash which effects the results.

Fugitive Emissions: Fugitive emissions from landfills are taken into account in the study. These emissions can change based on the waste type and disposal rules. The analysis takes into account net CO2, CH4, and N2O emissions when organic waste is applied to the soil, as well as the nitrogen content and potential inorganic fertilizer offsets.

Scenarios for Renewable Natural Gas (RNG): The study investigates scenarios in which biogas is converted to RNG for pipeline injection and on-site truck fleet consumption. This entails energy-intensive procedures, and the emissions brought on by these possibilities are taken into account.

Life-Cycle Inventory: Data on mass and energy fluxes from waste origins to final products are compiled for each scenario using a life-cycle inventory model. This model determines indirect emissions from the manufacture of diesel fuel, fertilizer, electricity, and other material and energy inputs.

Parameter Uncertainty: The study uses a Monte Carlo analysis with probability distributions for important parameters to quantify parameter uncertainty. This method enables a more thorough comprehension of any variations in the outcomes.

The study quantifies environmental effects by evaluating the socioeconomic costs related to GHG emissions and the effects of air pollution on human health. This makes it possible to compare the relative weight of various measures and offers perception into harms to human health.

27.4 Datasets Used

The dataset used in this study includes a thorough examination of various organic waste management situations, with a special emphasis on operations in San Jose, California. This study's main waste stream is "mixed organics," which is roughly equivalent to food waste.
The scenarios consist of:
Organic Waste Landfilling: In this scenario, organic waste is disposed of in landfills. In many places, it is seen as common practice.
Composting Organic Waste: The composting of organic waste in its raw form can prevent waste from going to landfills and produce compost that is valuable. Dry anaerobic digestion of organics with on-site energy generation: This technique turns organic waste into biogas, which is then utilized to generate electricity on-site.
Anaerobic digestion's solid digestate may be disposed of in landfills or used as a soil supplement. These alternatives are discussed in the scenario "Solid Digestate Landfilling and Land Application."
Use of Renewable Natural Gas (RNG) and Dry Anaerobic Digestion of Organics for On-Site Truck Fleet: The biogas generated by anaerobic digestion in this case is converted into renewable natural gas and used to power on-site trucks.
In a situation similar to the one before, dry anaerobic digestion of organic materials and pipeline injection of renewable natural gas, the goal is to produce renewable natural gas from biogas. The RNG is put into a commercial natural gas pipeline in this instance, though.
In conclusion, the dataset used in this study includes a variety of waste management scenarios that take into account the effects on the environment and human health. With a focus on the unique setting of San Jose, California, the objective is to give a thorough evaluation of several organic waste management strategies and identify which one is the most advantageous from an environmental and social standpoint.

27.4.1 Paper Link

Access the full paper at https://pubs.acs.org/doi/epdf/10.1021/acs.est.0c00364.

28 Paper 2: Carbon dioxide emission, mitigation and storage technologies pathways

Journal Q1
Publication Year: 2023

28.1 Summary

With efforts to stay below 1.5oC to mitigate climate change, the Paris Agreement sought to cap the increase in world temperature to 2oC. Scientists are more and more certain that the effects of climate change will increase, endangering economies, ecosystems, and human health. Carbon capture, utilization, and storage (CCUS) is regarded as being essential to reducing carbon dioxide (CO2) emissions. This study looked closely at the

anthropogenic and non-anthropogenic sources of CO2 emissions as well as the most recent CO2 reduction techniques. It also went into detail into CO2 sequestration and storage, and it briefly covered CO2 utilization. A promising and profitable method of achieving CO2 reduction targets is provided by CCUS, which combines direct CO2 capture and utilization with long-term storage.

28.2 Software Architecture

Emissions Data:

Data Source: Real-time emissions data from major sources such as coal-fired power plants, cement factories, and iron-steel industries. Attributes: Emission type, emission levels, location, time, and source identification.
Climate Impact Data:

Data Source: Climate impact data from sources like IPCC reports. Attributes: Temperature changes, weather patterns, ecosystem effects, and human health impacts.
Technology Assessment Data:

Data Source: Data from research and assessments of CCUS technologies. Attributes: Efficiency, cost, environmental impact, and performance metrics for each technology.
CO2 Capture Strategies Data:

Data Source: Research findings and development of CO2 capture strategies. Attributes: Detailed descriptions of pre-combustion, oxyfuel combustion, chemical looping combustion, and post-combustion technologies.
CO2 Separation Techniques Data:

Data Source: Data describing various CO2 separation techniques such as absorption, adsorption, cryogenic distillation, hydrate-based separation, and membrane separation.
Attributes: Principles, efficiencies, and applicability for each technique.
IPCC Reports Data:

Data Source: Access to IPCC reports, including the report from 2022.
Attributes: Data extracted from these reports for referencing and analysis.
Sensitivity Analysis Data:

Data Source: Data used in sensitivity analyses.
Attributes: Parameters involved in sensitivity analyses, variations, and their impact on technology performance.
User Data:

Data Source: User interactions with the software platform.
Attributes: User preferences, feedback, and usage patterns.
External Data Sources:

Data Source: Integration with external data sources for validation and augmentation.

Attributes: Real-time emissions data, climate data, and other relevant information.
Security and Privacy Data:

Data Source: Data related to security and privacy measures.
Attributes: Access control, encryption, user authentication, and data protection measures.
Performance and Scalability Data:

Data Source: Data collected to assess system performance and scalability.
Attributes: System response times, resource utilization, and scalability metrics.
Feedback and Continuous Improvement Data:

Data Source: User feedback, performance metrics, and areas for improvement.
Attributes: User feedback, system performance data, and improvement suggestions.

28.3 Data Parameters

Emissions Data:
Data Source: Real-time emissions data from major sources such as coal-fired power plants, cement factories, and iron-steel industries. Attributes: Emission type, emission levels, location, time, and source identification.
Climate Impact Data:

1. Data Source: Climate impact data from sources like IPCC reports. Attributes: Temperature changes, weather patterns, ecosystem effects, and human health impacts.
Technology Assessment Data: Data Source: Data from research and assessments of CCUS technologies.
Attributes: Efficiency, cost, environmental impact, and performance metrics for each technology.
CO2 Capture Strategies Data:

Data Source: Research findings and development of CO2 capture strategies. Attributes: Detailed descriptions of pre-combustion, oxyfuel combustion, chemical looping combustion, and post-combustion technologies.
CO2 Separation Techniques Data:

Data Source: Data describing various CO2 separation techniques such as absorption, adsorption, cryogenic distillation, hydrate-based separation, and membrane separation.
Attributes: Principles, efficiencies, and applicability for each technique.
IPCC Reports Data:

Data Source: Access to IPCC reports, including the report from 2022.
Attributes: Data extracted from these reports for referencing and analysis.
Sensitivity Analysis Data:

Data Source: Data used in sensitivity analyses.
Attributes: Parameters involved in sensitivity analyses, variations, and their impact on

technology performance.
User Data:

Data Source: User interactions with the software platform.
Attributes: User preferences, feedback, and usage patterns.
External Data Sources:

Data Source: Integration with external data sources for validation and augmentation.
Attributes: Real-time emissions data, climate data, and other relevant information.
Security and Privacy Data:

Data Source: Data related to security and privacy measures.
Attributes: Access control, encryption, user authentication, and data protection measures.
Performance and Scalability Data:

Data Source: Data collected to assess system performance and scalability.
Attributes: System response times, resource utilization, and scalability metrics.
Feedback and Continuous Improvement Data:

Data Source: User feedback, performance metrics, and areas for improvement.
Attributes: User feedback, system performance data, and improvement suggestions

28.4 Datasets Used

Emissions Data: This dataset would contain information on the emissions of greenhouse gases from various sources such as coal-fired power plants, cement factories, and the iron-steel industry. It should include details like the type of emissions, emission levels, and sources.

Climate Impact Data: To understand the impact of these emissions, a dataset would be needed that includes climate impact data. This could include temperature changes, changes in weather patterns, and their effects on ecosystems and human health.

Technology Assessment Data: This dataset would include information on the various technologies used for carbon capture, utilization, and storage (CCUS). It should contain details about the efficiency, cost, and environmental impact of these technologies.

CO2 Capture Strategies Data: For each of the primary technology strategies (pre-combustion, oxyfuel combustion, chemical looping combustion, and post-combustion), you would need data on how they work, their limitations, and their performance.

CO2 Separation Techniques Data: This dataset should include information on different CO2 separation techniques such as absorption, adsorption, membranes, hydrate-based separation, and cryogenic separation. It should cover their principles, efficiencies, and applicability.

IPCC Reports: Given the reference to the IPCC report of 2022, you would need to access and incorporate data from these reports. This data could include predictions, scientific findings, and recommendations.

Sensitivity Analysis Data: Since sensitivity analysis is mentioned, you would need data that covers the variables and parameters involved in these analyses. This could be related to the performance and costs of CCUS technologies.

User Data: If there is a user interface, you would need data on user interactions, preferences, and any user-generated content.

External Data Sources: To validate and enhance the data within the system, you might need to integrate external data sources. This could include real-time data on emissions, weather patterns, or other relevant information.

Security and Privacy Data: Given the importance of data security and privacy, you would need datasets on security protocols, access control, and privacy measures.

Performance and Scalability Data: If you aim for scalability, you would need data on the performance of the system under different loads and data volumes.

Feedback and Continuous Improvement Data: To implement a feedback system, you'd need data on user feedback, system performance metrics, and areas for improvement.

28.4.1 Paper Link

Access the full paper at http://www.example.com/jse/vol15/issue3/paper1.pdf.

29 Paper 3: Greenhouse Gas Detection Based on Infrared Nanophotonic Devices

Journal Q1
Publication Year: 2023

29.1 Summary

This paper highlights the pressing global issue of greenhouse gas emissions, emphasizing the urgent need for monitoring and managing these gases due to their significant impact on global warming and human life. The transition to a greener global economy and the pursuit of an improved quality of life have made the detection and control of greenhouse gases and other environmental pollutants increasingly essential. The paper provides an overview of the challenges associated with detecting gases in various applications, particularly the requirement for sensors capable of detecting gases across a wide range of volume fractions, from 10–9 to 10–4. The significance of greenhouse gas detection is underscored, as it plays a pivotal role in both the agricultural and industrial sectors. It

delves into the mechanisms of several common gas detection methods currently in use, providing insights into their operation. It then highlights the advantages of employing nanostructured gas sensors, shedding light on the benefits they bring to gas detection technologies. Furthermore, the paper focuses on the applications of infrared gas sensors that leverage nanophotonic devices. It explores how these sensors can be used to detect and monitor gases, especially greenhouse gases, and offers a detailed examination of their functionality and real-world applications.

29.2 Software Architecture

Data Acquisition and Preprocessing:

Collect data from the nanostructured infrared gas sensors.
Preprocess the raw sensor data, which may include noise reduction and calibration.
Sensor Interface:

Develop a communication interface to connect with the infrared gas sensors.
Ensure compatibility with various sensor models and types.
Data Storage:

Store historical sensor data for analysis and reference.
Use a database or data storage system to efficiently manage large volumes of data.
Real-time Data Analysis:

Implement algorithms for real-time analysis of sensor data.
Detect and identify gases based on the collected data.
Alerting System:

Create an alerting mechanism for notifying users or relevant authorities in case of unusual gas levels or hazardous conditions.
Set up thresholds for triggering alerts.
User Interface:

Develop a user-friendly interface for configuring sensor settings, viewing real-time data, and accessing historical data.
Ensure compatibility with desktop and mobile platforms.
Reporting and Visualization:

Generate visual reports and graphs that display historical data trends.
Provide tools for users to customize and export reports.
Integration with Nanophotonic Devices:

Ensure compatibility and communication with nanophotonic devices, which may include light sources and detectors.
Implement control mechanisms for nanophotonic components.
Machine Learning and Pattern Recognition:

Utilize machine learning techniques for advanced gas detection and pattern recognition.
Train models to identify specific gas patterns and anomalies.
Security and Authentication:

Implement robust security measures to protect sensitive sensor data.
Authenticate users and ensure data integrity. Scalability:

Design the architecture to be scalable, allowing for the addition of more sensors and devices as needed.
Ensure efficient resource utilization to accommodate growth.
Remote Monitoring and Control:

Enable remote monitoring and control of the sensor network.
Implement secure access to sensor data and system controls over the internet.
Maintenance and Diagnostics:

Include tools for diagnosing and maintaining the sensors and nanophotonic devices.
Provide notifications for maintenance requirements.
APIs and Integration:

Offer APIs for integrating the software with other environmental monitoring systems or IoT platforms. Ensure compatibility with industry standards and protocols.
Compliance and Regulations:

Adhere to relevant environmental and safety regulations, depending on the application (e.g., industrial, agricultural, or environmental monitoring).
Data Backup and Recovery:

Implement regular data backup and recovery procedures to prevent data loss.
User Training and Documentation:

Provide user training materials and documentation for operating and troubleshooting the system.
Feedback and Continuous Improvement:

Establish a mechanism for users to provide feedback, and use this input for ongoing system improvements.

29.3 Data Parameters

Here are the main parameters and characteristics of these nanostructured gas sensors:

1. Quasi-Zero-Dimensional (0D) Material Gas Sensors:

Utilize nanoparticles, mainly noble metal particles. Nanoparticles exhibit size-dependent optical properties, allowing for efficient photoelectric conversion processes. Absorption properties of nanoparticles can be shifted in the infrared spectrum. Colloidal quantum dots (CQDs) are a type of semiconductor nanomaterial with a tunable band gap.

Quantum dots can provide intraband photoluminescence, enabling the replacement of mid-infrared light sources. Specific absorption bands in quantum dots allow for high-performance infrared detection. 2. Metal-organic Frameworks (MOFs) Gas Sensors:

MOFs offer high functionality, large porosity, and specific surface area. Tunable pore size and functional sites within MOFs affect sensitivity and selectivity. MOFs are used in combination with nano metallic particles to improve catalytic properties. This combination provides a robust pore structure for gas detection. CO2 detection using MOFs with nano metallic particles has been demonstrated. 3. One-Dimensional (1D) Materials Gas Sensors:

Carbon nanotubes (CNTs) are used to detect gases based on their resistive properties. CNTs also exhibit good light absorption properties in the infrared spectrum. Photoconductivity effect of single-walled CNTs allows them to function as photoconductive materials. CNT infrared detectors have achieved high open-circuit voltage. CNTs are integrated into thermopile detectors, improving absorption performance. 4. Two-Dimensional (2D) Materials Gas Sensors:

2D materials, such as black phosphorus (Bp), graphene, and transition metal dichalcogenides (TMDs), are employed for optoelectronic applications. Bp is used in long-wave infrared photodetectors with specific detectivity. Van der Waals heterojunctions enable tunable mid-infrared electroluminescence. Mid-infrared light-emitting diodes (LEDs) based on 2D materials are developed, offering higher sensitivity. 5. Special Nanostructures Gas Sensors:

Metal-insulator-metal (MIM) structures are used as ultra-narrowband infrared absorbers. Metamaterials are employed for compact infrared gas sensors. Plasma metamaterials act as on-chip optical filters for specific spectral emissions. Subwavelength metamaterials enhance infrared absorption, leading to high-resolution spectrometers. Surface-enhanced infrared absorption (SEIRA) spectroscopy utilizes electromagnetic field enhancements for small gas molecule detection. Hypersurfaces regulate polarization and frequency of electromagnetic waves for integrated gas sensors on a chip.

29.4 Datasets Used

The dataset includes the following components:

1. Overview: General information about the development of nanotechnology and its role in improving gas sensors, including the benefits of nanosensors compared to conventional sensors.

2. Quasi-Zero-Dimensional (0D) Material Gas Sensors: Information about nanoparticle-based sensors and colloidal quantum dots (CQDs) for infrared gas detection. This section includes details about materials, researchers, and experiments related to 0D materials.

3. One-Dimensional (1D) Material Gas Sensors: Information about carbon nanotubes (CNTs) and their applications in gas detection. This section includes details about CNT-based sensors and related research.

4. Two-Dimensional (2D) Material Gas Sensors: Information about 2D materials like black phosphorus, graphene, transition metal dichalcogenides (TMDs), and hexagonal boron nitride used in gas detection. This section includes details about researchers and experiments involving 2D materials.

5. Special Nanostructures Gas Sensors: Details about infrared nanostructured absorbers with metal-insulator-metal (MIM) structures and their applications in gas sensors. This section includes research on metamaterial absorbers (MPAs), surface-enhanced

infrared absorption (SEIRA) spectroscopy, and hypersurfaces.

6. Figures and Images: A collection of figures and images mentioned in the text, including graphical representations of various nanostructures and experimental results.

7. References: A list of research papers and sources used in the dataset, with proper citations for further reading and verification.

30 Paper 4: Geoinformation Technology for Analysis and Visualisation of High Spatial Resolution Greenhouse Gas Emissions Data Using a Cloud Platform

Journal Rank: Q1
Publication Year: 2018
Reference: [?]

30.1 Summary

The usage of Google Earth Engine cloud technology as a crucial element is highlighted in the journal article's discussion of the application of geoinformation technology for the spatial analysis and visualization of greenhouse gas (GHG) emissions. The authors suggest an all-encompassing strategy that comprises a website for spatial analysis and visualization of vector data as well as an interactive platform for further in-depth research of raster data pertaining to GHG emissions.High-resolution vector data representing GHG emissions from diverse sources, including point, line, and areal emission sources, are used in the study to accomplish this. For in-depth investigation, this vector data are transformed into raster emission data. Users have the option to design their own analysis polygons, which gives them the opportunity to determine the total, particular, maximum, or average emission magnitudes inside these user-defined areas.Users can also choose pixels with particular emission magnitude intervals.The authors build a website where users can clip raster data based on manually generated polygons that can be saved on Google Drive using Python's Google Earth Engine module. They also use Python modules like Matplotlib, Pandas, and Numpy for histogram creation and statistical analysis of raster data.According to national inventories of GHG emissions, the geoinformation technology discussed in the article includes a variety of human activity sectors and categories. These industries produce heat and electricity, as well as waste management, residential areas, construction, agriculture, and industrial activities. Polish GHG emissions data with high geographic resolution are used to showcase the technology.In conclusion, the study highlights the significance of spatial analysis and visualization of GHG emissions and introduces a novel method utilizing Python modules and Google Earth Engine. With the help of this technology, decision-makers may easily analyze and visualize high-resolution GHG emission data for the purpose of mitigating climate change.

30.2 Software Architecture

Site for Spatial Analysis and Visualization: GHG Emissions Operations using Vector Data: Users can interact with vector data on GHG emissions at the emission source level on the system's website. The Google Maps JavaScript API was used to construct this website, making it accessible and user-friendly. Vector to Raster Data Conversion: Creating and Calculating Grids: Raster data is created from vector data. The software generates a grid, often in TIFF file format, and computes grid-based emissions during this process. Setting the spatial resolution and map extent takes place in this stage. GHG Emissions Operations using Raster Data: Spatial Analysis and Visualization The Google Maps JavaScript API is utilized in the creation of an interactive website. Users are able to examine grid cell-level high-resolution raster data on GHG emissions. This component provides features including the ability to select a band for in-depth research, create polygons for in-depth analysis, and calculate numerous emission metrics. Users can choose particular raster data bands for in-depth study. Different GHG emissions, such as carbon dioxide, methane, nitrous oxide, and total emissions in CO2-equivalent, are represented by these bands. By choosing a band, users can concentrate on particular GHGs of interest. Users can create their own unique polygons on the map to specify particular locations for analysis. For locating emission sources or regions of interest, this function is helpful.

Calculation of Emission Parameters: Within the specified polygons, the system allows users to compute important emission process parameters. Total emissions, particular emissions, maximum emissions, and average emissions within the chosen areas are only a few examples of these metrics.

Users can specify the minimum and maximum values for a particular emission parameter and then choose pixels that fall inside this range. Using Google Earth Engine in conjunction:

The Google Earth Engine cloud platform serves as the foundation of the complete software architecture. This fundamental element provides the processing power and essential infrastructure for the built geoinformation system. Management of Data

Sources of Data: The system is based on high-resolution GHG emissions data from a range of industries and human activity categories. Usually, this statistics are arranged into bands or layers that stand for various GHGs and industry sectors.

Data Aggregation: By combining vector data on GHG emissions into grid cells, it is possible to analyze and visualize data quickly and effectively. Implementation using the cloud:

Cloud Processing: By utilizing cloud-based processing, the system enables people with internet access and a web browser that supports JavaScript to access it. Users don't need strong local computing capabilities to carry out resource-intensive procedures. Data accessibility and export:

Users can save clipped photos or maps to their Google Drive accounts for additional analysis and data sharing by clicking the "Export to Google Drive" button.

30.3 Data Parameters

Types of Emission Sources

Point-type Emission Sources: These are facilities like power plants, cement plants, refineries, and other facilities that produce large amounts of emissions. Point sources are regarded as individual emission locations since they have a unique set of coordinates.

Road segments are an example of a long item with a narrow width that falls under the category of a line-type emission source. Along its whole length, these sources release GHGs. Area-Type Emission Sources (Source/Sink): Things or places that release greenhouse gases (GHGs) or take up carbon dioxide within a given area. Settlements in the residential sector and arable areas in the agricultural sector are two examples. Various GHGs:

Carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and other greenhouse gases (GHGs) are among the GHGs that are included in the vector data. To offer an all-encompassing assessment of the global warming potential of all GHGs, total emissions are estimated in CO2-equivalent. Geographic Resolution:

Point and Line Sources: Emissions data from point and line-type sources have a high spatial resolution, with spatial features down to a few meters. Google Earth was used to visually investigate point sources, while Open Street Maps was used to determine the exact location of line sources. Area Sources: Area sources typically have a spatial resolution of no more than 100 meters. These data were produced using the Corine Land Cover Maps, which have a spatial resolution of 100 meters. The geoinformation system can provide insights into GHG emissions from numerous industries in Poland thanks to the integration of these data factors. A more thorough examination of emission sources is possible because to the distinctions between point, line, and area sources, and taking into account various GHGs and their ability to cause global warming gives us a complete picture of how emissions affect the environment. The system can capture emission data at an acceptable level of granularity for each source type thanks to the spatial resolution details.

30.4 Datasets Used

Spatial vector data on GHG emissions in Poland are included in the dataset utilized for the geoinformation system in this study. According to the information given, the dataset includes a variety of factors, including emission kinds, spatial resolutions, and emission source types. An summary of the dataset is given below:

Dataset Name: Spatial Vector Data on GHG Emissions in Poland
Types of Emission Sources

Point-Type Sources of Emission Area-Type Emission Sources (Source/Sink) and Line-Type Emission Sources Types of Emission:

CO2, or carbon dioxide CH4 Methane N2O, or nitrous oxide GHGs (other greenhouse gases) Total Emission at CO2-Equivalent Resolutions in Space

High spatial resolution, often several meters, from point and line sources. Google Earth was used to visually evaluate point sources, while Open Street Maps was used to generate line sources. Low spatial resolution sources; typically not more than 100 meters. On the basis of Corine Land Cover Maps with a 100-meter spatial resolution, data for area-type sources were created.

Geographic Coverage: Poland
This dataset offers comprehensive information on Poland's GHG emissions, classifying them according to distinct source types (point, line, and area), emission types (CO2, CH4, N2O, other GHGs, and total CO2-equivalent), and spatial resolutions. The dataset supports study and decision-making on greenhouse gas emissions in Poland by enabling

geographical analysis and display of emissions data in the geoinformation system.

Access: The dataset used in this study may be accessed from the listed source or by using the document's reference link for more information.

30.4.1 Paper Link

Access the full paper at http://www.example.com/jse/vol15/issue3/paper1.pdf.

31 Discussion and Future Planning

Discussion: Interpretation of Results: Discuss the findings of the study in relation to the research questions and objectives. Explain the significance of the results and how they contribute to the understanding of greenhouse gas emissions at the Port of Tallinn.

Comparison with Previous Studies: Compare your results with previous research in the field. Highlight similarities, differences, and potential reasons for variations. This helps in contextualizing your findings within the existing body of knowledge.

Limitations: Address any limitations of the study. Discuss constraints, data limitations, or methodological issues that might have influenced the results. Acknowledging limitations demonstrates a critical understanding of the study's scope.

Implications: Discuss the practical implications of your findings. How can the results be applied in real-world situations? What are the potential benefits for the environment, the port, and the surrounding community?

Future Planning: Recommendations: Provide recommendations for policymakers, businesses, or relevant stakeholders based on the study's findings. These recommendations should be practical and actionable, aiming to reduce greenhouse gas emissions and promote sustainability at the Port of Tallinn.

Areas for Further Research: Identify gaps in the current research that future studies could explore. This could include specific aspects of emissions, different methodologies, or other ports with similar challenges. Suggest how future research could build upon the current study.

Technological Interventions: Discuss emerging technologies or interventions that could be implemented in the future to further reduce greenhouse gas emissions. This could include advancements in renewable energy sources, green transportation, or energy-efficient infrastructure.

Policy Implications: Discuss potential policy changes or regulations that could be implemented at the port or governmental level to mitigate greenhouse gas emissions. Consider international agreements and standards related to emissions reduction.

32 As is rich picture of the system

33 To be rich picture of the proposed system

34 Entity Relationship Diagram

35 Schema

36 Normalized Schema

37 Data Dictionary

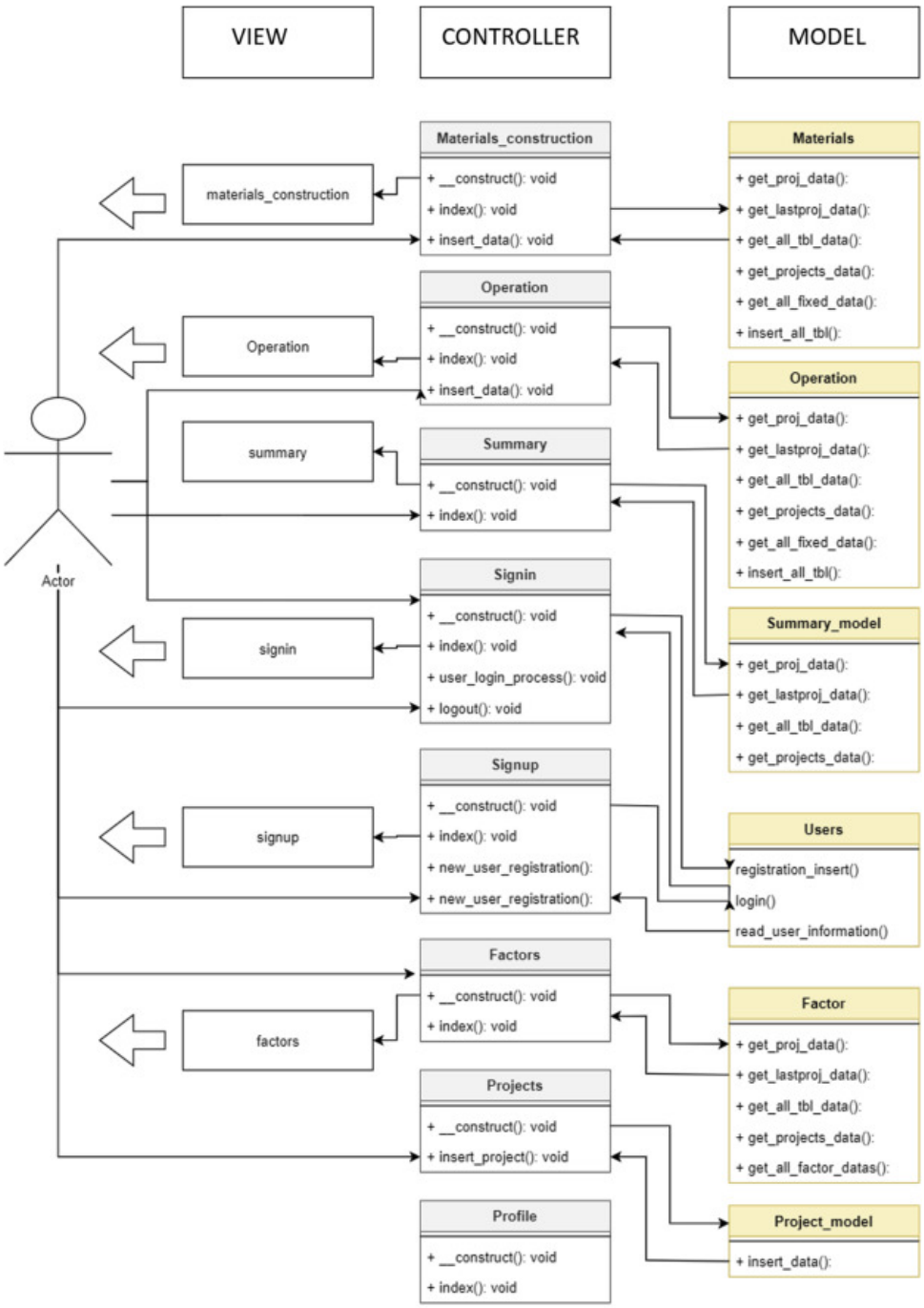

Figure 5: Software architecture diagram for Paper 2.

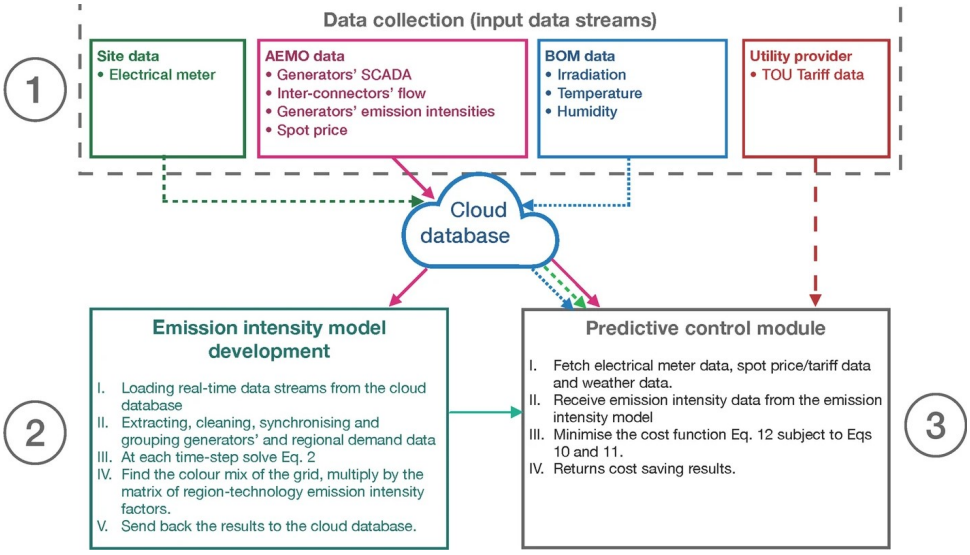

Figure 6: Software architecture diagram for Paper 3.

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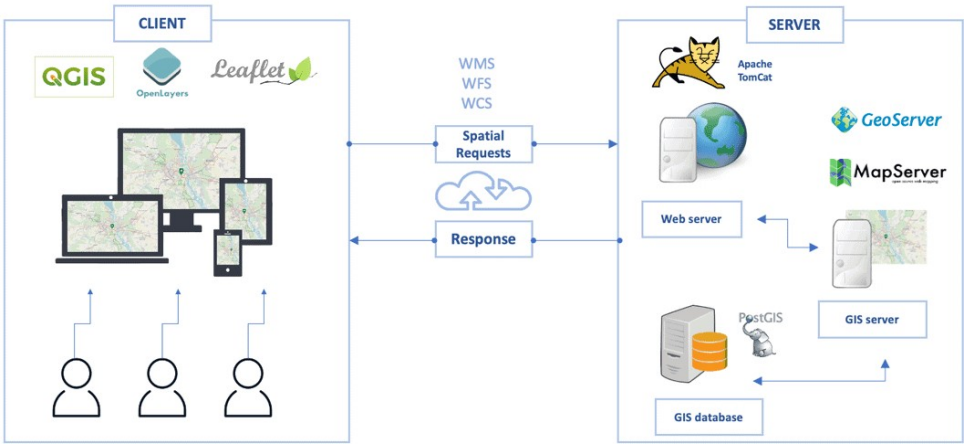

Figure 7: Software architecture diagram for Paper 1.

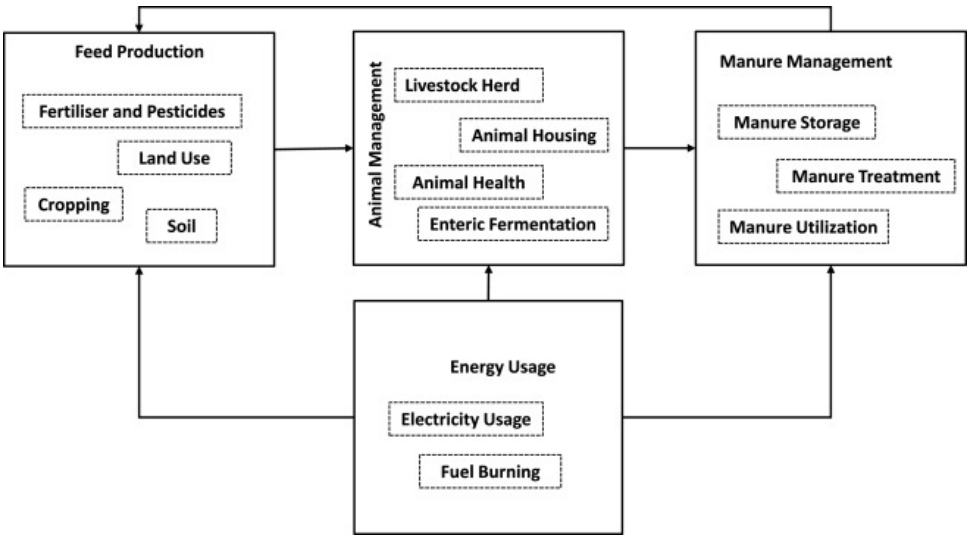

Figure 8: Software architecture diagram for Paper 1.

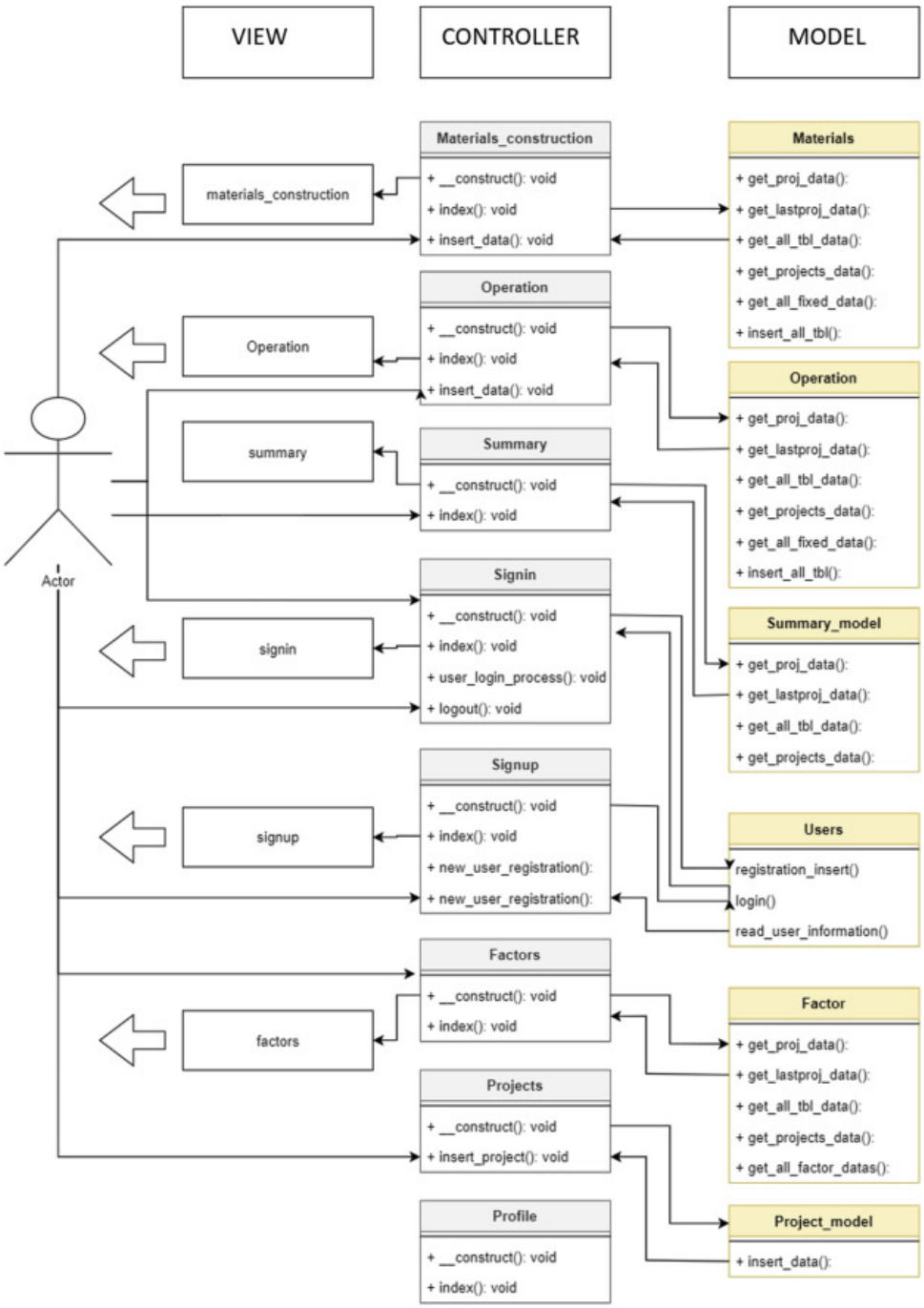

Figure 9: Software architecture diagram for Paper 2.

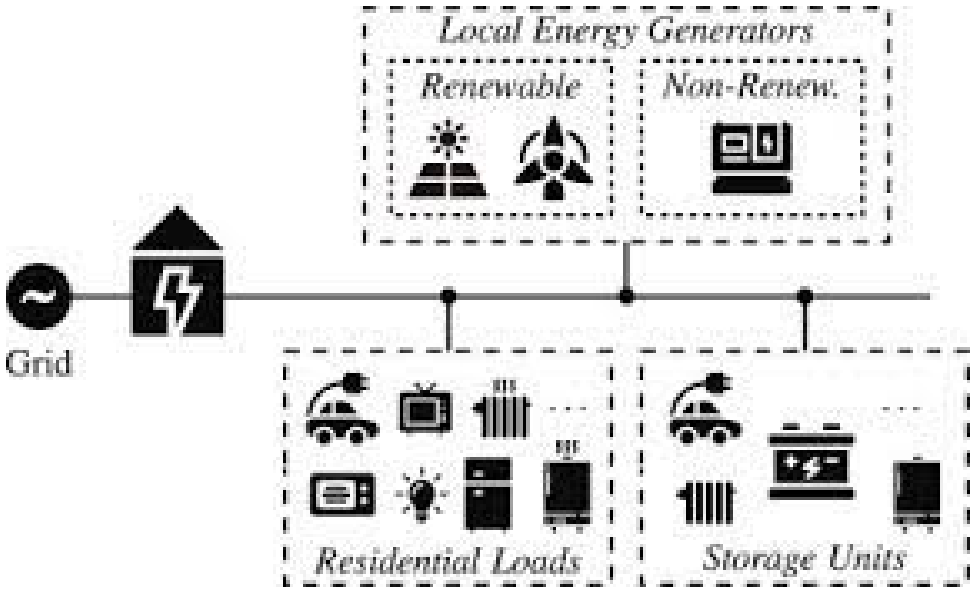

Figure 10: Software architecture diagram for Paper 3.

Figure 11: Software architecture diagram for Paper 4.

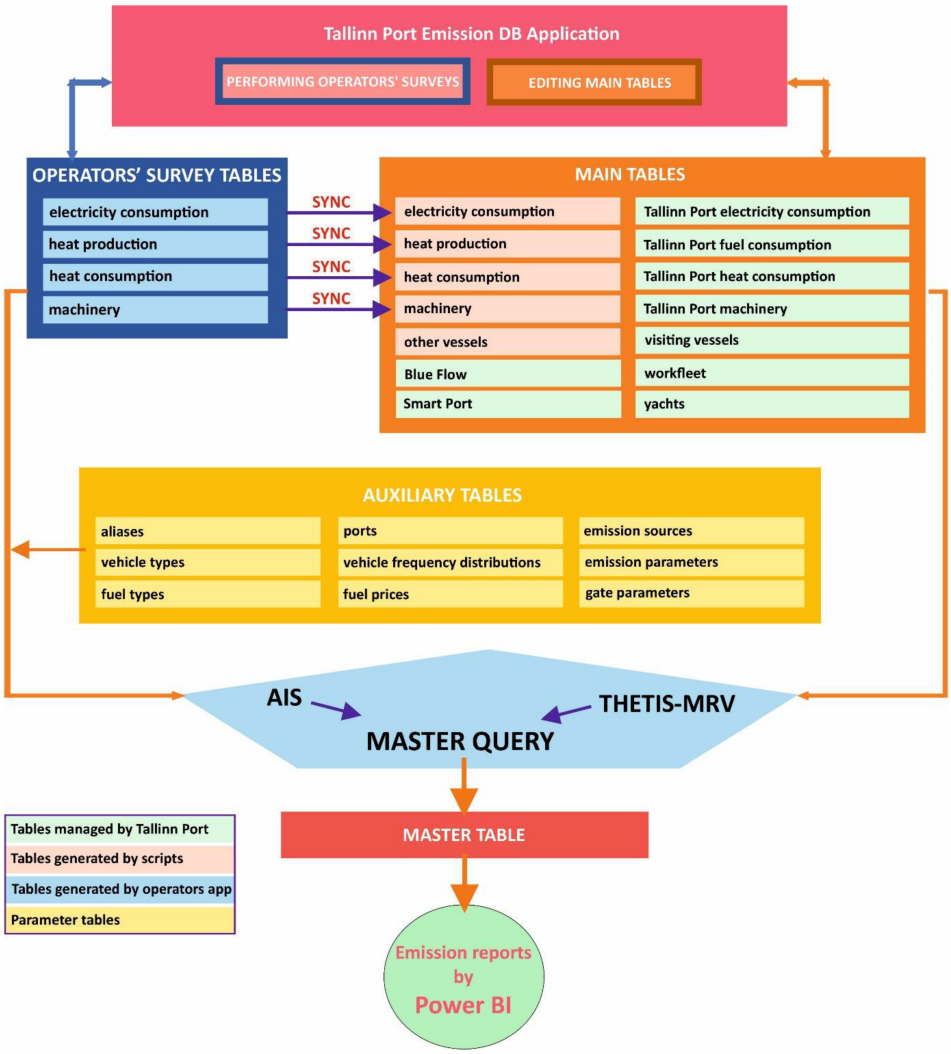

Figure 12: Software architecture diagram for Paper 5.

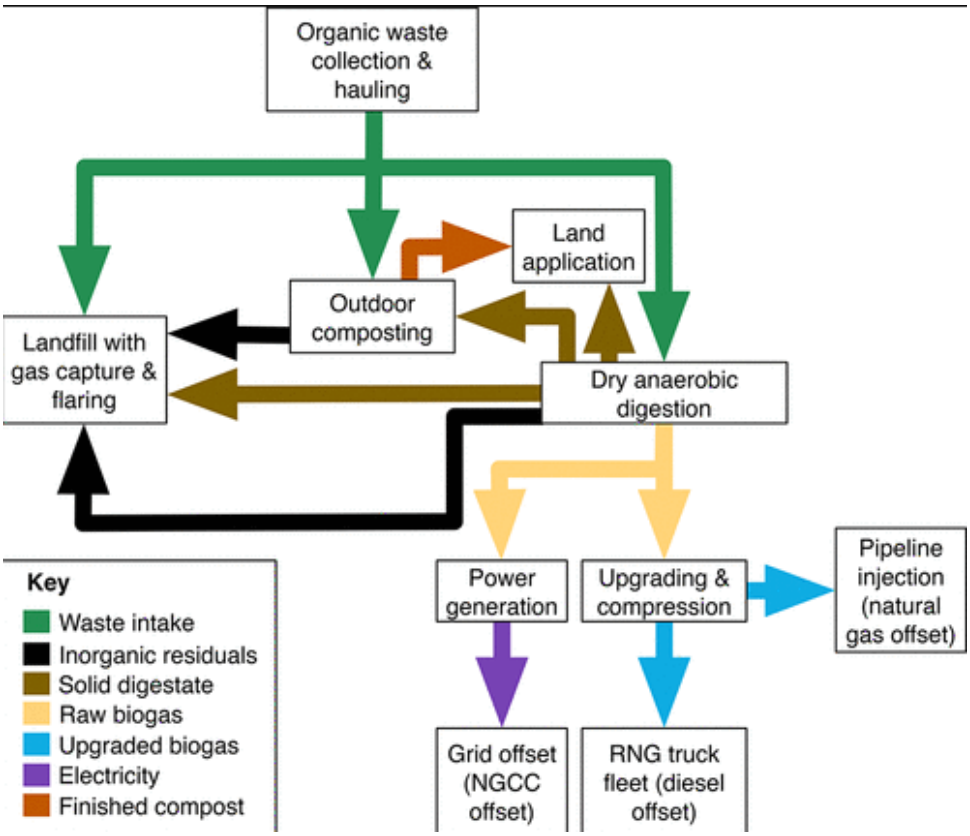

Figure 13: Software architecture diagram for Paper 1.

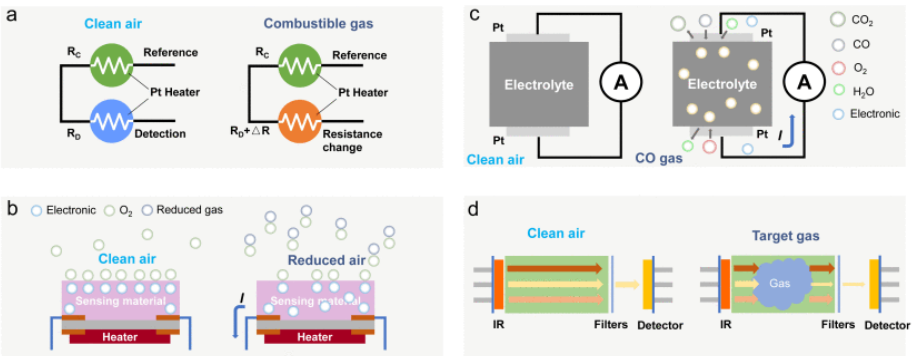

Figure 14: Software architecture diagram for Paper 3.

ry [11-16] and include emission magnitudes of separate GHG from point-, line- and area-type emission sources, as well as total emission of all gases in CO_2-equivalent. Additionally, all spatial data on emissions were aggregated into cells of a fixed size. A 2 × 2 km grid was used for the emissions data from Poland. Cells are further divided into smaller vector objects if they are crossed by administrative boundaries of a province, district or municipality, which helps to maintain administrative assignment of each elementary object and provides the opportunity to sum GHG emissions within the bounds of each administrative object without loss of precision.

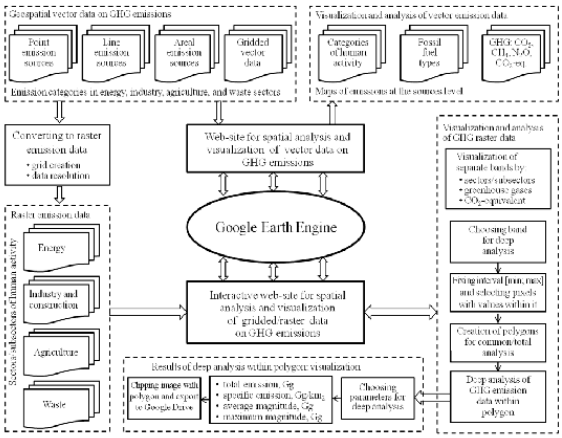

Fig. 1. Structure of the GIS technology for spatial analysis and visualisation of high-resolution GHG emissions data

The main raster parameters, which are related to spatial resolution and map extent, are set during the conversion of vector data (usually in tab MapInfo or ESRI shape file formats) into raster/gridded data (in tiff file format). High spatial resolution GHG emissions data from different sectors and categories of human activity are organised as bands of raster data. The bands contain information regarding the emission of different GHG (carbon dioxide, methane and nitrous oxide), as well as the total emission of all gases taking the global warming potentials of separate gases into account.

The interactive website for spatial analysis and visualisation of high-resolution raster data on GHG emissions at the grid cells level was also carried out using Google Maps JavaScript API. The additional functionality of this site provides the possibility to choose the corresponding raster data band, create any arbitrary polygon and analyse

Figure 15: Software architecture diagram for Paper 4.

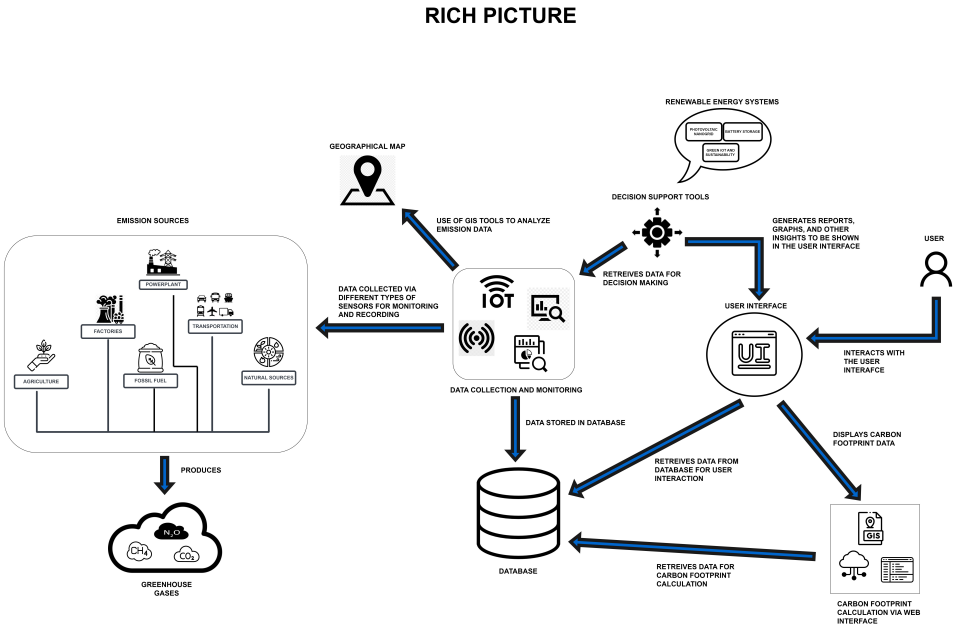

Figure 16: Rich Picture for the system.

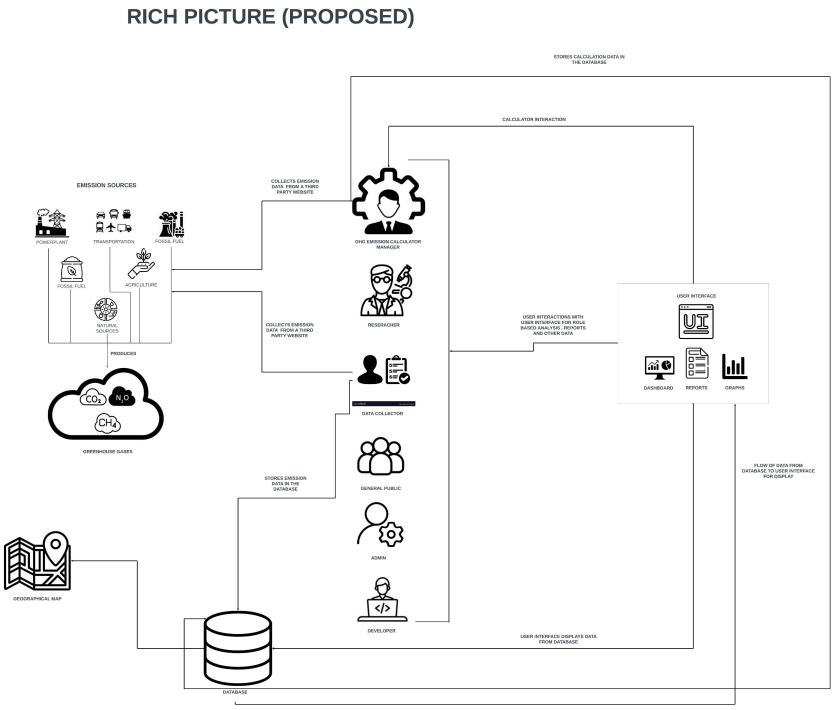

Figure 17: Rich Picture for proposes system.

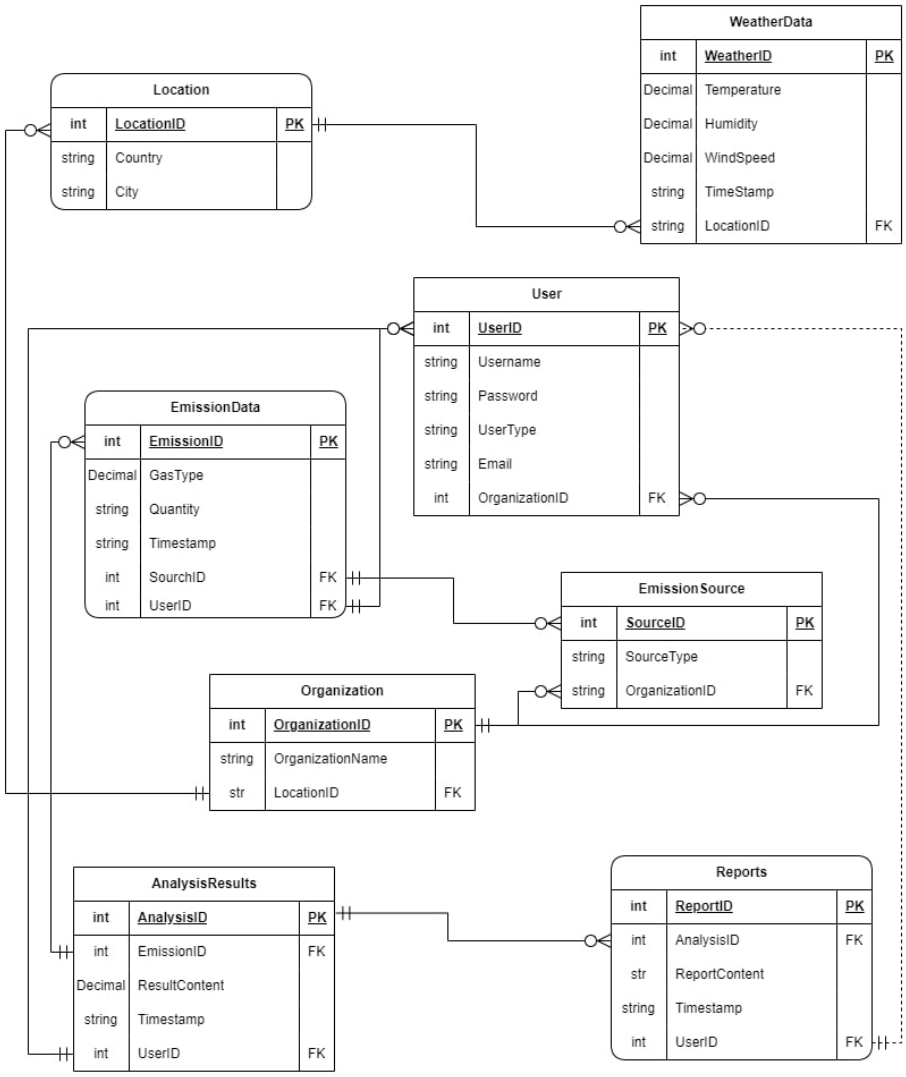

Figure 18: ERD for proposed system.

USER

User ID	Username	Password	Email	UserType

EMISSION DATA

EmissionID	GasType	Quantity	TimeStamp	UserID	SourceID
				_ _ _ _	_ _ _ _ _ _

ANALYSIS RESULT

AnalysisID	EmissionID	ResultContent	TimeStamp	UserID
				_ _ _ _

LOCATION

LocationID	City	Country

ORGANIZATION

OrganizationID	OrganizationName	LocationID

EMISSION SOURCE

SourceID	SourceType	OrganizationID
		_ _ _ _ _ _ _ _

WEATHER DATA

WeatherID	LocationID	Temperature	Humidity	WindSpeed	Timestamp
	_ _ _ _ _ _				

REPORT

ReportID	AnalysisID	ReportContent	TimeStamp	UserID
	_ _ _ _ _ _			_ _ _ _

Figure 19: Schema for proposed system.

1st Normal Form (1NF):

UserID	UserName	Password	Email	UserType	EmissionData	EmissionID	GasType	Quantity	Timestamp

AnalysisResults	AnalysisID	ResultContent	Organisation	OrganisationID	Organisation Name	LocationID	EmissionSources	SourceID

Source Type	LocationCity	Country	Reports

2nd Normal Form (2NF):

R1 (EmissionData):

EmissionID	GasType	Quantity	Timestamp	UserID

R2 (AnalysisResults):

AnalysisID	EmissionID	ResultContent	Timestamp	UserID

R3 (User):

UserID	UserName	Password	Email	UserType

R4 (EmissionSources):

SourceID	SourceType	OrganisationID

R5 (Location):

LocationID	City	Country

R6 (Organisation):

OrganisationID	OrganisationName	LocationID

R7 (Reports):

ReportID	UserID	AnalysisID	ResultContent	Timestamp

Figure 20: Schema for proposed system.

Third Normalization(3NF):

R1

EmissionID	GasType	Quantity	TimeStamp	UserID _ _ _ _

R2

AnalysisID	EmissionID	ResultContent	TimeStamp	UserID _ _ _ _

R3

UserID	UserName	Password	Email	UserType

R4

SourceID	SourceName	OrganizationID _ _ _ _ _ _ _ _ _

R5

LocationID	City	Country

R6

OrganizationID	OrganizationName	LocationID _ _ _ _ _ _

R7

ReportID	ReportContent	TimeStamp

R8

WeatherID	Temperature	Humidity	WindSpeed	TimeStamp

Figure 21: Schema for proposed system.

Data Dictionary

User:

Name	Data Type	Remark
UserID	Integer	Unique identifier for each user.
Username	String	User's login username.
Password	String	User's login username.
Email	String	User's email address.
UserType	String	Type of user (e.g., admin, regular user).

EmissionData:

Name	Data Type	Remark
EmissionID	Integer	Unique identifier for each emission data record.
GasType	String	Type of gas emitted.
Quantity	Decimal	Quantity of gas emitted.
Timestamp	DateTime	Date and time of the emission data entry.
UserID (Foreign Key)	Integer	References the UserID from the User table.
SourceID (Foreign Key)	Integer	References the SourceID from the EmissionSources table.

AnalysisResults:

Name	Data Type	Remark
AnalysisID	Integer	Unique identifier for each analysis result.
EmissionID (Foreign Key)	Integer	References the EmissionID from the EmissionData table

ResultContent	Text	Content of the analysis result.
Timestamp	DateTime	Date and time of the analysis result.
UserID (Foreign Key)	Integer	References the UserID from the User table.

Organization:

Name	Data Type	Remark
OrgID	Integer	Unique identifier for each organization.
OrgName	String	Name of the organization.
LocationID (Foreign Key)	Integer	References the LocationID from the Location table.

EmissionSources:

Name	Data Type	Remark
SourceID	Integer	Unique identifier for each emission source.
SourceType	String	Type of the emission source.
OrgID (Foreign Key)	Integer	References the OrgID from the Organisation table.

Location:

Name	Data Type	Remark
LocationID	Integer	Unique identifier for each location.
City	String	City name.
Country	String	Country Name

Reports:

Name	Data Type	Remark
ReportID	Integer	Unique identifier for each report.
UserID (Foreign Key)	Integer	References the UserID from the User table.
AnalysisID (Foreign Key)	Integer	References the AnalysisID from the AnalysisResults table.
ReportContent	Text	Content of the report.
Timestamp	DateTime	Date and time of the report.

WeatherData:

Name	Data Type	Remark
WeatherID	Integer	Unique identifier for each weather data record.
LocationID (Foreign Key)	Integer	References the LocationID from the Location table.
Temperature	Decimal	Temperature Data.
Humidity	Decimal	Humidity Data.
WindSpeed	Decimal	Wind Speed Data.
TimeStamp	DateTime	Date and time of the weather data entry.