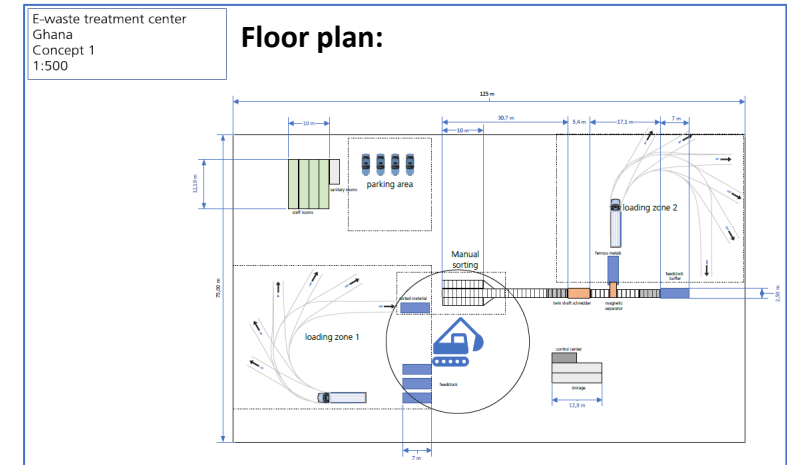
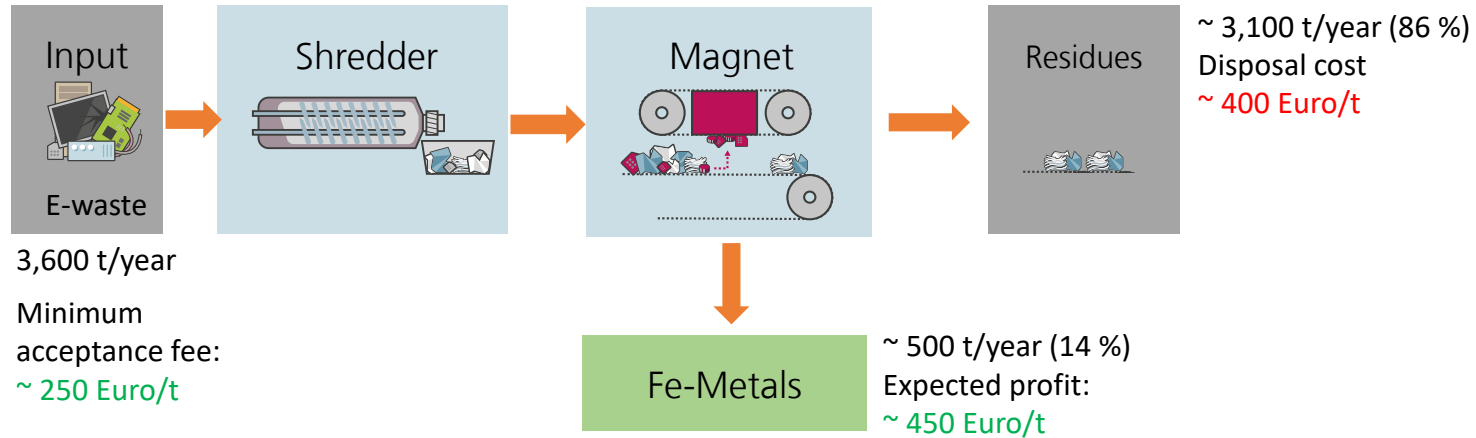


Recycling Concept 1: Basic Mechanical Treatment for E-Waste*

Schematic overview:



Technical key points:

Concept can be combined with manual dismantling.
Degree of technical complexity: Low
Suitable feedstock: Whole devices or metal-rich e-waste fractions
Source and availability of feedstock: Informal sector, formal recycling companies
Output marketability: Smelters for Fe-metals available.

Socio-economic framework conditions:

Ghana has a large and well-organised informal sector that collects and dismantles e-waste and recovers a considerable share of the ferrous metals. Thus, Concept 1 competes with the activities of the informal sector. The Ministry of Environment, Science and Technology and Innovation (MESTI) plans to introduce an EPR for e-waste as well as acceptance fees. A governmental „national e-waste fund“ has been set up to subsidise treatment in the future. Customers and treatment pathways for Fe-metals are available.

Financial key points:

Initial invest: ~ 815,000 Euro
Necessary acceptance fee for profitable operation: ~ 250 Euro/t
Expected profit after 10 years: ~ 600,000 Euro

Environmental key points:

Material recycling rate: ~ 15 %, energy recovery rate: 0 %,
landfill rate: ~ 85 %
Energy consumption: low

Administrative requirements:

Permits for treatment facilities are granted by EPA Ghana. All facilities are subjected to yearly audits.

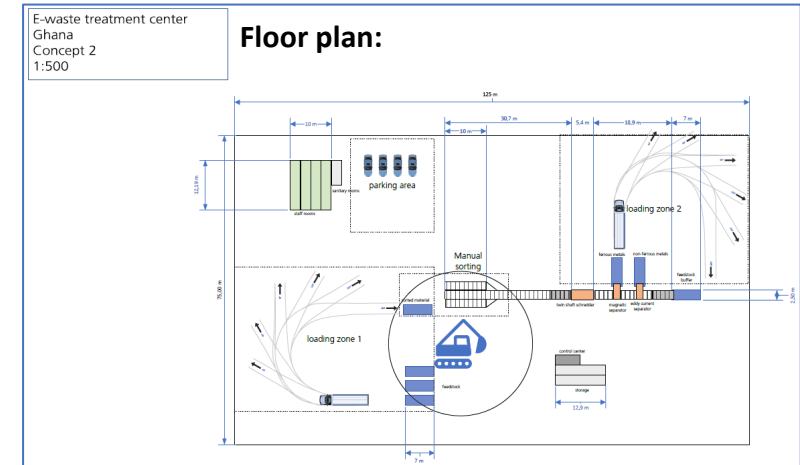
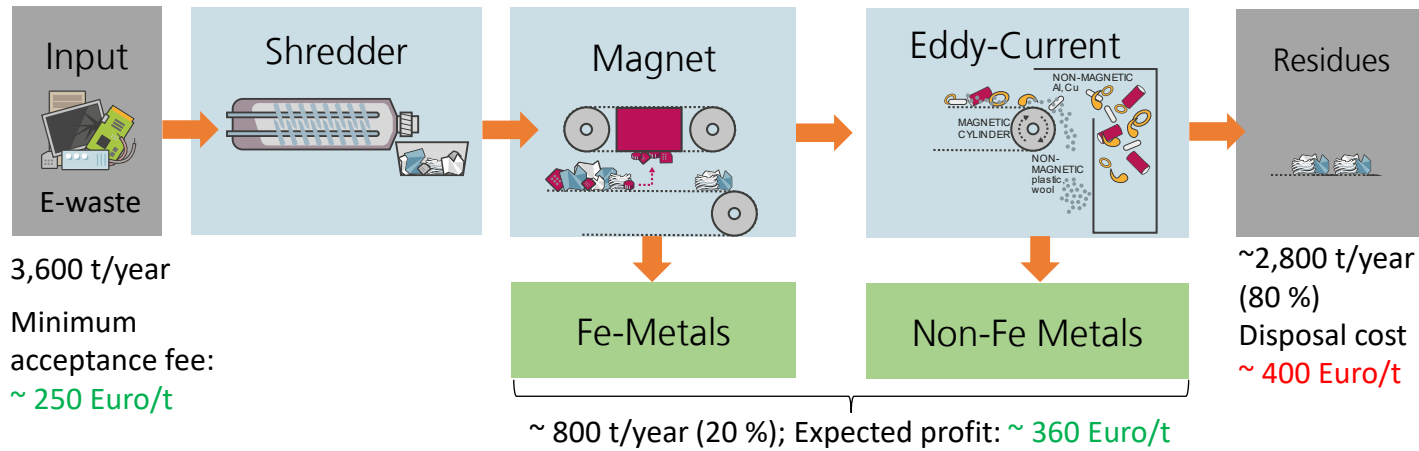
Time frame and risks of implementation:

Ready for implementation with low to moderate risk.

* All amounts, costs and expectable profits are estimates based average mixtures of material inputs and framework conditions like transport cost or availability of output marketability. Reference year 2021.

Recycling Concept 2: Advanced Mechanical Treatment for E-Waste*

Schematic overview:



Technical key points:

Concept can be combined with manual dismantling.
Degree of technical complexity: low-medium
Suitable feedstock: whole devices or metal-rich e-waste fractions
Source and availability of feedstock: Informal sector, formal recycling companies
Output marketability: Smelters for Fe-metals available. Copper and most Aluminum needs to be exported. This and the higher investment costs lead to lower profit than concept 1.

Socio-economic framework conditions:

Due to limited expectable prices of material output, Concept 2 depends on a co-financing via an acceptance fee. The Ministry of Environment, Science and Technology and Innovation (MESTI) plans to introduce an EPR for e-waste as well as acceptance fees in the near future. Customers and treatment pathways for Fe-metals are available.

Financial key points:

Initial invest: ~ 940,000 Euro
Necessary acceptance fee: 250 Euro/t
Expected profit after 10 years: 980,000 Euro

Environmental key points:

Material recycling rate: 20 %, energy recovery rate: 0 %,
landfill rate: ~ 80 %
Energy consumption: low

Administrative requirements:

Permits for treatment facilities are granted by EPA Ghana. All facilities are subjected to yearly audits.

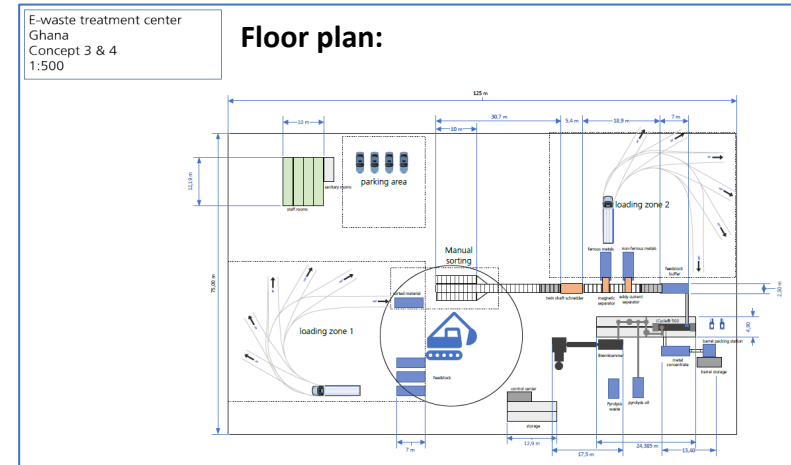
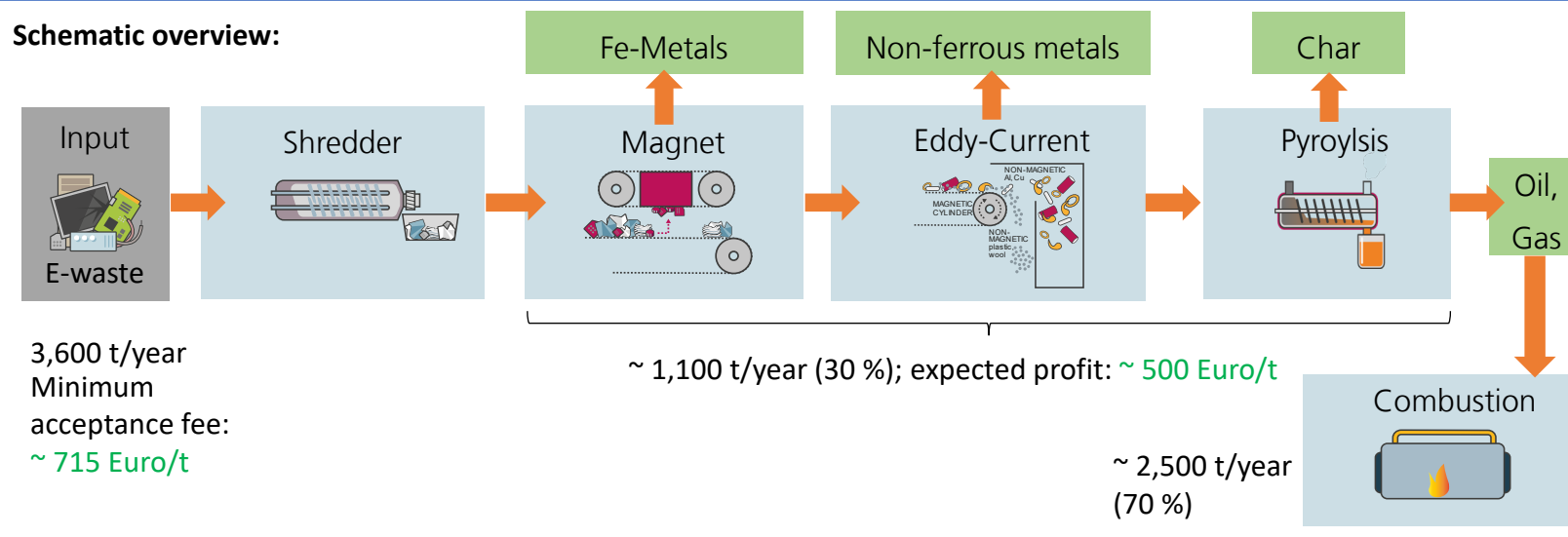
Time frame and risks of implementation:

Ready for implementation with moderate risk.

* All amounts, costs and expectable profits are estimates based average mixtures of material inputs and framework conditions like transport cost or availability of output marketability. Reference year 2021.

Recycling Concept 3: Advanced Mechanical Treatment with Downstream Pyrolysis for E-Waste*

Schematic overview:



Technical key points:

Degree of technical complexity: high
Suitable feedstock: whole devices or metal-rich e-waste fractions
Source and availability of feedstock: Informal sector, formal recycling companies
Output marketability: difficult, copper and char need to be exported. No local utilisation of pyrolysis oil and gas, thus on-site combustion for energy generation.

Socio-economic framework conditions:

Due to limited expectable prices of material output, Concept 3 depends on a co-financing via an acceptance fee. The Ministry of Environment, Science and Technology and Innovation (MESTI) plans to introduce an EPR for e-waste as well as acceptance fees in the near future. Due to the current lack of sale opportunities for pyrolysis products (char, oil, gas), Concept 3 is currently not yet economically feasible. Concept 3 is to be regarded either as a standalone possibility once the Ghanaian recycling sector is more developed or as an upgraded, more profitable continuation of Concept 4.

Financial key points:

Initial invest: ~ 3,600,000 Euro
Necessary acceptance fee: 715 Euro/t
Expected profit after 10 years: ~ 3,750,000 Euro

Environmental considerations:

Material recycling rate: ~ 30 %, energy recovery rate: ~ 70 %, landfill rate: <1 %
Energy consumption: high (partially covered by oil/gas output from pyrolysis)

Authorisation/ Administration:

Permits for treatment facilities are granted by EPA Ghana. Afterwards, yearly audits are held.

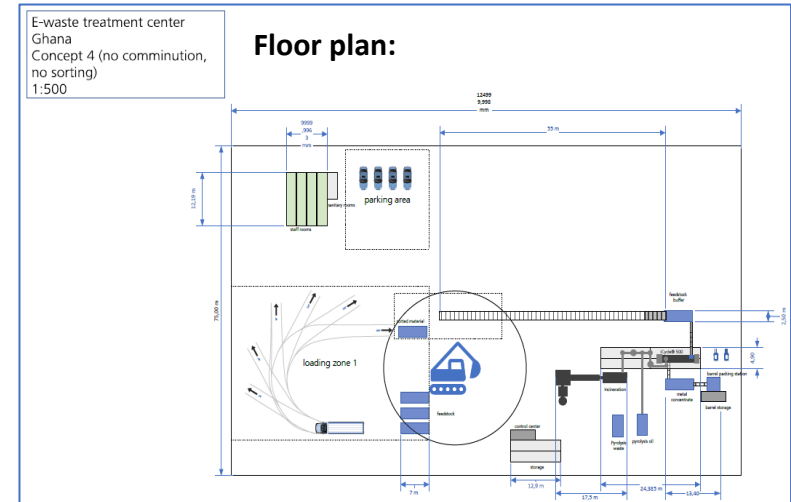
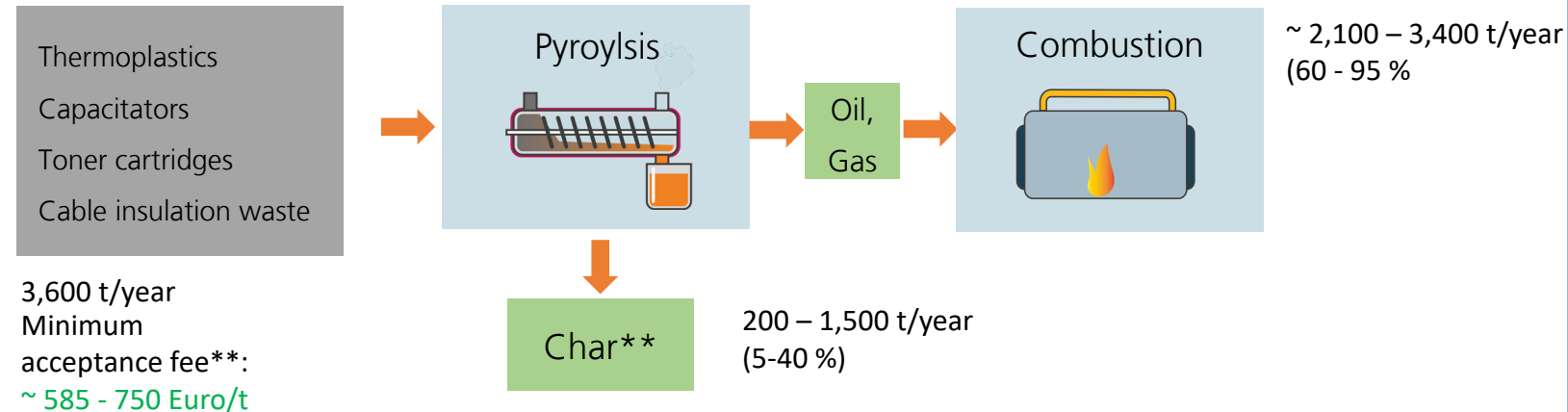
Time frame and risk of implementation:

Future business opportunity based on a development of local marketability of pyrolysis outputs and energy security.

* All amounts, costs and expectable profits are estimates based average mixtures of material inputs and framework conditions like transport cost or availability of output marketability. Reference year 2021.

Recycling Concept 4: Pyrolysis for Selected Downstream Materials*

Schematic overview:



Technical key points:

Degree of technical complexity: High
Suitable feedstock: Problematic waste streams with high demand of disposal solution
Source and availability of feedstock: Informal sector, Handover Center (HOC)
Output marketability: Concept focuses on disposal rather than generation of marketable outputs. Oil, gas outputs are combusted to fuel the disposal process. Metal char from capacitors needs to either cracked on site or exported (current situation).

Socio-economic framework conditions:

Concept 4 is a disposal facility for some of the most problematic downstream plastic-rich streams in Ghana. Due to the very low content of marketable metals (except for capacitors), the concept depends more on government intervention (e.g. funding or enforcement) than concepts 1-3. The Ministry of Environment, Science and Technology and Innovation (MESTI) plans to introduce an EPR for e-waste as well as acceptance fees.

Financial key points:

Initial invest: ~ 2.9 – 3.9 Mio. Euro**
Necessary acceptance fee: ~ 585 - 750 Euro/t**
Expected profit after 10 years: ~3,000,000 Euro**

Environmental key points**:

Recycling rate: ~0-40 %, energy recovery rate: ~60-100 %, landfill rate: <1 %
Energy consumption: high (partially covered by oil/gas output from pyrolysis)

Administrative requirements:

Permits for treatment facilities are granted by EPA Ghana. All facilities are subjected to yearly audits.

Time frame and risk of implementation:

The economic success of concept 4 is dependent on government intervention.

* All amounts, costs and expectable profits are estimates based average mixtures of material inputs and framework conditions like transport cost or availability of output marketability. Reference year 2021.

** Depending on material mix of feedstock