INVESTMENT MEMORANDUM

➢ PROJECT

Production of biochar, steam, heat and / or electricity on a large scale from the organic feedstock (agricultural waste such as chicken or cow manure, forestry residues, crops stems, leftovers from juice production etc.).

➢ INVESTMENT VOLUME

1 – 10 mln Euro per 1 small & middle size factory (1-5 machines) up to 50+ mln Euro depending on the scale and technical requirements for the output, what does the Employer want as the output, e.g. biochar with carbon credits and electricity.

The machines can be added to each other in parallel, thus capacity is limited by the size of a factory and available feedstock.

A typical industrial machine (“T:CRACKER”) looks as follows:

➢ RETURN. COMMERCIAL ASPECT.

Break-Even point is usually within 5 years.

Profit Margin range is 10-30%.

IRR range is 15-30% with the highest return achieved while combining production with participation in a carbon credits program.

The profitability of industrial machines designed for biochar, heating, and electricity production can vary significantly based on several key factors, including technology type, scale, feedstock, energy prices, and regulatory incentives. That said, let's break down average profitability indicators for each component and overall profitability factors in the biochar industry.

1. Biochar Production Profitability

- **Revenue Potential**: Biochar is valued for its soil-enhancing properties, carbon sequestration, and pollution control. Typical market prices for biochar range from $500 to $2,000 per ton depending on quality and use case (agricultural, environmental remediation, etc.).
- **Production Cost**: On average, producing biochar might cost around $200–$500 per ton, but costs vary based on feedstock, production scale, and technology.
- **Profit Margins**: Biochar production can yield profit margins between 20% and 50% when sold at competitive prices. Profitability is often higher when there are incentives or carbon credits, as biochar sequesters carbon.

2. Heating Production Profitability

- **Revenue Potential**: Biomass heating systems sell heat to local consumers, commercial operations, or even municipal facilities. Heating value is measured in terms of megawatt hours (MWh), with prices between $10–$50 per MWh based on the region.
- **Production Cost**: For biomass-based heating, costs include feedstock, labor, and operational expenses. Production costs generally range from $5–$25 per MWh, depending on technology and scale.
- **Profit Margins**: Biomass heating can offer a margin of 10–30%, depending on feedstock cost stability, labor expenses, and heating demand. Additionally, regions with renewable energy subsidies or carbon credits can see higher profitability.

3. Electricity Production Profitability

- **Revenue Potential**: Biomass-to-energy plants typically sell electricity back to the grid, often benefiting from feed-in tariffs or renewable energy credits in some regions. Rates vary widely but typically range from $0.05 to $0.15 per kilowatt-hour (kWh).
- **Production Cost**: Biomass-based electricity generation costs vary significantly, generally falling between $0.04 and $0.12 per kWh when accounting for feedstock, maintenance, and operational costs.
- **Profit Margins**: Electricity generation from biochar plants may have lower margins, often around 5–15%, due to high initial costs. Profitability can improve substantially with government incentives or when combined with heat production in a combined heat and power (CHP) system.

4. Overall Profitability Factors

- **Combined Heat and Power (CHP)**: CHP systems can significantly enhance profitability by utilizing the heat generated during electricity production, thus generating additional revenue.
- **Feedstock Costs and Quality**: Consistent, low-cost, and high-quality feedstock enhances profitability, as it reduces input costs for biochar and energy production.
- **Government Incentives**: Many regions offer subsidies, carbon credits, or feed-in tariffs that enhance profitability.

- **Carbon Credits**: Carbon credits, offered due to the carbon sequestration properties of biochar, can add significant revenue. Carbon offset prices can add around $110 per ton of biochar.

Typical ROI Ranges

- **Small-Scale Plants**: Small plants might see ROI within 5–10 years, depending on scale and regional incentives.
- **Medium to Large Plants**: Larger, more integrated facilities may achieve ROI in 3–7 years due to higher economies of scale and revenue streams from multiple outputs (biochar, heat, electricity).

The **Internal Rate of Return (IRR)** for large-scale biochar production projects combined with heat and electricity generation can vary significantly depending on various factors, such as the scale of operations, feedstock availability, project location, carbon credit prices, and overall investment costs. However, in general, such projects can achieve IRRs ranging from **15% to over 30%**, especially when revenue from carbon credits is included.

Key Factors Influencing the IRR:

1. **Revenue Streams**:
    - **Biochar Sales**: Biochar can be sold for soil amendment, water filtration, or as an additive in building materials, often fetching prices of $200 to $500 per ton depending on quality and market demand.
    - **Electricity Generation**: Selling surplus electricity to the grid or to nearby industries can provide a stable income stream, especially in regions where electricity is expensive or scarce.
    - **Carbon Credits**: Generating **carbon credits** through platforms like Puro.Earth or Verra can add substantial revenue, especially with current biochar credits trading around $100 to $160 per ton of CO_2 removed
2. **Operating Costs**:
    - The availability and cost of **feedstock** (agricultural waste, forestry residues, etc.) are critical. Africa's abundant biomass resources can help reduce feedstock costs, improving profitability.
    - Maintenance and labor costs can vary, but projects in regions with lower labor costs can benefit from reduced operating expenses.
3. **Capital Expenditure (CapEx)**:
    - Large-scale biochar and biomass power plants typically require significant upfront investments, ranging from **$10 million to $50 million**, depending on scale and technology.
    - Access to **financing options** (like green bonds, impact investments, or concessional loans) can significantly affect the project's IRR.

Estimated IRR for Large-Scale Projects:

- For **fully integrated projects** (biochar + heat + electricity), the IRR can range from **20% to 35%**, especially when leveraging multiple revenue streams, including carbon credits.
- Projects that focus solely on **biochar production** may have lower IRRs, around **15% to 20%**, unless they secure premium prices for biochar or have access to high-value carbon credit markets.
- With optimized operations, favorable biomass feedstock costs, and robust carbon credit monetization, some projects can achieve IRRs above **30%**.

Challenges and how to overcome them:

- **Volatility of Carbon Credit Markets**: While carbon credits can substantially boost IRR, prices can fluctuate based on regulatory changes and market dynamics.
    - EU legislation is imposing a more stringent requirements and taxes for CO2 pollution, this most likely will boost the carbon offsets prices up in the next decade.
- **Logistics and Infrastructure**: In regions like Africa, infrastructure challenges can impact feedstock supply chains and electricity distribution, potentially lowering profitability.
    - Consider production clusters in the East Africa region and start from the most polluted areas with the highest amount of organic waste.
- **Technology Risk**: Scaling up pyrolysis technology for continuous, high-capacity operations requires careful planning to avoid downtime and inefficiencies.
    - Our experts have the production line and have 10+ years of experience in the field.

➢ MINIMUM REQUIREMENTS FOR A FEEDSTOCK

2 000 ton per location per annum as the very minimum size.

Ideally factories with the huge quantities of waste. For instance, a middle-size fruit juice producer (100 ton processing per day) can generate up to 30 000 ton waste per annum.

➢ PRE-ENGINIEERING STAGE

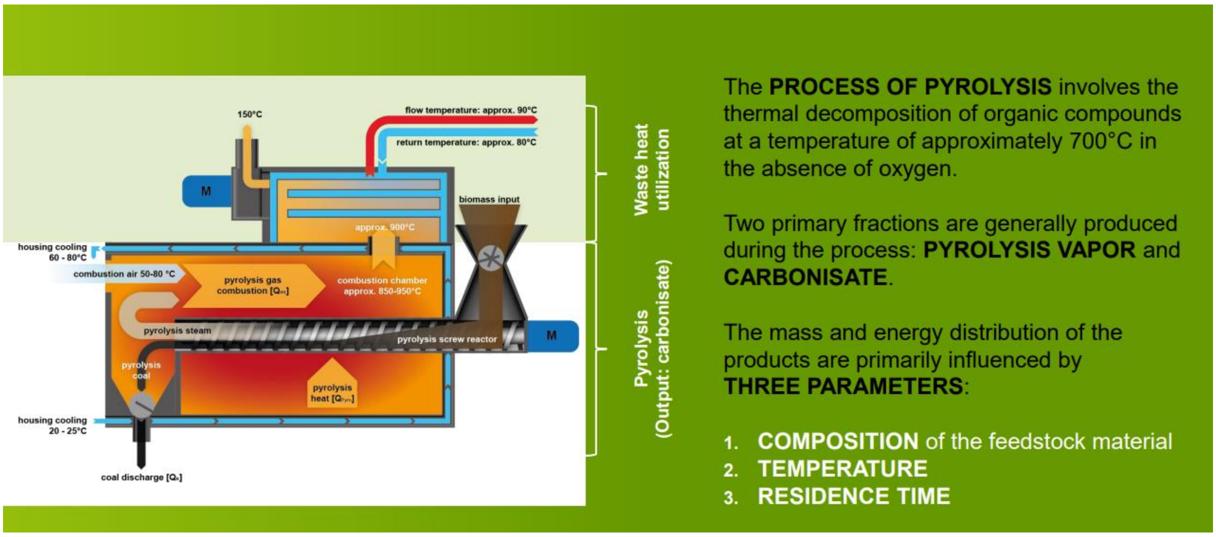
The project is complex and there are no standard solutions, thus each project is “made-to-suit”.

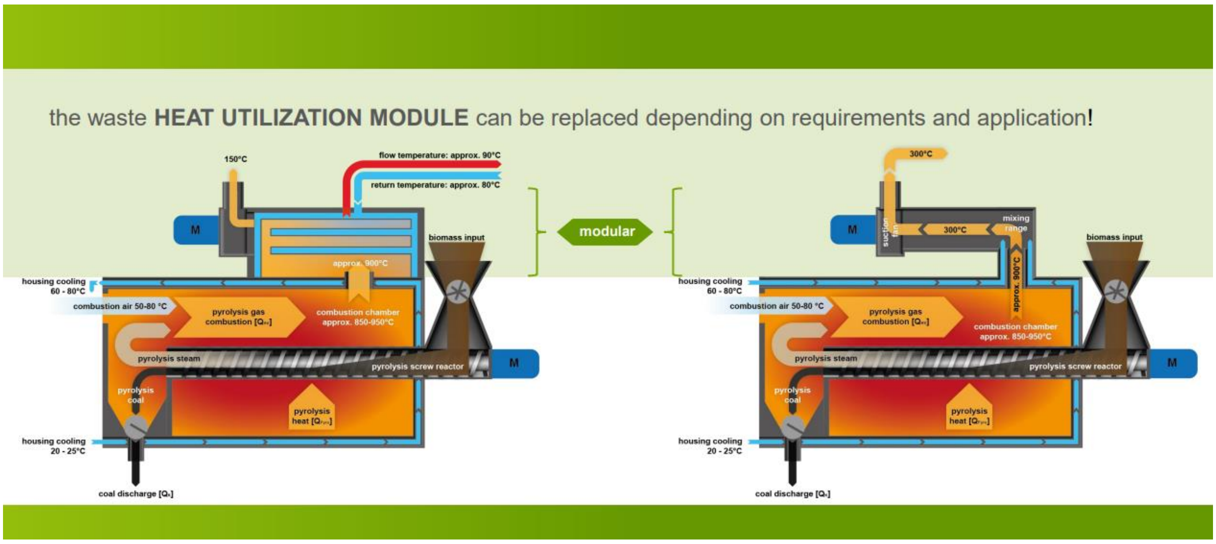
Before the finance investment model can be finalised, the questionnaire should be filled in and the calculations in terms of input and output should be given.

➢ TECHNOLOGY PROCESS

The project is complex and there are no standard solutions, thus it is "made-to-suit". There are different types of equipment and thus capacities.

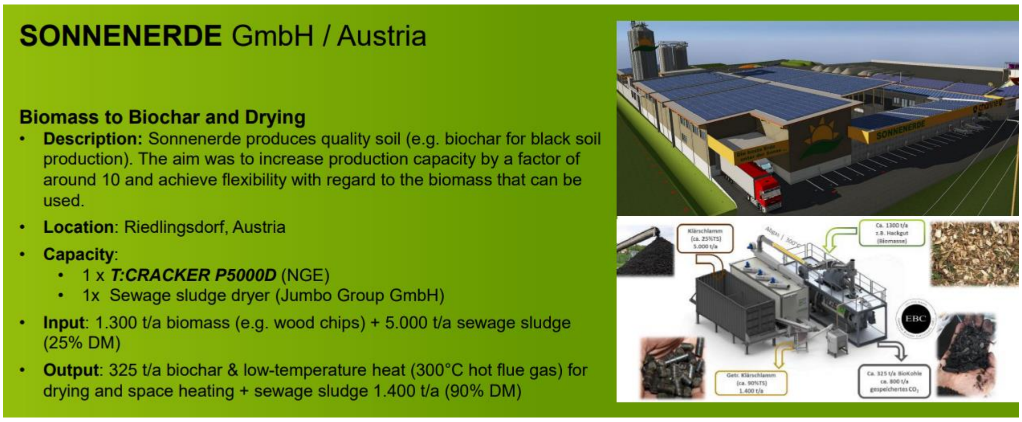
Basic technology process looks as follows:





➢ EXAMPLES OF PROJECTS

✓ The client “Sonnenerde GmbH” is burning sewage:



✓ One of the machines is located in Austria, in Stanglwirt hotel, and this machine produces heat and electricity out of wood (biochar, heat, electricity). https://www.stanglwirt.com/
The equipment is around 2 mln Euro. Amendment to convert heat into electricity costed to the company + 400 k Euro, therefore it is necessary to define your projected output in advance, it will cost higher to amend technical spec afterwards.

✓ Another example is KWK Ternitz. They are burning wood and generate electricity and feed the heat into the grid.