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Aligning Waste-to-Energy (WtE) Projects with Circular Economy Principles: A Comparative Analysis of the European Union and India's Path Forward

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ABSTRACT
The growing global challenge of waste management has reached alarming levels, with approximately 4.5 million tonnes of waste generated every day worldwide—a figure that is expected to exceed 8 million tonnes by 2050, according to the World Bank. Although there have been notable improvements in how waste is managed, it has transitioned from being just a public concern to becoming a booming industry, particularly seen in the rise of the Waste-to-Energy (WtE) sector across the globe.
Given this growing problem, many experts agree that addressing waste requires a shift toward a "circular economy," an approach aimed at minimizing waste altogether. This strategy is in line with the United Nations' 2030 Agenda for Sustainable Development, particularly Sustainable Development Goal 12, which focuses on responsible consumption and production.
While WtE technologies seem like a sustainable option, the process of turning waste into energy using advanced facilities raises questions about their true compatibility with circular economy principles. The UN has proposed a framework to guide WtE projects, suggesting that these frameworks can help in the transition to a circular economy—especially in terms of energy recovery. However, this requires innovative public-private partnerships (PPPs) that emphasize people-first values and the adoption of best practices by both governments and the private sector simultaneously.
The main focus of this paper is to highlight the need to align WtE projects with circular economy principles to ensure sustainable and effective waste management. While this model has made significant progress in EU (European Union) countries, it is still in the early stages of development in India. This paper explores the framework used in the EU and discusses how India can successfully adopt and implement similar practices.

Key Words: WtE, PPP, People first PPP, Sustainability, circular economy, waste management,

INTRODUCTION

Waste to energy's Compatibility with circular economy!
The current linear economy model, which follows a "take-make-use-dispose" cycle, has led to the creation of around 4.5 million tonnes of waste every day globally. This unsustainable pattern has resulted in serious environmental impacts, including rising energy demands and an increase in global Municipal Solid Waste (MSW). As the consequences of this linear

model become more apparent, the idea of transitioning to a circular economy is gaining momentum. A circular economy seeks to preserve the value of products, materials, and resources by reducing waste and minimizing resource consumption [1], [2].
This shift presents a promising solution to the challenges posed by conventional landfills, especially as industries continue to generate massive waste. Recycling and composting programs have become essential in urban waste management, delivering both economic benefits and helping conserve natural resources. Alongside these efforts, Waste-to-Energy (WtE) technologies have emerged as a potential solution, utilizing heat to convert waste into energy or fuels [3]–[6].

Globally, over 1,200 WtE plants are operational, with countries like China, the EU, Japan, the United States, South Korea, and Singapore leading the way in capacity. Despite its potential to contribute to renewable energy, the WtE sector remains dominated by a few major players. The market, valued at USD 31 billion in 2019, is expected to grow significantly. However, questions persist about how well WtE aligns with the principles of a circular economy.
This in-depth analysis examines the shift from a linear to a circular economy, the challenges of traditional waste management, and the role of Waste-to-Energy (WtE) in tackling the escalating waste crisis. The study explores the global landscape of WtE, the key players in the market, and the challenges in aligning these systems with circular economy principles. The findings emphasize the importance of strategic, collaborative efforts between governments and the private sector to achieve sustainable waste management and foster circularity (Waste to Energy in the Age of the Circular Economy, 2020) [7]–[9].

The core aim of the waste management hierarchy is to create a framework that prioritizes reducing environmental harm, minimizing public health risks, and enhancing resource efficiency by diverting waste from landfills. Maintaining this principle as a key focus in legislation and policy development is essential for addressing pressing environmental challenges.

The big debate for and against Waste-to-Energy (WtE)
Over the years, countries have adapted innovative approach to the WtE industry. It is pertinent to explore the arguments both opposing and supporting WtE, as outlined in Table 1.

Table 1. Pros and Cons of Waste-to-Energy

Arguments for WtE	Arguments Against WtE
WtE can complement a comprehensive waste management strategy. In the EU, landfilling is reduced through a combination of recycling, composting, and WtE initiatives.	WtE may discourage recycling and composting, acting as a barrier to circular economy practices and zero-waste goals. Converting unsorted and recyclable waste into fuel reduces the incentive for communities to prioritize reducing, reusing, and recycling.
In the U.S., municipalities that implement WtE often see an increase in recycling rates alongside WtE operations.	WtE raises environmental concerns, including contributions to climate change, toxic emissions, and air pollution.

Arguments for WtE	Arguments Against WtE
Modern WtE technologies can operate with minimal environmental impact. WtE plants must meet rigorous environmental standards, such as the EU Industrial Emissions Directive.	Despite advances, WtE plants still pose health risks, potentially emitting carcinogens and harmful pathogens into the air.
WtE facilities with advanced Air Pollution Control (APC) systems significantly reduce the impact on air quality.	WtE may present public health risks, with concerns over the release of harmful substances that could negatively affect nearby populations.
Some WtE plants have been designed to benefit local communities, such as providing heat for district heating or cooling. Notable examples include plants in cities like Brescia, Osaka, Paris, and Vienna, some of which have even become tourist destinations.	Communities often oppose the construction of WtE plants near residential areas. In some countries, local protests reflect concerns about potential health risks from nearby facilities.

Source: Adapted from Economic Commission for Europe (ECE)'s working party on PPP guidelines promoting People first PPP 2020

Waste-to-Energy (WtE) can serve as a transitional measure on the path to more circular and sustainable development, depending on each country's starting point. While its role is anticipated to diminish as recycling and reusing increase, WtE continues to be crucial for managing residual mixed waste. Factors such as the existence of non-recyclable products, the need to reduce landfill use, and advancements in technology all support WtE's ongoing relevance in contributing to the principles and practices of a circular economy.

RESEARCH METHODOLOGY

This research draws primarily from the UNECE study (Guidelines on Promoting People-First PPPs, 2019) and related literature that aligns with EU frameworks, offering comparative insights and guidelines for adopting people-first Public-Private Partnerships (PPPs) globally. A comprehensive review of global waste management issues, including current trends, challenges, and projections, was conducted to understand the global perspective on circular economy practices and public perceptions of Waste-to-Energy (WtE) as part of the circular economy (Cobo et al., 2018).

The literature review delves into existing studies on the circular economy and its principles, with a specific focus on how these principles align with waste management practices. It also examines the evolution, successes, and challenges of WtE initiatives. This analysis highlights factors that contribute to the success or obstacles faced in adopting circular economy models, taking into account cultural, economic, and regulatory variances.

The study further compares waste management strategies across countries to identify common patterns and best practices. Several national and international policies concerning waste management particularly those governing WtE projects were analyzed. The evaluation

also assesses the effectiveness of policies that either promote or impede the integration of WtE initiatives with circular economy principles.
Interviews were conducted with key stakeholders in the waste management and WtE sectors, including government officials, industry experts, and representatives from NGOs in India, to explore best practices and gather their perspectives on whether WtE fits within the circular economy framework. These interviews offer valuable insights into stakeholders' views on circular economy principles in waste management and the role of PPPs in promoting circularity and people-first approaches in WtE projects (Tripathy & Tyagi, 2019).

Drawing from the findings, the research aims to provide policy recommendations for both governments and the private sector to advance circularity in WtE projects (Priyadarshini & Abhilash, 2020). It also suggests strategies for improving PPPs, with an emphasis on people-first principles and sustainable waste management practices. These recommendations are aligned with the United Nations Sustainable Development Goals, especially SDG 12 on responsible consumption and production for the Government of India.

By integrating these methodologies, the research explores the intersection of waste management, circular economy principles, and WtE initiatives. The combination of quantitative analysis, policy evaluation, and stakeholder input contributes to a deeper understanding of the challenges and opportunities involved in aligning WtE projects with circular economy objectives.

LIMITATIONS

During the research on the intersection of waste management, circular economy principles, and Waste-to-Energy (WtE) initiatives, a number of limitations were encountered. It is important to acknowledge these challenges to ensure the transparency, accuracy, and reliability of the research outcomes. The key limitations include, but are not limited to:

- **Incomplete or Inaccurate Data**: The availability and reliability of waste management data, particularly in India, is limited or inconsistent, which can affect the accuracy of findings.
- **Lack of Standardization**: The variation in waste reporting standards and methodologies between different countries could pose a challenge to developing a standardized approach applicable globally.
- **Policy Implementation Gaps**: While policies may support circular economy principles, the effective implementation of these policies is often delayed, potentially impacting the success of WtE projects.
- **Limited Generalizability**: Findings from specific WtE case studies may not apply universally due to differences in regional contexts, regulatory frameworks, and project scales.
- **Rapid Technological Changes**: The fast-paced evolution of technology within the WtE industry means that the research may quickly become outdated if it doesn’t account for the latest technological advancements.
- **Cultural and Contextual Differences**: Socio-economic and cultural variations across regions can influence how findings and recommendations are interpreted and applied, limiting their general applicability.

- **Differing Definitions of Circular Economy**: Variations in how circular economy principles are understood and adopted can impact the assessment of their alignment with WtE initiatives.

Despite these limitations, the research provides general guidelines that can be applied to WtE projects across different locations and technological contexts.

DISCUSSION

Risk Factors for the Sustainability of PPP-Based Waste-to-Energy (WtE) Projects

For Waste-to-Energy (WtE) projects to be sustainably viable over the long term, financial considerations are crucial for securing investment. This makes Public-Private Partnerships (PPPs) a popular model in many countries across various sectors, including the WtE industry. In a typical PPP arrangement for WtE projects, the developer takes on the responsibility of project development using the Design-Build-Own-Operate (DBOO) model. Under this model, the developer secures independent financing, manages construction, ownership, maintenance, and operation of the WtE facility, ensuring it meets contracted energy capacity requirements throughout the project's lifespan, typically lasting 25 to 30 years.

Given the substantial upfront investments required for WtE facilities, developers and their financial partners often seek guarantees from the government agencies commissioning these projects. These assurances are critical for ensuring that the returns on investment will be satisfactory throughout the duration of the project.

In addition to government incentives, WtE projects generate revenue primarily through two sources: the "gate fee" (or tipping fee), which is charged when municipalities, businesses, or other entities dispose of waste at the facility, and the sale of energy (electricity and/or heat) produced by the facility to local power grids. A smaller, third source of income comes from the sale of by-products like bottom ash, which result from the incineration process. The gate fee is influenced by the volume of waste processed, while energy sales depend on the amount of heat and electricity generated.

The combustibility of waste, such as plastics, paper, and wood, directly impacts the furnace temperature and Calorific Value (CV) of the waste. The mix of combustible and non-combustible materials plays a key role in determining the revenue streams of the WtE facility. Additionally, safety regulations require that facilities are designed for a specific thermal capacity. If the volume of combustible waste exceeds the facility's designated CV, the operator must reduce the waste input, potentially lowering gate fees. On the other hand, if the CV is too low, the facility may not generate enough electricity to meet sales expectations.

Therefore, maintaining the right balance between CV and waste quality becomes a significant challenge for PPP-based WtE projects.

Beyond financial and operational challenges related to waste characteristics, other risks could affect the long-term sustainability of WtE projects. These risks must be carefully identified, analyzed, and mitigated by the various stakeholders involved to ensure the project's success and sustainability (Gupta & Verma, 2020).

Strategies to Mitigate Risks in WtE Projects

While it can be challenging to predict all the risks associated with long-term infrastructure projects like Waste-to-Energy (WtE) facilities, there are effective strategies to reduce these risks. By thoroughly identifying, categorizing, and addressing risks throughout the project's lifecycle, many of the potential challenges can be minimized. The following table outlines various approaches to manage and mitigate risks in WtE projects:

Table 2: Risk Mitigation Strategies to be adopted

Risk	Mitigant
Technology	Use proven, established technologies and avoid "First of a Kind" facilities.
Regulatory/Subsidy	Assess regulations on a case-by-case basis, avoid reliance on anticipated policies, and use subsidies to enhance the project rather than as a foundational element.
Project Phase (Development or Construction)	Link funding releases to project milestones, such as permits, leases, and approvals, to better manage and evaluate risks during development and construction.
Operational	Enter into Operation and Maintenance (O&M) contracts with experienced and reliable service providers.
Feedstock	Secure diversified, long-term agreements with creditworthy suppliers for waste feedstock.
Offtake	Negotiate long-term agreements with creditworthy off takers, while allowing for some merchant exposure to capitalize on potential upside.
Exit	Structure a portfolio of projects that can be optimized and demonstrate strong performance, leveraging these to improve economic returns.

Source: made by Author

By applying these strategies, the risks associated with WtE projects can be effectively managed, helping to ensure long-term sustainability and success.

The concept and integration of People-First PPPs in WtE Projects

For Waste-to-Energy (WtE) projects to align with the principles of a circular economy, they must adopt a people-first approach. This means that all WtE projects should be based on the concept of People-first Public-Private Partnerships (PPPs). The Economic Commission for Europe (ECE) promotes a holistic development model, advocating that People-first PPPs prioritize sustainable development with people as the central beneficiaries. These partnerships focus on "quality infrastructure" investments that create value for both people and the planet. People-first PPPs aim to achieve five key outcomes, as outlined in Table 3 below:

Table 3: Outcomes Vis-à-vis Benchmarks for People first PPP in WtE Projects

Outcomes	Benchmarks
Access and Equity	• Provide essential services • Improve affordability and universal access • Promote equity and social justice • Plan for long-term access and equity
Economic Effectiveness and Fiscal Sustainability	• Prevent corruption and ensure transparent procurement • Maximize economic viability and fiscal sustainability • Focus on long-term financial viability • Enhance employment and economic opportunities
Environmental Sustainability and Resilience	• Reduce greenhouse gas emissions and improve energy efficiency • Minimize waste and restore degraded land • Reduce water consumption and wastewater discharge • Protect biodiversity • Assess risks and resilience for disaster management and Allocate resources for resilience and disaster response Promote community-driven development
Replicability	• Encourage the scalability of successful models • Strengthen government, industry, and community capacity • Support innovation and technology transfer
Stakeholder Engagement	• Plan for inclusive stakeholder engagement and public participation • Maximize engagement with stakeholders and the public • Ensure transparency and quality in project information • Address public grievances and user feedback effectively

Source: Adapted from Economic Commission for Europe (ECE)'s working party on PPP guidelines promoting People first PPP 2020

By adhering to these principles, WtE projects can contribute meaningfully to both the people and the planet, ensuring that they are sustainable, equitable, and beneficial to all stakeholders involved.

Key Challenges for Establishing People-First Waste-to-Energy Projects

Transforming Waste-to-Energy (WtE) initiatives into "high quality" investments and "People-first" endeavours poses considerable challenges for the industry. This section delves into each of the five People-first outcomes individually, illustrating the nature of challenges under each outcome and how projects are addressing and overcoming these issues.

Enhancing Access and Promoting Equity

Increasing access and promoting equity means evaluating whether a project facilitates essential services, such as energy, especially for populations that have been underserved or receive lower-quality services. One of the primary challenges in achieving this outcome is the cost of Waste-to-Energy (WtE) projects, which are often more expensive compared to other energy sources. As a result, WtE projects can be less affordable for low- and middle-income communities. Critics often highlight that the WtE industry tends to focus more on presenting itself as an energy generation solution rather than as a waste management system. Historically, WtE plants have contributed modestly to national energy grids, but this trend is changing. For example, projects in Olsztyn, Poland, and Klaipeda, Lithuania, have made significant strides in addressing local energy needs while supporting transitions away from fossil fuels.

While WtE projects can be a valuable energy source for smaller countries with lower energy demands, they may not play a significant role in nations with high energy consumption. In these countries, WtE should be viewed less as an energy provider and more as a tool for tackling critical health and environmental challenges.

In many cases, WtE projects are viewed as social infrastructure, and local governments, such as those in India, may offer support for these initiatives. Beyond their energy generation potential, WtE projects can be seen as key initiatives for improving public health and addressing environmental concerns.

Enhancing Economic Effectiveness and Fiscal Sustainability of Projects

This criterion emphasizes the project's role in generating quality jobs, fostering innovation, optimizing economic assets, and ensuring profitability. While Waste-to-Energy (WtE) projects can offer economic benefits, their impact on local economies—particularly in terms of quality employment—can be limited. Issues such as fair wages, knowledge transfer, and benefits for marginalized groups, like informal waste-pickers, are often a concern. In some cases, WtE facilities may negatively affect local communities, especially those dependent on informal recycling practices for their livelihood.

However, there are successful examples that demonstrate the potential of WtE projects to benefit local populations. For instance, the Cox’s Bazar project in Bangladesh engaged refugees in construction work, while the Dublin, Ireland project created job opportunities, provided training, and allocated significant resources to community development. Additionally, many WtE projects fail to adequately address gender equality and women’s empowerment, which highlights the need for a stronger focus on these issues in future initiatives.

Enhancing Environmental Sustainability and Resilience

Environmental sustainability focuses on safeguarding the planet and addressing climate change while aligning with the Sustainable Development Goals (SDGs). While Waste-to-Energy (WtE) combustion does release CO2 emissions, which can affect public health, there are additional concerns about meeting recycling targets and adhering to the waste hierarchy. However, some WtE projects, such as those in Barcelona, Spain, and Glasgow, United Kingdom, have made significant strides in reducing CO2 emissions and improving recycling efforts. Integrated approaches seen in cities like Barcelona, Glasgow, and Singapore

showcase best practices in circularity, driving both environmental resilience and economic benefits (Malinauskaite et al., 2017). These projects highlight the potential of WtE to contribute positively to environmental sustainability while supporting long-term resilience.

Replicability

Replicability focuses on the ability to scale and transfer technologies and programs to different regions or contexts, requiring significant capacity building and skills development. For the Waste-to-Energy (WtE) model to be replicable, it is essential to invest in comprehensive skills transfer, training, and local workforce development, which can be expensive. While WtE companies often offer training, selecting the wrong technology can result in substantial financial losses, as demonstrated by the Tees Valley project in the United Kingdom. Successful replicability depends on carefully selecting the right technologies and ensuring effective skills transfer to local teams.

Stakeholder Engagement

People-First PPPs encourage developers to actively engage all stakeholders impacted by a project, ensuring transparency and the availability of data for evaluation. However, projects often fail to account for the need to engage communities that may oppose the initiative, leading to the "not in my backyard" (NIMBY) phenomenon. The main challenges in stakeholder engagement are overcoming local opposition and ensuring clear communication. Some projects, such as those in Trimmis, Switzerland, have successfully engaged local communities, while others have faced strong resistance, highlighting the importance of robust engagement strategies.

Despite these challenges, People-First WtE projects have the potential to achieve significant social and environmental goals in line with circular economy principles. Scaling these efforts requires proactive involvement from both governments and stakeholders to help elevate the sector. Embracing these strategies can transform WtE projects into effective, sustainable, and people-first public-private partnerships.

Best Practice Options for Adapting and Transforming Projects into People-first Waste-to-Energy Public-Private Partnerships

In line with People-first PPPs, this section outlines seven best practices for transforming Waste-to-Energy (WtE) projects to fully embrace circular economy principles. These practices are designed for governments, the private sector, and civil society organizations, addressing key challenges and offering strategies to create People-first Waste-to-Energy Public-Private Partnerships. WtE is evolving due to factors such as climate change policies, technological advancements, and the adoption of circular economy strategies.
Based on experience, three potential scenarios for WtE integration emerge:

- **Scenario 1**: WtE continues to be treated as a landfill option within the waste hierarchy.
- **Scenario 2**: WtE is positioned at the same level as landfills.
- **Scenario 3**: WtE is fully integrated into circular economy activities.

Scenarios 1 and 2 fail to address the growing global waste crisis and the escalating rate of waste generation. The real solution lies in **Scenario 3**, where WtE is fully integrated into

circular economy activities and recognized as a vital component of a country's broader economic transition. This approach is crucial for countries like India, where the public often views waste management as the sole responsibility of the government, and where people generally do not take ownership of the waste they generate.

To incorporate WtE into the circular economy and make it part of an integrated economic system, the following seven best practices are proposed for the successful implementation of these scenarios.

Option 1: Integrate Circular Economy Goals into Government Policies, Focusing on Waste as a Resource

People-first WtE PPPs should adopt business models driven by a clear purpose, emphasizing their role in advancing the circular economy. Waste should be seen as a valuable resource, and projects must prioritize efficient waste collection and pre-processing systems to minimize the loss of potentially useful materials. Additionally, efforts should be made to reduce the reliance on landfills, promoting more sustainable waste management practices.
To foster the growth of WtE, it is essential to stress the importance of waste prevention, reuse, and recycling as fundamental aspects of waste management. This can help ensure that WtE is seen not just as an alternative to landfills but as a key part of the broader effort to minimize waste and its environmental impact.

Furthermore, there is a critical need to encourage the adoption of WtE technologies in low- and middle-income countries, where such initiatives are still relatively rare. These countries often rely on cheaper landfill methods, which pose significant risks to public health and the environment. Shifting from landfilling to WtE technologies in these regions could help mitigate these dangers, while also contributing to global circular economy goals.

Option 2: Internalize Externalities, Foster Social Acceptance, and Attract Investments by Revising the Waste Hierarchy to Address Circular Economy Challenges

The waste hierarchy should be redefined to align with circular economy principles. In this revised hierarchy, two key activities should be prioritized: resource management and waste management. Resource management involves promoting innovation and establishing a robust regulatory framework to encourage smarter product use and manufacturing, while also extending product lifecycles. Waste management, on the other hand, should focus on maximizing resource and energy recovery, rather than relying on landfilling or incineration without energy recovery.

People-first PPPs should also give special attention to marginalized and vulnerable populations, such as refugees and indigenous communities, who are increasingly affected by environmental and social challenges. Emphasizing industrial symbiosis can help maximize recycling and energy recovery across industries. Furthermore, it's important to address the "residual" waste—lower-quality waste that remains after recycling efforts—by generating renewable energy from biodegradable materials through WtE processes. Additionally, ensuring the recovery of valuable products from bottom ash and the sustainable disposal of fly ash should be central to the approach. This holistic strategy will help secure greater social

acceptance, drive investment, and promote a more sustainable and inclusive waste management system.

Option 3: Choose Appropriate, Innovative, and Less Polluting Technologies while Fostering Local Skills Development

People-first WtE PPPs should focus on selecting technologies that enhance the circular economy, ensuring that harmful substances are effectively removed from the process to reduce environmental impact. Additionally, these projects should contribute to local economic development by providing skills training to help communities effectively use and manage these technologies.

To ensure environmental sustainability, WtE PPPs must integrate advanced Air Pollution Control systems and ensure their emissions stay below stringent standards, such as those set by the Industrial Emissions Directive. Furthermore, it is essential to establish a robust monitoring system for emissions from WtE plants, with centralized registers managed by the relevant public environmental agencies. This approach will not only promote cleaner technologies but also support the capacity building of local economies, enabling them to fully benefit from the adoption of these innovations.

Option 4: Offer Economic Incentives and Price Support to Boost Circular Economy Practices in People-First WtE PPPs

People-first WtE PPPs should be supported by fiscal incentives that promote the adoption of circular economy practices and elevate projects within the waste hierarchy. Governments can encourage these initiatives by raising landfill taxes and providing credits for WtE projects producing renewable energy, such as through feed-in tariffs or the issuance of tradable green certificates with guaranteed minimum market values for installed capacity. Additionally, results-based financing mechanisms, like environmental impact bonds, should be considered to address the risks associated with construction, operations, and counterparty reliability in WtE investments (Wang et al., 2020). These measures can provide the financial impetus needed to drive sustainable, circular practices within the WtE sector.

Option 5: Identify Strategic Partners and Monitor Performance, Focusing on Compatible WtE Technologies and Circular Economy Values

When selecting partners for WtE projects, priority should be given to cost-effective, locally appropriate technologies over high-end solutions that may not suit the regional context. Local innovations, when properly harnessed, can provide environmentally friendly and people-centered solutions. Governments should play a key role in facilitating the adoption of successful technologies by guiding local urban bodies and state agencies in their implementation. A robust scoring methodology can be used to evaluate and select the best alternatives.

In addition, local financial institutions should be targeted for funding these projects, helping to foster green economies and promote investment in sustainable ventures. However, it is crucial to ensure that procurement frameworks are transparent and well-governed, as weak

frameworks can result in transparency issues and poor project outcomes (Patil & Laishram, 2016). By fostering strong partnerships and carefully selecting technologies, WtE projects can contribute to both local development and circular economy goals.

Option 6: Implement Transparent, Open Procurement Processes with a Zero-Tolerance Approach to Corruption, Upholding Circular Economy Values in People-First WtE PPPs

Local governments should establish clear, transparent procurement processes that prioritize integrity and uphold a zero-tolerance stance toward corruption. Adhering to international standards, such as the ECE's Zero Tolerance Approach, or developing a localized framework tailored to the specific context, ensures that procurement is conducted ethically. In addition, fostering stakeholder and community engagement at every stage of the procurement process is critical for promoting accountability and ensuring alignment with circular economy values. By reinforcing transparency and ethical practices, People-first WtE PPPs can enhance trust, drive sustainable development, and deliver long-term positive impacts.

Option 7: Foster Local Participation, Empower Women and Vulnerable Groups, and Establish a "Social Contract" with Stakeholders for Strong Community Engagement

The concept of a "social contract" (Biygautane et al., 2019) is an innovative approach that can significantly increase stakeholder involvement by outlining the health and environmental benefits of WtE projects. This contract should emphasize the mutual benefits for local communities and actively engage them as partners in the design, construction, and operation of WtE plants, based on their skills and capabilities. Special attention should be given to empowering women and vulnerable groups, ensuring they are integral to the process.
Furthermore, the contract could extend to community-driven initiatives, such as land restoration and the development of green spaces, fostering a sense of ownership and involvement in projects that enhance both environmental and social wellbeing. This approach not only strengthens community ties but also ensures that the benefits of WtE projects are broadly shared, contributing to long-term sustainability and equity.

Aligning with the People-First PPP Framework (Sample Project Format and outcomes)

- Project Description: Provide a concise overview of the project, including its scope, objectives, key stakeholders, and the expected environmental, social, and economic outcomes.
- Compliance with the People-First PPP Framework: Outline how the project adheres to the People-First PPP framework, highlighting any relevant country-specific adaptations. Explain how the project is designed to prioritize sustainable development, community involvement, and circular economy principles.
- Implementation of People-First Approach: Detail how the project integrates the People-First approach by addressing one or more of the following key outcomes:
  - Access and Equity: How does the project ensure affordable and equitable access to services, particularly for marginalized or vulnerable communities?
  - Economic Effectiveness and Fiscal Sustainability: What strategies are in place to maximize economic viability and employment opportunities, particularly for local communities?

- Environmental Sustainability and Resilience: How does the project contribute to reducing environmental impacts, enhancing resilience, and promoting resource recovery?
- Replicability: What measures are being taken to ensure the project's success can be scaled or replicated in other regions or contexts?
- Stakeholder Engagement: How is the project fostering meaningful engagement with stakeholders, ensuring transparency, and addressing public concerns throughout its lifecycle?

By framing the project through these lenses, the format ensures a comprehensive understanding of its alignment with People-First PPP principles**.**

Outcome 1: Expand Access to Essential Services and Address Social Inequality

For example:

- The project needs to answer whether it address the needs of socially and economically vulnerable populations? And whether it has improved access to essential services for communities that were previously underserved? In what ways does the project work to reduce socioeconomic and gender disparities?

Outcome 2: Strengthen Resilience and Foster Environmental Responsibility

For example:

- Does the project contribute to environmental sustainability by reducing greenhouse gas emissions, waste, and energy or water consumption? Were environmental standards adhered to during construction and operation? Is the facility designed to withstand climate-related challenges? Has the overall quality of services been enhanced through environmental improvements?

Outcome 3: Enhance Economic Effectiveness and Long-Term Viability

For example:

- Does the project provide value for money and ensure long-term fiscal sustainability? Does it generate local, decent, and sustainable employment, fostering annual income growth in the community? How does the project promote gender equality, including women's economic empowerment and addressing the unique needs of different genders?
- Does it empower economically marginalized or vulnerable groups, particularly local businesses and communities? Have operational efficiencies been achieved, leading to cost reductions or better resource allocation?

Outcome 4: Foster Replicability and Expansion of Future Projects

For example:

- Is the project designed to be replicated or scaled in other regions or contexts? Did the project contribute to building local capacity, enabling staff and governments to replicate similar initiatives?
- Were local workers trained, facilitating the transfer of skills for future projects?

Outcome 5: Ensure Comprehensive Stakeholder Engagement and Protection

For example:

- Were all relevant stakeholders—both directly and indirectly affected by the project—consulted during the planning, design, and implementation phases? Did the project engage groups that traditionally have had limited involvement?

- Were the interests and concerns of affected communities carefully considered and protected throughout the project lifecycle?

By framing these outcomes and embedding these in the project itself, it can be ensured that a holistic approach is integrated to evaluate the effectiveness of People-First PPPs, emphasizing social impact, environmental sustainability, economic resilience, and inclusive governance.

The Indian Context: Implementing Best Practices for People-First PPPs in Waste-to-Energy Projects for Sustainable Development

Under the *Solid Waste Management Rules, 2016*, the Government of India mandates that municipal bodies ensure the proper segregation and routing of recyclable materials to designated vendors. Only non-recyclable, high-calorific waste is directed to Waste-to-Energy (WtE) plants, refuse-derived fuel (RDF) production, co-processing in cement plants, or thermal power plants. As part of the *Swachh Bharat Mission (SBM)*, the government reimburses 100% of the cost for preparing the detailed project report (DPR) in line with unit costs and guidelines set by the National Advisory Review Committee (NARC). Additionally, state-level committees approve the DPRs, with institutes of national repute designated to assess these projects.

The central government offers financial support for WtE projects through grants or viability gap funding (VGF), with up to 35% funding available for each project. States are required to contribute at least 25% of the funds for waste management projects, with a reduced share of 10% for northeast and special category states. This strong financial backing fosters the growth of the WtE sector in India, creating significant opportunities for private players looking to enter the waste management market (Annepu, 2013).

Moreover, Niti Aayog actively promotes the development of WtE projects as part of India's waste reduction and minimization efforts. The government encourages the growth of a commercial waste-to-energy market, further incentivizing private sector involvement.

India's commitment to adopting best practices for People-First PPPs in WtE projects is evident through its policy initiatives, fostering a sustainable and inclusive approach to waste management.

Table 4: Best Practices in the Indian Context

Best Practices	Indian Scenario
Option 1: Integrate circular economy visions into government policies, prioritizing waste as a resource.	The Indian Government's Waste-to-Energy (WtE) program supports the establishment of WtE projects to generate Biogas, BioCNG, Power, or syngas from urban, industrial, and agricultural waste. The program provides Central Financial Assistance (CFA) to project developers, incentivizing the commissioning of plants for energy generation.
Option 2: Internalize externalities, gain social acceptance, and mobilize investments. Modify the waste hierarchy to reflect circular economy challenges.	Efforts are being made to account for environmental and health costs in specific projects, which increases societal acceptance despite higher project costs. Projects in Andhra Pradesh, for instance, factor in these elements during the competitive bidding process, ensuring increased social support and project

Best Practices	Indian Scenario
	viability.
Option 3: Choose suitable, innovative, and less polluting technologies. Promote local skills development for technology utilization.	WtE technologies are selected based on waste availability and local conditions to maximize local employment opportunities in plant operation and maintenance. This approach fosters skill development and supports the local economy.
Option 4: Provide economic incentives and price supports. Implement fiscal incentives to promote circular economy processes in People-first WtE PPPs.	Economic incentives include central financial assistance, tax benefits, and the classification of WtE under the Renewable Energy category, ensuring preferential tariffs for WtE projects. These measures incentivize the adoption of circular economy practices in the sector.
Option 5: Identify suitable partners and monitor their performance. Collaborate with enterprises aligned with WtE technologies and circular economy values.	Project developers with relevant experience in waste management are selected to build, operate, and maintain WtE plants. Companies like A2Z Infrastructure, Essel Infra, Ramky Group, Jindal, and SPML Infra are among the key players with proven expertise in the WtE sector.
Option 6: Establish transparent, open procurement processes with a zero-tolerance approach to corruption. Ensure People-first WtE PPPs align with circular economy values.	The procurement process has shifted to competitive bidding to ensure transparency and a clean, corruption-free approach in the establishment of WtE projects, maintaining adherence to circular economy principles.
Option 7: Enhance local participation, including women's empowerment and vulnerable groups. Establish a "social contract" with stakeholders and ensure robust community engagement.	Local participation is encouraged by employing waste pickers and local residents in various roles at WtE facilities. Women, in particular, are engaged in waste segregation and sorting activities, providing them with stable livelihoods and promoting gender inclusivity.

Source: Made by Author

Conclusion

The ambition of a circular economy—one where materials perpetually circulate with no waste—is a lofty but essential goal. Though challenges such as technological limitations and deeply ingrained human behaviour patterns remain, the responsibility to manage waste sustainably is undeniable. Waste-to-Energy (WtE) presents itself as a critical component of this journey, serving not just as a bridge but as a catalyst in the transition toward a more sustainable, circular future.

Today, WtE stands as a transitional technology with immense potential. Positioned within the waste hierarchy, it holds the promise of evolving into a key pillar in the circular economy, provided it can shed its traditional image and embrace its new role. This transformation requires the right conditions: a regulatory environment that fosters both the principles of the

circular economy and the operational success of WtE. Governments, stakeholders, and industry players must adopt the seven best practices outlined in this framework to propel WtE towards a future of sustainability and circularity. Effective project planning, smooth execution, and minimizing local resistance are crucial to the success of this transition.

To further solidify the role of WtE in the circular economy, the following recommendations are presented. First, the promotion of discussions on WtE guidelines and best practices should be prioritized among governments, businesses, and civil society. Insights from both established and emerging markets should be shared to foster collaborative efforts and best practice adoption. Local governments, such as municipalities and panchayats, should be provided with resources to help them evaluate and monitor WtE projects, driving a stronger framework for implementation.

The UNECE model for People-first PPPs, which evaluates whether projects align with People-first principles, offers a valuable template. In India, this model can be adapted to assess WtE projects, allowing both current and upcoming initiatives to align with circular economy goals. By creating a WtE-specific index, India can not only measure project adherence but also help mitigate resistance through a more transparent, accountable process.

Guidance on maximizing WtE's contribution to the circular economy should be clear and actionable. Local urban bodies, in collaboration with project promoters, should offer practical strategies to advance sustainable practices. India's government has already laid the groundwork with fiscal incentives, such as financial assistance, tax exemptions, and renewable energy benefits for WtE. By aligning these incentives with the People-first PPP framework, India can encourage a structured, measurable approach to circularity in the sector. An incentive-and-penalty system, including landfill taxes and feed-in tariffs, should also be explored to push WtE projects toward meeting circular economy goals. With these measures in place, WtE projects can not only improve environmental outcomes but also create a robust model for future sustainable waste management.

As we continue to navigate the intricate challenges of waste and energy management, the holistic adoption of these best practices will drive the WtE sector from aspiration to reality. Through innovation, collaboration, and an unwavering commitment to People-first principles, WtE can play an instrumental role in the circular economy's evolution, transforming waste into a resource for a sustainable future.

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