THE ROLE OF ENERGY FROM WASTE IN A CIRCULAR ECONOMY:

CREATING A STABLE PROJECT STRUCTURE

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Australian Industrial Ecology Network

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Disclaimer

Contents

What is the AIEN?

The Australian Industrial Ecology Network (AIEN) is a vibrant network of like-minded individuals, companies and institutions with a common interest in sustainable development through the study and practice of industrial ecology. We advocate the principles and concepts of industrial ecology in policy formation and business practice. The AIEN actively engages with organisations to facilitate improved performance and environmental benefits.

The AIEN is also a forum in which people can discuss ideas, seek advice from one another, connect with resources associated with the practice and study of industrial ecology or simply keep in touch through the network with developments and best practice in their areas of interest.

The AIEN was established as a proprietary limited company in October 2014 to promote and facilitate industrial sustainability through the application of industrial ecology. The company aims to provide a 'window on the world' of industrial ecology by relaying news, canvasing new ideas, producing position papers on topics such as energy from waste, organising events and alerting people to developments in academia and in practice. In effect, AIEN aspires to become the 'go-to' organisation for all things to do with industrial ecology, including collaboration on the design, planning and implementation of IE projects.

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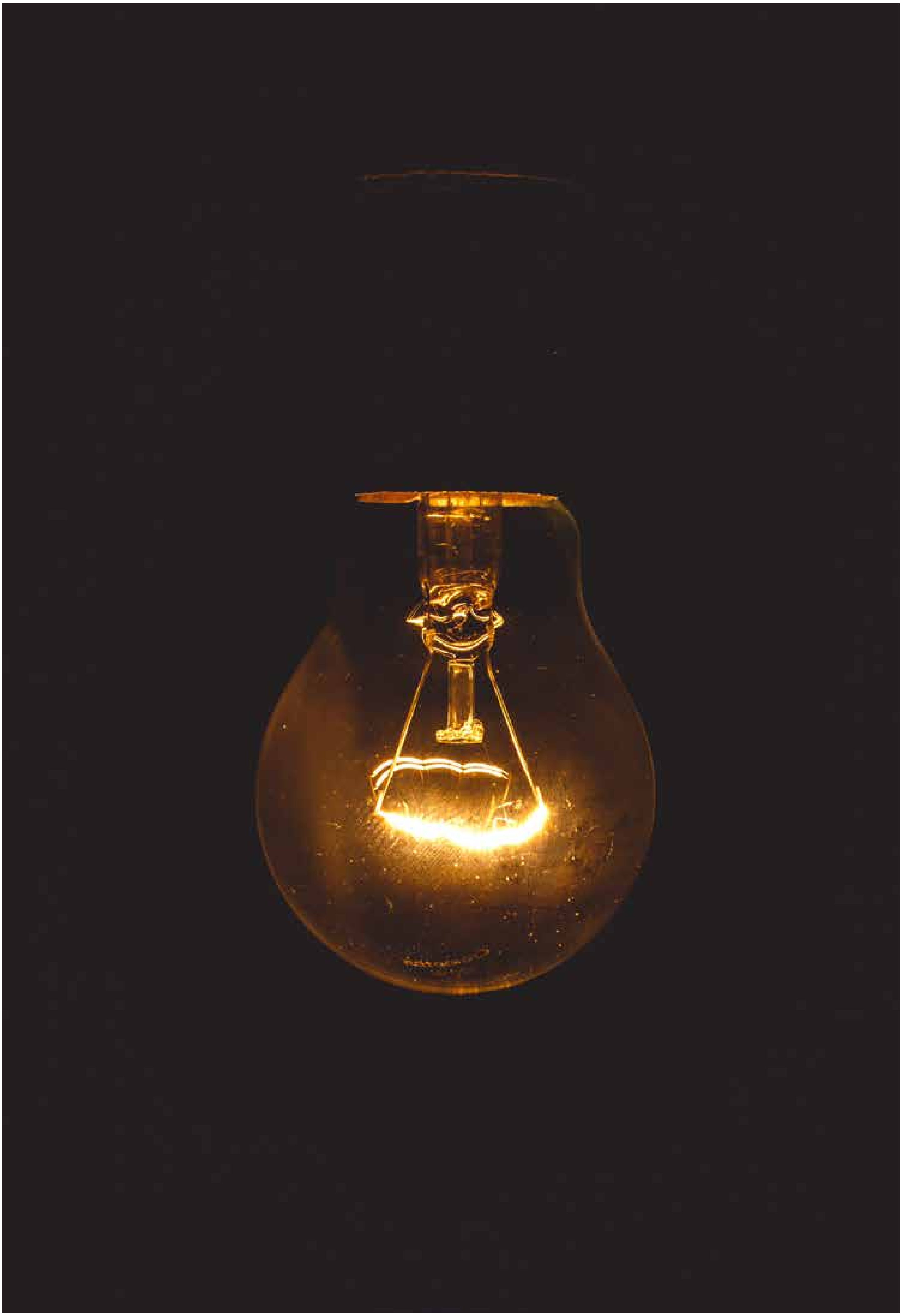


Introduction

Waste to Energy or Energy from Waste (EfW) is the process of recovering the latent energy in waste materials and turning it into a useable form of energy.

Although the main focus has been on producing energy in the form of electricity and waste heat, there are several other forms of EfW technologies, such as liquid and gaseous fuels (e.g. jet fuel and diesel and methane).

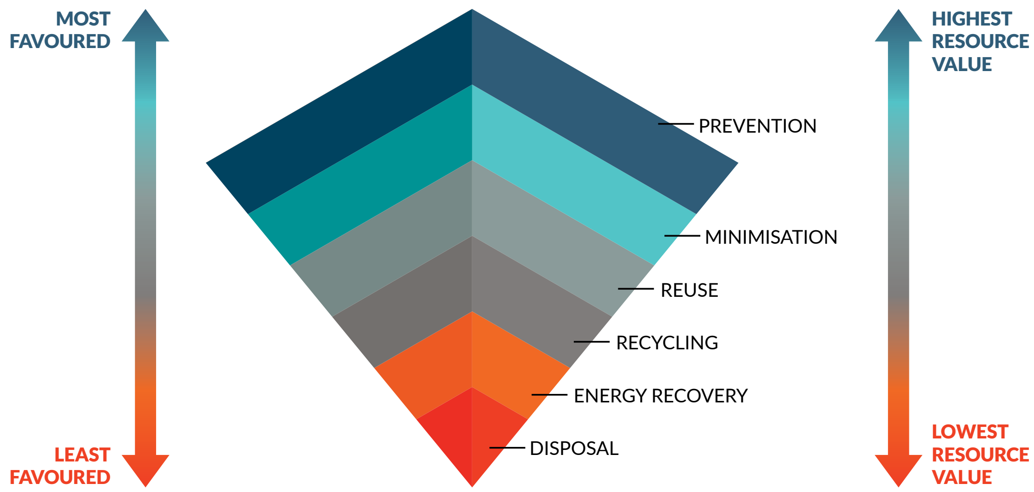
Preamble – Energy from Waste in a Circular Economy

Within the concept of a circular economy, the AIEN recognises the need for recovery of materials prior to assessing opportunities for Energy from Waste (EfW) technologies and that there are already well-established and emerging processes and supply chains available for the recycling/reuse of mixed plastics, rubber, glass, timber, aggregates, etc., as valuable resources in higher value-added product markets.

Further, the AIEN endorses the concept of Highest Net Resource Value (HNRV) as worthy of detailed consideration and promotion. It is a concept enshrined within the waste hierarchy but with a more tangible and measurable output.

HNRV reflects an approach that seeks to achieve or retain the highest possible resource value from the materials under consideration, 'net' of the cost and effort to achieve such an outcome.

The waste hierarchy is normally presented only in the context of environmental/social good. The AIEN has re-imagined the waste hierarchy as representing the notional value applied to a given 'resource'. At the low-end, disposal to landfill implies the generator places a negative value on the resource. At the high end, the generator places full commercial value upon the resource through avoidance/prevention and/or minimisation, with which comes an absence from the waste stream. Said another way, it is not present and therefore does not require management.



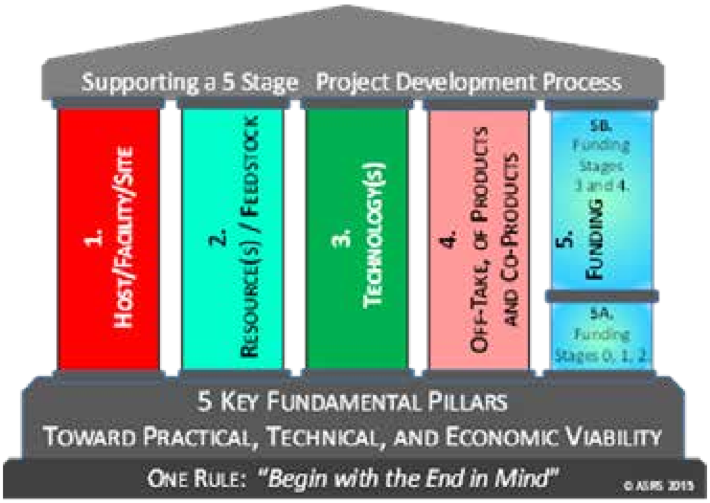
Any failure to properly consider the importance of the waste hierarchy and HNRV principles may result in losses in the longer term through stranded investment. When resource/material availability becomes a constraint, resources will always flow to those who can afford to pay the most for them. Additionally, the Australian political climate has an appetite for market intervention such as plastic bags bans, container deposit schemes and packaging reduction targets and in some states, disposal levies may be applicable in an energy from waste environment. Over-investment in energy technologies, with its 20-year plus time span, is fraught with danger and may not be recommended.

In certain circumstances, including remote geographic locations, small and highly diffuse resource quantities suggest there may be valid arguments that energy recovery represents the HNRV achievable for resources otherwise considered as wastes. However, it would be lazy in the extreme to settle for lower resource values simply for ease and expedience. Energy from waste should only be considered where:

- HNRV alternatives have been fully saturated with the resources they require. This means energy recovery activities are restricted to 'residual' resources not required by the higher value adding processes; or
- Very unusual circumstances are such that energy recovery is the only feasible process for the recovery of economic value from resources that would otherwise be wasted in landfill.
- Proponents have well defined projects and ensured that all aspects of the project are supported. We refer to this as the 5 pillars required for a successful project.

The Five Pillars

- Host/Facility/Site (H/F/S)
- Resources/Feedstock
- Technology(s)
- Off-Take Agreements
- Funding



These 5 pillars, which are not in any particular order, are integral to any project development process, whether an EfW, a distributed generation (DG), a microgrid application of DG projects, or a fully integrated resource recovery and EfW project.

The AIEN believe the failure to ensure that appropriately developed and defined strategies are established for each of these 5 pillars – during and for each sequential stage of the multi-stage project development process – could be catastrophic for any project (as well as for, in some cases, the credibility and reputation of the developer, the technology provider, and the H/F/S owner), as you run the risk of effects from the commonplace phenomenon often described by the proverbial "Fire-Ready-Aim."

Although these pillars are stand alone, they are inextricably linked. While a project may have one, two or three pillars well determined as viable and optimal for a project – thereby tempting the inexperienced, ignorant or conflicted developer, or the eager ill-advised customer/client, to proceed to the next stage of development – without all five pillars prudently vetted, it's likely the project will fail from a practical, technical or economic viability perspective.

Blueprint for action

Number One Rule – BEGIN WITH THE WELL-DEFINED 'END IN MIND'.

Over the past few years, each State Government in Australia has prepared, or is in the process of preparing, a response to Energy from Waste by developing and issuing public consultation drafts for their respective Energy from Waste guidelines.

In their own way, each document has asked the same questions, pointing towards having a similar basis for accepting or approving the implementation of an EfW project within their respective jurisdiction.

The common themes across the documents are:

- EfW plants are at the bottom end of the waste hierarchy
- Feedstock for EfW plants must have undertaken pre-treatment prior to disposal at the site
- Technology must be proven
- Air emissions must meet standards usually at a minimum set by the EU Large Combustion Plant Directive[1] (LCPD, 2001/80/EC)[2]
- Sites must have a minimum buffer to nearest sensitive receptor and must have social licence to operate
- In most jurisdictions, site planning approvals are deemed to be state significant, with the process undertaken at a state rather than local level

The AIEN believes that the implementation of EfW in the context of Australia should be streamlined, so that each state acts in accordance with a nationally developed policy framework. We find it difficult to believe that in the 21st Century, our regulators cannot approach this potentially 'brand new' to Australia industry, with a view towards a standard Australia-wide approach.

Many projects suffer from attempting and taking shortcuts, primarily in regard to marginalising the value and reducing the thoroughness of the project definition and pre-feasibility studies.

Care should be taken, as in an effort to save resources at the front end of the project development process and/or to hurry toward and into the design/procurement/build stages of the process, an ill-advised Host/Facility/Site owner or an inexperienced or conflicted energy project consultant/developer may be tempted or be convinced to reduce the steps, activities and costs of these definition stages. Steps and costs that can be perceived or portrayed as irrelevant, unnecessary or unjustifiable can cause catastrophic outcomes for the project.

Unless ground work has been thoroughly undertaken and the 'end in mind' is thoroughly defined and vetted, the risk of excessive cost over-runs, loss of profitability and even potential project failure is increased.

[1] The Large Combustion Plant Directive was superseded by the Industrial Emissions Directive on 1 January 2016.

[2] The Large Combustion Plant directive specified emission limits for sulphur dioxide, nitrogen oxides, and dust.[2] The directive was issued in October 2001. It replaced the earlier EEC directive on large combustion plants, 88/609/EEC, issued in November 1988.

With the above in mind, the AIEN's recommendations and thoughts are outlined on the following pages. These recommendations have been defined and refined from the many presentations at Australia's premier Energy from Waste Forum held in Ballarat, Victoria each year.

<table>
<tr><th colspan="7">Project Development Feasibility Matrix</th></tr>
<tr><td colspan="2">Prospective Project:</td><td colspan="5"></td></tr>
<tr><td colspan="2" rowspan="2">5 Key Fundamental Pillars for Project Go/No Go & Pre-Feasibility</td><td colspan="3">(Qualification Spuriousness, Prioritisation) Viability Factors</td><td colspan="2">'Project' Stage 1 Pre-Feasibility Assessment</td></tr>
<tr><td>Practical Viability</td><td>Technical Viability</td><td>Economic Viability</td><td>Go</td><td>No Go</td></tr>
<tr><td>1</td><td>Host/Facility/ Site (H/F/S)</td><td>• Producer of feedstock/ resources
• Off-taker of one or all products & co-products (Pillar 4)
• (Retail Energy Sale) of Electric Heat or CHP
• Utility-side-of-metre - Wholesale energy sales (or FIT)</td><td>• Project/System Footprint
• Room for Ingress and Egress (for system and delivery of resources/feedstock)</td><td>• Costs associated with location and distance between Generation Plant and Feedstock Source(s)</td><td colspan="2"></td></tr>
<tr><td>2</td><td>Feedstock/ Resources</td><td>Availability - ready and reliably available nearby of quality and quantity/frequency rates needed to satisfy System's appetite</td><td>Available and Capturable Energy Input - toward serving input/usage requirements of
• The H/S/F(s) and/or
• The Technology serving the H/F/S(s)</td><td>Cost (if any) of Feedstock and cost per EC</td><td colspan="2"></td></tr>
<tr><td>3</td><td>Technology</td><td>Evidence (vs. Artistic Renditions), that Technology(s) has impeccable rather than questionable plausibility, via:
> Photographs and videos
> Sample outputs
> Thorough spec sheets
> Installed projects & references
Input requirements (e.g. feedstock/ resources) fit outputs fit (<=) Requirements of H/F/S, and /or off-takers.
Manufacturer can/does support integration, interconnection, construction, commissions and O&M</td><td>Fundamental Mass Balance Vetting
Fundamental Energy Balance Vetting/Assessment, including existence of detailed reports defining and valuating:
• Energy (e.g., Btu/Hr) Input requirements (Feedstock as well as parasitic inputs)
• Energy (e.g., Btu/Hr) Outputs
• Conversion Efficiencies
Interconnection Requirements
> Plant to H/F/S
> Plant to Utility Grid
Technical Support from manufacturer</td><td>Installed Project Cost
If Technology is capable of performing as it's purported; determine if data/facts exist to reveal/prove that the technology can produce (products and co-products) both economically for its market(s), as well as profitably for the producer?</td><td colspan="2"></td></tr>
<tr><td>4</td><td>Off-take of Products and Co-Products</td><td colspan="2">Products and Co-Products (e.g. kWh, MMBtu, RECs, BioChar, BioChar/Ash, Carbon Black etc. practical (and/or nearby) existence of demand and usage profile(s) that are greater than or equal to the capacity and production capability of the technology(s) products and co-products
> H/F/S(s) as well as other consumers (e.g. remote net-metering) may be off-taker
> MoU, LoI or Secured Off-Take Agreements</td><td>Term and Revenue of/from Off-Take agreements sufficient to exceed both COGS & Operating Expenses</td><td colspan="2"></td></tr>
<tr><td rowspan="3">5</td><td rowspan="3">Funding</td><td colspan="3">Development Capital - determine and/or validate, during Stage 0 (the Qualification/Spuriousness,Prioritisation Stage). Funding availability - secured or securable for activities (Stage-Gate). Efforts and risks associated with- and categorised into two to three parts (i. Project Development Consulting, ii. Project Development Success Fee, and iii. Project Equity Capital)</td><td colspan="2"></td></tr>
<tr><td colspan="3">5a Project Definition Development / Consulting Costs - Consulting Fee, Success Fee or Combination
Cost of Stage 0 (Qualification/Spuriousness/Prioritisation) Activities
Cost of Stage 1 (Level One Pre-Feasibility Assessment) Activities
Cost of Stage 2 (Level Two Feasibility Analysis) Activities</td><td>5a</td><td></td></tr>
<tr><td colspan="3">5b Project Development Equity Capital to Design, Construct and Commission the Project
Cost of Stage 3 (Detailed Design & Engineering) Activities
Cost of Stage 4 (Project Implementation/Construction & Commissioning) Activities</td><td>5b</td><td></td></tr>
<tr><td colspan="2">About the Inquirer - investigating, considering, desiring a 'project'</td><td colspan="5">Consideration of the 'Inquirer' can also drive the viability factors to examine, due diligence and caution w/r/t spuriousness, prioritisation, and qualification. Inquiry sources include:
> H/F/S Owner (i.e. owner or controller of property where the DG/Microgrid Project is to be sited)
> Technology Manufacturer/Integrator (or Agent for) - peddling its Technology (rather than an ESA)
> DGCO / ESCO (as a technology-neutral representative of Client with H/F/S)
> DGCO / ESCO (without yet a H/F/S Client)
> Utility
> Funding Source (w/ or w/o determined H/F/S, w/ or w/o Technology/application)
> Feedstock Supplier</td></tr>
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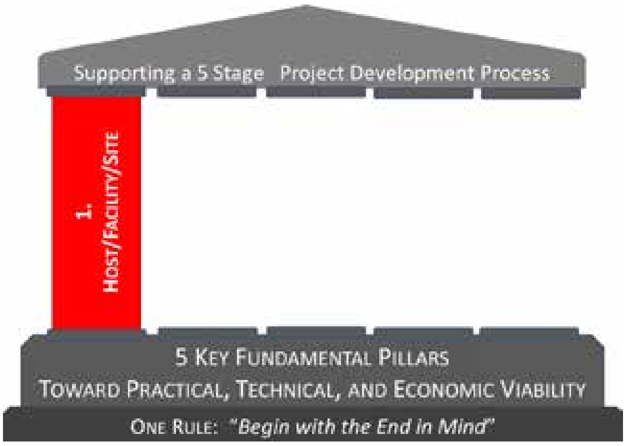
KEY AREA 1:

The Host, Facility, Site (H/F/S)

Where will the Facility be located? We refer to this as the host facility site.



The AIEN recommends, at a minimum, proponent(s) should define the following factors to evaluate and steps to take during the definition stages to assess the Host/Facility/Site:

- Preliminary Analysis, Conceptual Design(s), traffic flows, sensitive receptors (buffer zones) and whether the site is adequate for all proposed site activities.
- Is the community receptive? Will you be able to gain a social licence to operate?
- Data gathering, including and not limited to: anecdotal data on actual or estimated (in cases of green-field development) energy demand and use profiles access to grid (in the case of electricity) and required permitting.
- Available resources, including waste stream definition and supply quantification. Will the community and local government enter into the required long-term supply agreements?
- In addition to other available renewable energy generation and delivery resources, in consideration/comparison of H/F/S energy demand and use profiles (actual and/or forecasts).
- Investigating/Researching technical, permitting (i.e., and/or regulatory questions).

Generally, proponents should define and consider the following site characteristics to evaluate a proposed site's suitability:

1. Should have sufficient space for the Project's System's Footprint, and for ingress and egress for delivery of Feedstock/Resources and outputs (products and co-products), taking into account the diverse swept path requirements of various vehicle types.
2. Key will be matching the H/F/S location to nearby access to sufficient feedstock. Preferably and optimally Project Partner provided feedstock that is also provided reliably on a long-term basis, as a result of a long-term ROW Clearing Project.
3. The H/F/S may be source or producer of feedstock/resources or a green fields site may be chosen as suitable. Assess the H/F/S owner(s) willingness and ability to enter long term ESA or PPA, sufficient to optimally allow the systems to be owned and self-financed by the enterprise.
4. The geographic location of the proposed site is important with respect to the location/distance from sources of feedstock/resources, as well as access to power offtake/grid connection waste and heat offtake, (if required), as this can affect the economic viability of the project.
5. The H/F/S may be the off-taker of one or all products and co-products. In the case of energy products:

    2.a. the interconnection points for (retail sale) off-take of electric energy (with Net Metering, Remote Net Metering, or Community DG Net Metering), heat energy or both (i.e. CHP); and,

    2.b. the interconnection point for (wholesale energy delivery/sales, or FIT) utility-side-of-customer(s)' meter(s).

6. Energy (electric and thermal) Load Profiling and Energy Use Cost Modeling. Profiling factors include:

    - Power (kW) Demand: Peak Demand, Average Demand and Base Demand;
    - Electric Energy Demand and Usage, Heat Energy Demand and Usage and Coincidence of occurrence of these.

    Profiling parameters include: Energy (electric and thermal) Demand and Use Profiles and Costs – per year, per month and typical weekday and weekend day.

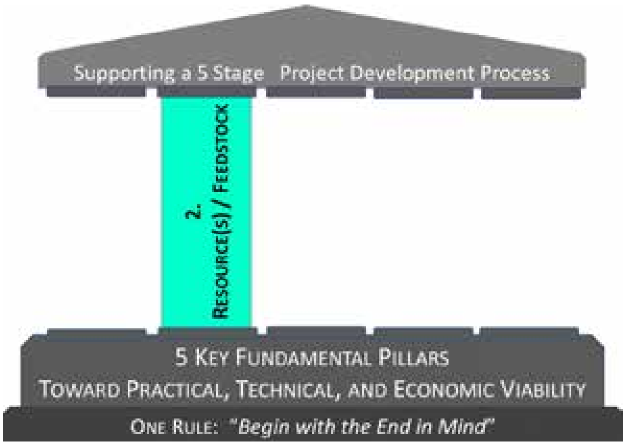
    Cost modeling should consider/include usage and applicable tariffs for the before (existing conditions) and the after OSG, and should utilise review of actual utility bills.

7. Comparison/Matching of H/F/S Load Profile vs. Output of Generation Technology(s)/application, and vs availability/locality of resources/feedstock for the generation technology/application. Helping to consider whether:

    - the feedstock/resources should drive determination of H/F/S, or
    - the H/F/S should drive determination of feedstock/resources location(s), or both. Hence an inextricable link between Pillar 1 and Pillar 2.

KEY AREA 2:

Resources/Feedstock



The AIEN recommends that, at a minimum, the proponent should define the following factors to evaluate and steps to take during the definition stages to assess the potential feedstock availability and suitability:

- Preliminary Analysis of the available materials
    - Calorific Value
    - Moisture content
    - Ash Content
- Will the community, Local Government and commercial industry enter into suitable long-term supply agreements to support the project investment?
- Will the targeted waste stream(s) meet the criteria for EfW feedstock within the H/F/S regulatory bodies' current framework?
- Available resources, including waste stream definition and supply quantification. Will the community and local government enter into the required long-term supply agreements?

The beginning of this document covered how EfW fits into the circular economy and the economic factors that have made the move to an EfW facility viable.

Let's look now at the factors that should be considered prior to choosing the technology.

This process will evaluate/determine if there are adequate suitable feedstocks available to fulfill optimal input requirements of the selected or proposed technology, and/or the input requirements of the H/F/S. Factors to consider include:

1. **Quantity.** Determination of feedstock (or fuel – in the case of biomass incineration, rather than gasification or pyrolysis) quantities.
2. **Energy Content.** Determination of feedstock energy content, before pre-processing as well as when fed into the conversion technology.
3. **Frequency or Availability.** Conditions vs. Requirements. Determine frequency of availability – with specific attention to ensuring quantities at estimated or (preferably) known moisture content (w/r/t feedstocks) and at estimated or (preferably) known energy content, is sufficient to meet or exceed the input (rates and energy input) requirements of the energy conversion technology (Pillar 3).
4. Noting also, that the input (and output) requirements of the energy conversion technology is often driven by the energy (electric and heat and cooling) profile of the available feedstock.

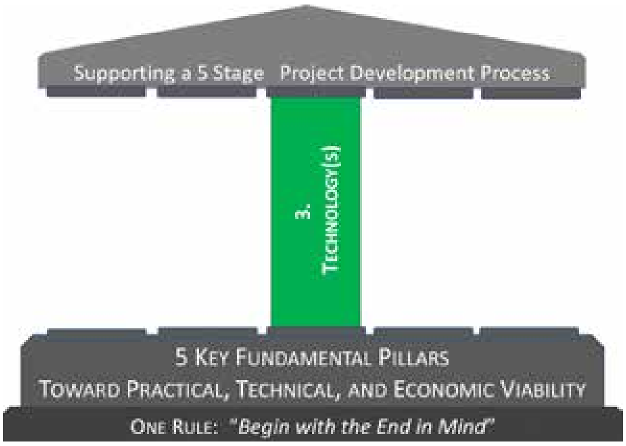
Waste Agreement

1. When considering a facility, you should start with the waste (feedstock) that you have available. We have defined the feedstock as Post-Recycled waste, with the concept of HNRV potentially coming into play. Initially, however, we start with the Post-Recycled waste that is available.

2. Prior to considering a technology, it is valuable to understand how much waste you have available. That is, how much waste you are willing to commit on an annual basis and what the make-up of the waste is. The make-up of the waste is more than its definition as Green, MSW, C&I, C&D or Medical/Hazardous but also what is the calorific value of the waste to be supplied, as well as it's moisture content.
3. When negotiating a Waste Agreement, you want to offer a tonnage that you will be comfortable supplying but that has a buffer to allow for further recycling to come into effect. It is also important to ensure that the agreement allows you to supply a greater amount of waste at the same gate fee that you have committed to, not penalising you for supplying more. Penalties to the waste supplier occur if the minimums are not met and to the technology owner if they cannot accept the waste.
4. The type of waste, as well as the amount of waste, will be used to determine what technology is most appropriate for the project.

KEY AREA 3:

Technology



The AIEN is technology agnostic in relation to the relevant technology options for EfW. At a minimum, the proponent should define the following factors for EfW evaluation:

- Social licence to operate Pillar 1
- Regulatory requirements Pillar 1
- Feedstock supply Pillar 2
- Offtake agreements Pillar 4
- Financial Viability Pillar 5

When determining generation system options – including system design and specifications, from Biomass-to-CHP, digester technologies – factors to consider include:

1. Feedstock Supply

- Is the source feedstock available in sufficient volumes for viable ongoing operations? Proponents should consider the life of the project and regulatory changes.
- Does the feedstock require pre-treatment processing prior to use in the facility?
- Characteristics of feedstock materials:
  - Moisture content
  - Calorific value
  - Ash content and potential contaminants

2. Social Licence to Operate

- Will the host community readily accept the technology and, as importantly, the requirement to import other communities' waste into the facility?

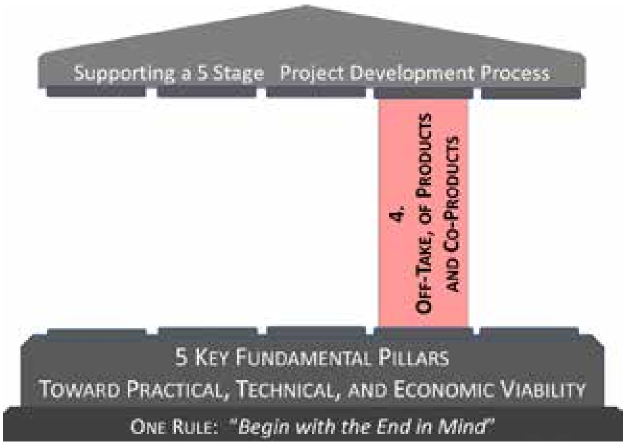
3. Regulatory Requirements

- Does the technology/process meet the regulatory guidelines for:
  - Emissions control
  - Residual materials from pre-processing/ recycling facility/3-bin kerbside collection residual bin
  - The chosen site (Buffer Zones etc.)
- Transport corridors:
  - Is the local transport infrastructure suitable for the additional traffic flows?

4. Financial Viability of Selected Technology

- Income:
  - What will be the average gate fee?
- Rise and fall provisions
- Will the material delivered for processing be subject to disposal levies:
  - What is the revenue from the energy/heat/ liquid fuel?
- Energy service agreements – term and ongoing options
- Will it be economical compared with traditional fuels?
- Will it be subject to relevant local fuel excises:
  - Will there be available revenue from solid residuals (digestate, ash, carbon)?
- Expenses:
  - Site operational costs, maintenance
  - Plant maintenance and R&D and O&M
  - Parasitic or grid delivered energy requirements
  - Employment, operational and administration costs
  - Emissions control data collection and analysis
  - Regulatory compliance
  - Residual materials management (ash, carbon, bag house dust, digestate (what is the disposal cost?)
  - Transport costs

KEY AREA 4:
Offtake Agreements



The AIEN recommends that, at a minimum, the proponent should define the following factors to evaluate and steps to take during the definition stages to assess the potential offtake of products and co-products:

- Preliminary market valuation of the available energy production
  - Electricity
  - Waste Heat
  - Liquid Fuel
  - Methane/Flammable Gasses
- Energy Service Agreement
  - Term of agreement(s)
  - Options for renewal or post establishment ESA
  - Ongoing grid access costs
- Preliminary market valuation of co-products
  - Ash content
  - Carbon Content
  - BioChar
  - Digestate

Key to determining the economic viability of a project is the determination of duration and value of off-take agreements for the products and co-products of the OSG system. In regard to the energy production from the conceptualised system, early in the OSG project development process it is important to determine the client's or H/F/S owner's project development preference.

The degree to which the client or H/F/S is inclined to maintain focus only on its core business, will likely dictate the preference toward one of the following two options:

- **Turnkey Project**. Owned by Client after Commissioning and:
  - Operated by Client
  - Operated by Developer or
  - Operated by Third Party
- **Energy Services Agreement - ESA**. Developer (or third party) as Owner/Operator after commissioning, whereby an energy supply agreement is executed between the Owner and Operator. A hassle-free energy generation and delivery alternative that, in addition to energy savings, assured energy supply, and plant availability, offers: core business focus, predictable (budgetable) results, no capital outlay requirements, no payments until start-up and a single contract (e.g., PPA).

Unique offtake agreements or understanding of co-products will be required dependent on the project defined technology option[1].

[1] A description of technologies is listed in the glossary of this communiqué

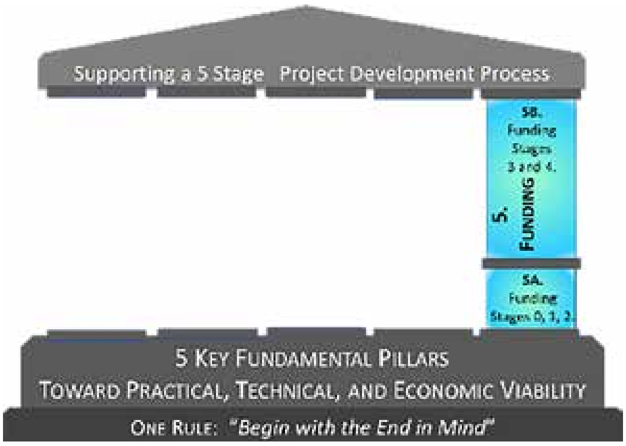
Thermal Treatments Technologies

- Combined Heat and Power (CHP):
  - Is there economical access to the grid if you will produce electricity?
  - Is there an offtake for waste heat?
- Liquid fuels:
  - Are you producing gas? Can it be readily converted to liquid fuel?
- What will be the condition and value of the solid residual waste?
  - Is it a saleable material that will meet regulatory guidelines –
    - Road base
    - Construction materials?
  - Will there be a disposal cost?
    - How will it be classified?
    - Will it be subject to landfill levy?

Anaerobic Digester Technology

- Combined Heat and Power (CHP):
  - Is there economical access to the grid if you will produce electricity?
  - Is there an offtake for waste heat?
- Liquid fuels:
  - As you are producing gas? Can it be readily converted to liquid fuel?
  - What is the infrastructure required for supply line to market?
  - Is there a ready local use for the fuel? Are vehicles bringing waste to site daily, on site mobile plant?
- What will be the condition and value of the residual digestate?

KEY AREA 5:
Funding



The AIEN recognises that the establishment cost of an EfW facility can be an enormous challenge to the project. Therefore, we recommend that the proponents ensure they have sufficient funds to make the project, what we refer to as, 'bankable'.

The 5a Funding will include the following costs:

- Pre-feasibility – full feasibility assessments. Pillars 1, 2, 4
- Technology and project design assessments Pillar 2, 3, 4

The 5b Funding should cover all costs associated with the project, from the full feasibility stage, and should include:

- Site purchase, establishment and development costs
- Full technical process design for construction:
    - o Site development, civils, weigh bridges internal road networks, firefighting requirements, and there similar
    - o Buildings, plant, equipment and emissions control
    - o Connections to power offtake/or end user
    - o Commissioning, start up and operational costs to self-sustainability

The Funding of the optimal project definition assessment and analyses work (the '5a Funding'), and the funding of the determined solution engineering/construction/commissioning (the '5b Funding').

The conceptual definition of the prospective project (conceptualised from Stage 0) tends to drive the determined costing. That is, scoping of the Project Definition stages (Stage 1 and Stage 2).

The costing (and Cost/Benefit Analysis) of the defined project's installed (and operating) cost. That is, the costs of engineering, design, construction/implementation and commissioning, are determined and reported at the conclusion of Stage 2.

The economic viability of the project, including the economic viability of each of the other four pillars, drives the funding assessment.

Glossary

Advanced Thermal Treatments (ATT) – are systems which incorporate emerging technologies that use heat to decompose waste in limited oxygen prior to energy extraction. These systems include pyrolysis and/or gasification processes.

Calorific Value (CV) – is a measure of the amount of energy contained within the waste that could be potentially released when it is completely combusted under specific conditions. It is a measure of heating power and is dependent upon the composition of the waste.

Commercial & Industrial Waste (C&I) – is a diverse waste stream, generated from commercial and industrial operations, including, but not limited to processing and manufacturing industries, service sector and the trade and transport and distribution sectors, primary production and mining.

Construction & Demolition Waste (C&D) – can refer to several different materials such as concrete, chemical containers, wood, excavated residuals and more.

Energy from waste (EfW) – is the process of creating energy, usually in the form of electricity or heat but also potentially biofuels, from the thermal treatment of a waste source via technologies such as incineration, Anaerobic Digestion, Gasification or Pyrolysis.

Highest Net Resource Value (HNRV) – reflects an approach that seeks to achieve or retain the highest possible resource value from the materials under consideration, 'net' of the cost and effort to achieve such an outcome.

Megawatt hour (MWh) – is a unit of energy equal to 1,000 kilowatt hours of electricity used continuously for one hour.

Materials Recovery Facility (MRF) – is a specialised plant that receives, separates and prepares recyclable materials for marketing to end-user manufacturers. Generally, there are two different types: clean and dirty MRFs.

Municipal Solid Waste (MSW) – is commonly known as refuse or rubbish and is a waste type consisting of everyday items that are discarded by the public. It covers household waste and household-like commercial and industrial waste (e.g. from offices or hotels).

Net Present Value (NPV) – a positive net present value indicates that the projected earnings generated by a project or investment (in present dollars) exceeds the anticipated costs (also in present dollars). Generally, an investment with a positive NPV will be a profitable one and one with a negative NPV will result in a net loss.

Power Purchase Agreement (PPA) – or electricity power agreement, is a contract between two parties: one which generates electricity (the seller) and one which is looking to purchase electricity (the buyer). The PPA defines all the commercial terms for the sale of electricity between the two parties, including when the project will begin commercial operation, schedule for delivery of electricity, penalties for under delivery, payment terms, and termination. A PPA is the principal agreement that defines the revenue and credit quality of a generating project and is thus a key instrument of project finance. There are many forms of PPA in use today and they vary according to the needs of buyer, seller and financing counter parties.

Process Engineered Fuel (PEF) – is a practical and sustainable alternative to the use of fossil fuels in cement kilns. The process harnesses the energy contained in combustible material such as recyclable plastics, cardboard, paper and waste timber that would usually go to landfill.

Refuse Derived Fuel (RDF) – is a fuel produced by shredding and dehydrating municipal solid waste (MSW) via a process such as MBT (see above). RDF consists largely of combustible components of municipal waste such as plastics and biodegradable waste.

Special Purpose Vehicle (SPV) – (SPE or in Europe and India, special-purpose vehicle/SPV, or, in some cases in each EU jurisdiction – FVC, financial vehicle corporation) is a legal entity (usually a limited company of some type or, sometimes, a limited partnership) created to fulfill narrow, specific or temporary objectives. SPEs are typically used by companies to isolate the firm from financial risk. A formal definition is: "The Special Purpose Entity is a fenced organisation having limited predefined purposes and a legal personality".

Waste to Energy (WtE) – is the process of creating energy – usually in the form of electricity or heat but also potentially biofuels – from the thermal treatment of a waste source via technologies such as incineration, Anaerobic Digestion, Gasification or Pyrolysis.

Technology Options

NON-THERMAL TECHNOLOGIES

Mechanical Biological Treatment (MBT) – As the name suggests an MBT consists of a Mechanical part and a Biological part. Depending on the order of the treatment, the unit can also be described as a Biological Mechanical Treatment unit (BMT). There are three main outputs from an MBT. These include recyclables such as plastics, low quality soil and RDF.

Anaerobic Digestion (AD) – Anaerobic Digestion is the biological conversion of biodegradable organic materials in the absence of oxygen at temperatures between 55 and 75 degrees Celsius. The feedstock must remain very homogeneous, as any contamination will impact the bacteria required for the process. The technology is only recommended for domestic sewage and organic waste treatment and not recommended for MSW. In many regions, Anaerobic Digestion is used primarily to reduce the quantity of sludge for disposal and/or possible reuse.

Outputs include Methane gas that is considered renewable and can be used to generate energy or in cases where the size of the facility is not conducive to energy generation, can be flared. There is also a stabilised organic matter, which after proper dewatering, can be used as a soil amendment.

THERMAL TECHNOLOGIES

As thermal technologies are not as susceptible to the impact of contamination as the non-thermal technologies, it is the thermal technologies that are most often used for EfW facilities employing MSW, C&I, C&D and Medical/Hazardous Wastes.

The four main types of Thermal EfW technologies that are defined by the amount of oxygen used during the waste conversion process:

Incineration – Incineration requires oxygen to fully combust the organic portion of the fuel. The waste is converted to ash, flue gas and heat. The ash is formed by the incineration of the non-organic portions of the waste. Particulates are carried by the flue gas and captured by the Air Pollution Control equipment as Fly Ash. The total amount of ash for MSW is typically 30% by weight when compared to the feed stock. We see about 300kg of ash for 1000kg of waste.

Gasification – Gasification converts carbon-based materials into syngas using minimum amounts of oxygen. Some heat is required to initialise and sustain the process, with oxygen being added for oxidisation but not enough for full combustion to occur.

Plasma Gasification – A form of gasification that differs from other forms of gasification by using plasma arc torches as the heat source. The plasma arc torch passes electricity through graphite and carbon electrodes with steam and/or oxygen/air to produce electrically conducting gas (Plasma).

Pyrolysis – Pyrolysis is the thermal degradation of organic materials using an external indirect source of heat. Usually at atmosphere but in the absence of oxygen. Temperatures are maintained for several seconds between 300-850 degrees Celsius.

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