Improvement of Mozambican Cashew processing competitiveness and sustainability through energetic conversion of cashew shell by-products

Presentation of results of the market study

Maputo, November 21, 2023

Co-funded by European Union
Implemented by giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
cooperação alemã DEUTSCHE ZUSAMMENARBEIT

Introduction of Nitidæ

Nitidæ is a French NGO whose objective is to develop and implement projects that combine the protection of the environment and the strengthening of sustainable economies.

Nitidae has been working in Mozambique since 2014 and brings together sector expertise, on the one hand agriculture, markets and value chains, on the other; conservation, bioenergies, climate and carbon project development; creating an innovation interface to propose solutions and technical support to companies that want to improve the performance of agricultural value chains, mitigate their impact on the environment.

Since 2018, Nitidae has been implementing the ACAMOZ project in partnership with IAM, IP and the support of the French Development Agency (AFD) and has notably carried out a study on the competitiveness of processing in Mozambique that has integrated the issue of shell by-products.

The project in brief

- **Duration :** 24 months until Dec 2023
- **Intervention area:** provinces of Nampula and Maputo
- **Implementing partners:**
  - GIZ
  - Nitidæ
  - IAM, IP
  - AICAJU
  - IPOMA / IFPELAC Nampula
  - MOGROUP
  - CNCaju
  - ADPP
- **Donor:** European Union / German Cooperation - GIZ

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nitidæ cadeias de valor & territórios

INSTITUTO DE AMÊNDOAS DE MOÇAMBIQUE

AICAJÚ Associação das Indústrias de Caju

Província de Nampula IPOMA Instituto Politécnico do Marrere

NOVATEXMOQUE

CN Cashew

ADPP Moçambique

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Project objectives

General: Demonstrate Mozambican Cashew processing competitiveness and sustainability potential through energetic valorisation of cashew shell by-products

- O1: Conduct a local market study for the sales of cashew shell by-products (cake, charcoal and CNSL) in Maputo and Nampula (Nampula - Nacala axis) provinces.
- O2: Realize two cashew shell by-product energetic pilots in industries
- O3: Realize a comparative business plan for one reference cashew factory
- O4: Dissemination of the study results and lessons learned

Scope and approach of the project

- Promote a circular economy that contributes to the creation of wealth and sustainability for the country and private actors.
- Hypothesis: In the context of the global energy crisis, high oil prices and climate urgency and the adoption of new policies → there are opportunities for the development of biomass energy
- The shell by-products considered are the shell, the CNSL (cashew shell liquid), cake (or cake) or charcoal (from shell or cake)

Charcoal

Firewood/biomass

Liquid fuel (diesel/HFO)

Shell

Shell cake

Shell charcoal

CNSL

Scope and approach of the project

- Focus of work with **processors, industries, small and medium-sized companies with energy needs,** which use large amounts of non-renewable fuel → **concentration of strong demand with a reduced number of users.**

- Industry/productive fuel users are looking for costs savings and are ready to make investments to switch fuels.

  - Nota Bene: the market study does not include the characterization of the volumes and types of fuels at the domestic level, as there are several studies that evaluate these aspects;

  - **The work focused on the economic analysis and characteristics of an industrial charcoal production to assess whether it can compete with artisanal charcoal in the domestic market.**

Basis of the market study

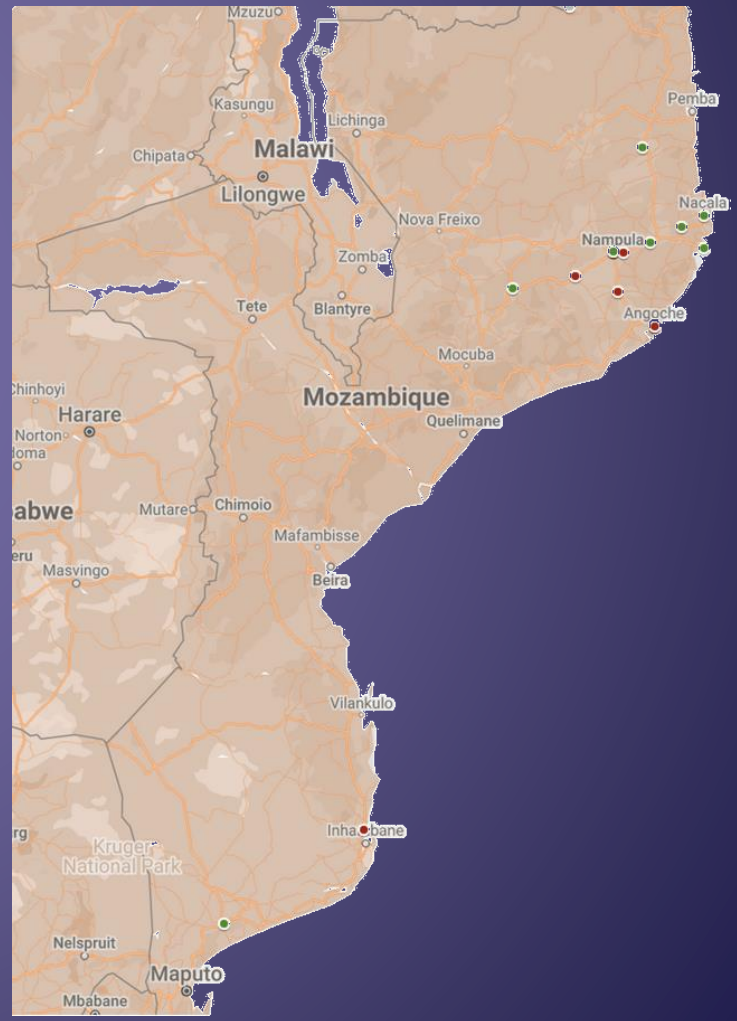
SEARCH

- Surveys in Nampula and Maputo provinces (+ Maputo city)

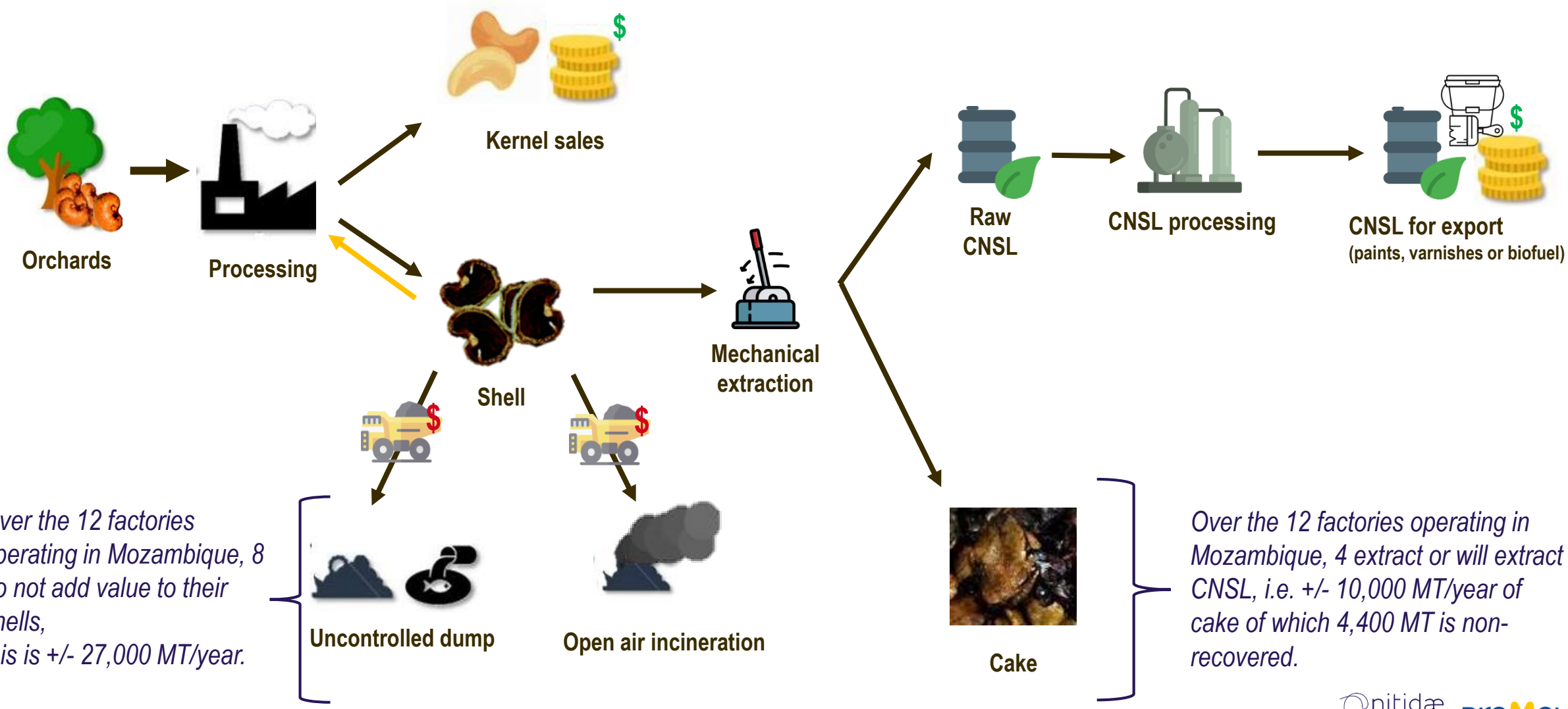
	Productive sector	Number of enquiries
Listed industries	1. Metallurgy 2. Mining 3. Textile 4. Food sector - Beverages, dairy 5. Food sector - Cakes, pasta 6. Food sector – Edible oil refining 7. green charcoal and biofuel producers 8. Seedling producer 9. Cement 10. Cashew processing	15
SMEs and collective kitchens	1. Hospitals 2. Military institutions 3. Reception of refugees 4. Bakery 5. Restaurants 6. Sales of wood charcoal 7. Production of green charcoal	48

OFFER

- Maximum production capacity of the 12 cashew processing factories currently operating in the country



Context: Current status of the energy valorisation of cashew shell by-products in Mozambique



Over the 12 factories operating in Mozambique, 8 do not add value to their shells,
this is +/- 27,000 MT/year.

Over the 12 factories operating in Mozambique, 4 extract or will extract CNSL, i.e. +/- 10,000 MT/year of cake of which 4,400 MT is non-recovered.

Expelling shells for biofuel production

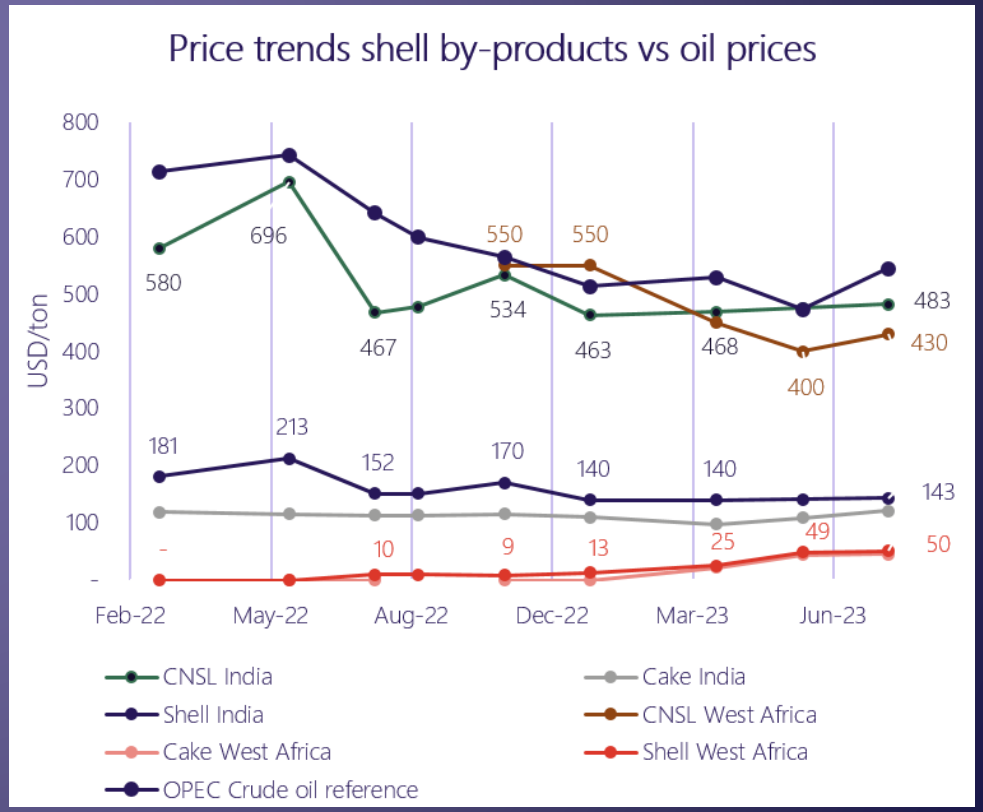
•In the current context of energy crisis there is a growing demand for renewable biofuels. **CNSL has acquired a role as a source of energy as fuel, for direct use** or treated in biorefineries

• The residual shell cake has alweays been used for fuel in Asia, and currently it is a much more generalized – and valuable – product due to rising fuel prices.

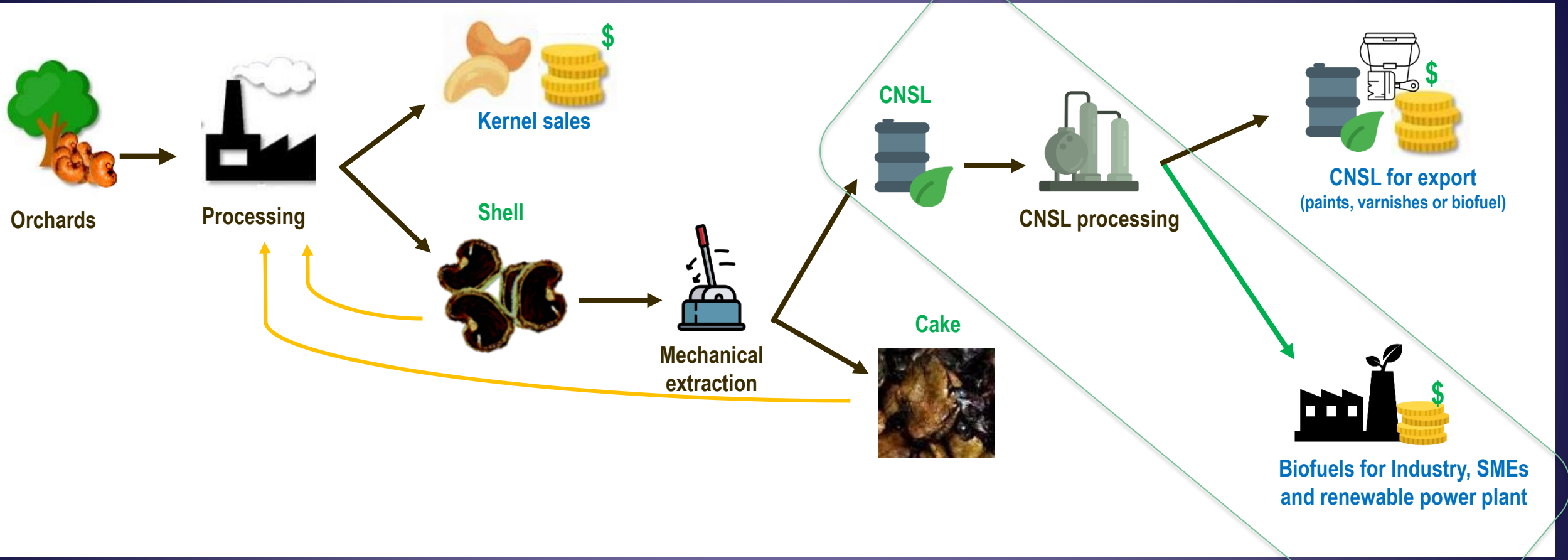
- Currently in Mozambique only 34% of the total CNSL potential is extracted.

- This is a loss of value for the processor (figure) - the shell has a market value!
  - shell India 140 USD/ton
  - CNSL India 468 USD/ton
  - Petromoc Oil 990 USD/ton
  - HFO Mozambique ~700 USD/ton

- <u>The first barrier is investment</u>: a CNSL extraction and processing plant with a capacity of 10 000 tons shell/year = 84 000 000 Mt (1.3 M USD).
  CNSL production would be 2 000 tons/year



CNSL: Cashew shell oil as biofuel



- CNSL content is close to 25% of the Shell weight (see Factsheet).
- Mechanical extraction of CNSL is already practised in 4 Mozambican factories, which are considering the international market
- So far only the international market has been considered, but CNSL can be used on a national scale.

Users of liquid fuel in Mozambique

Demand:

Profile of the actors found

- Food industry (liquid fuel used for specific operations or in combination with another fuel)
- Metallurgy (experience in the use of CNSL), mining

- Nampula:
  - Industrialists using electric heating are interested
  - Estimated consumption of food industries ~13,000 MT/year (n=3)
  - Estimated consumption metallurgy and mining, ~10,000 MT/year (n=3)

- Maputo (city and province):
  - Little use of liquid fuel due to the accessibility of gas
  - Estimated consumption industries ~1,400 MT/year (n=6)

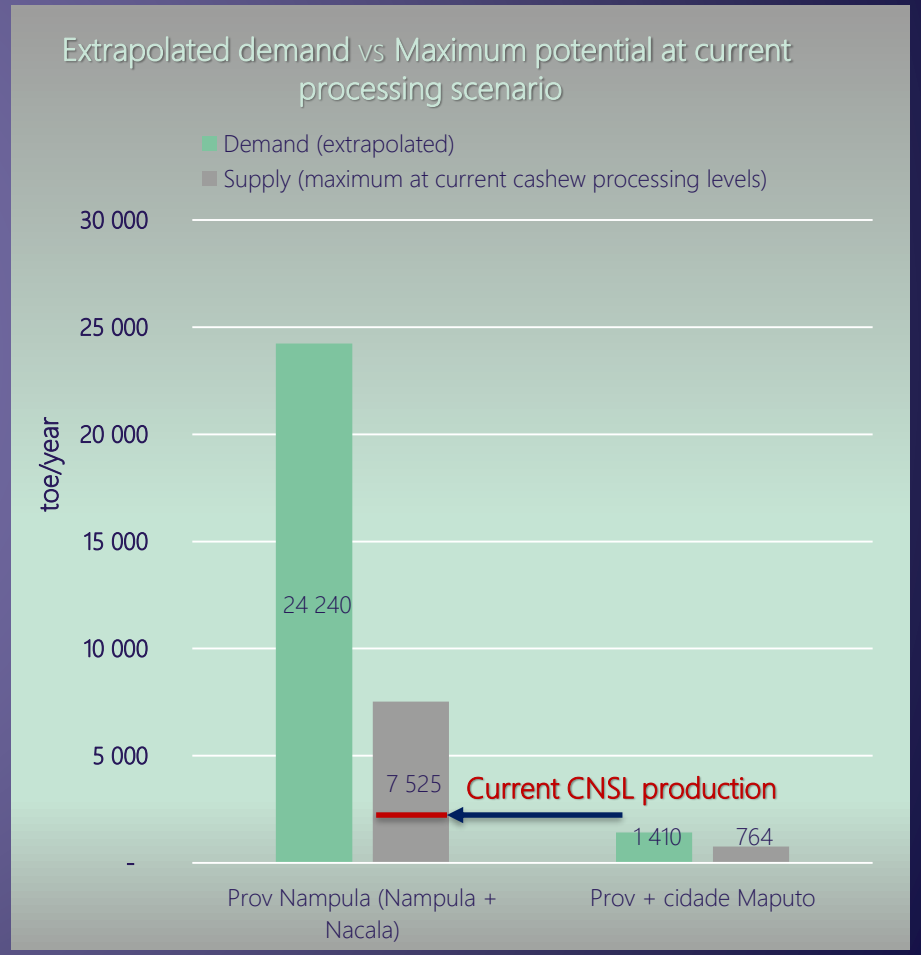
Users of liquid fuel in Mozambique

Supply: Potential production of CNSL

Potential CNSL production:

- Nampula
  - Up to 7 500 MT/year produced → could supply part of the demand
- Maputo
  - Only up to 760 MT/year to be produced (Macia, Gaza) → could supply part of the demand

- The selling price should be in line with the HFO (heavy fuel oil) type fuel price, currently ~700 USD/ton



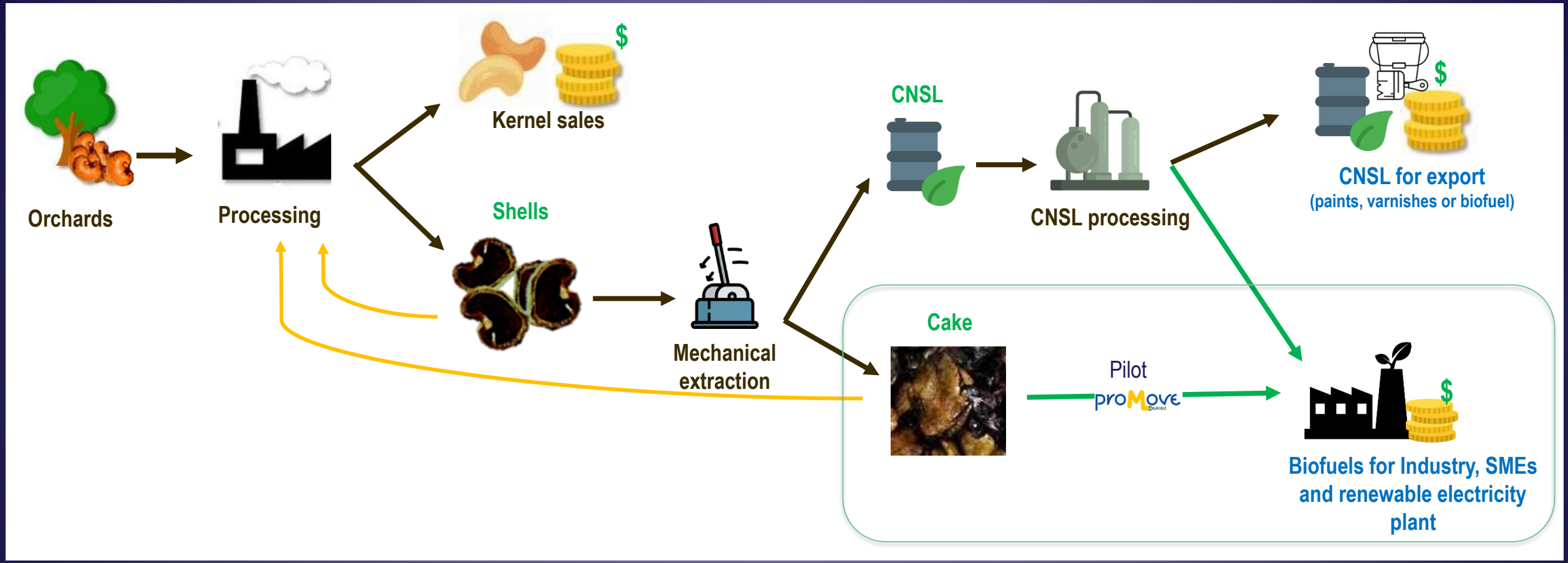
CNSL: conclusions, positioning

- The demand for CNSL in the local market can absorb all the potential CNSL production of the Mozambican cashew processing industry.
  - Safe market as there is always the option of selling CNSL on the international market.
- The selling price should be in line with the HFO (heavy fuel oil) type fuel price, currently ~700 USD/ton

- Today, there is a need to promote CNSL extraction within cashew processors in Mozambique. CNSL extraction can unlock all other shell by-products → there is room for investors.
  - The simplicity of CNSL processing allows the same cashew factory or a third party to invest/operate this business.

- CNSL industrial users need technical support and demonstration experiences to adapt combustion equipment in order to integrate CNSL into their energy mix.

Shell Cake: An effective substitute for firewood for productive uses and an additional gain for CNSL processors



- The cake corresponds to +/- 70% of the weight of the shell after extraction of the CNSL.
- Its composition and energetic power is similar to firewood (see table in Factsheet)
- The residual oil content greatly determines its quality and suitability for fuel use in various equipments

Solid fuel users in Mozambique

Demand:

Consumers profile

- Collective kitchens: hospitals, refugee centres, educational centres
- Bakeries
- Food industry and manufacturing

- Nampula:
  - Estimated consumption of collective kitchens ~720 MT/year (n=6)
  - Estimated consumption bakeries, average ~12 MT/month; extrapolation at ~7,200 MT/year (n=50)
  - **Estimated overall industry consumption ~21,000 MT/year (n=4, including new clinker factory)**

- Maputo (city and province):
  - Estimated consumption of collective kitchens ~3,000 MT/year (n=38)
  - Estimated consumption bakeries, ~12 MT/month; extrapolation at ~32,000 MT/year (n=210)

Solid fuel users in Mozambique

Offer: Potential production of shell cake

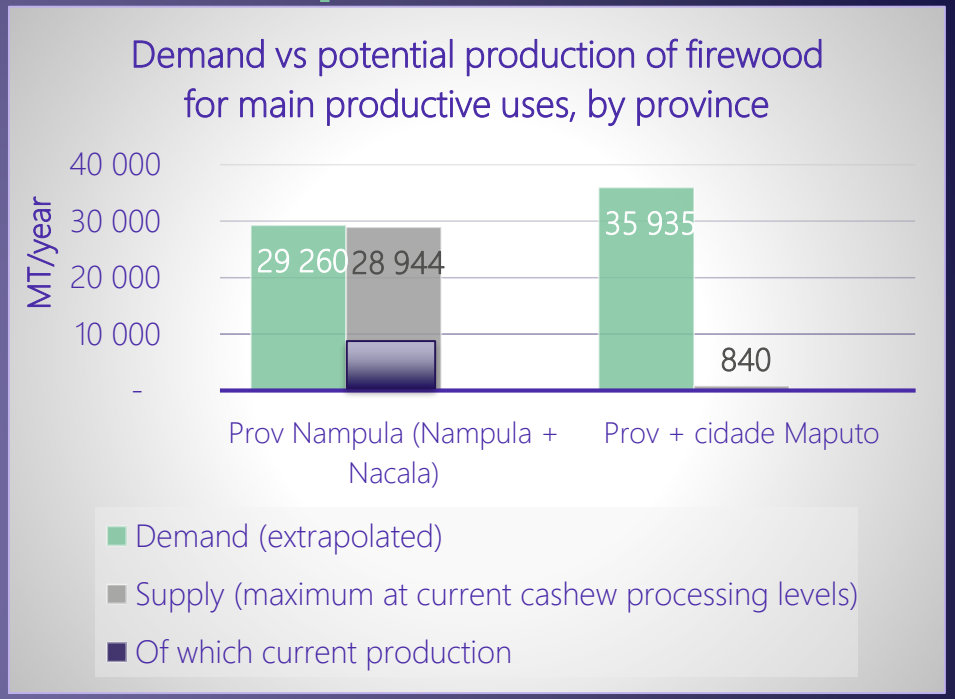
Potential production of shell/cake charcoal:

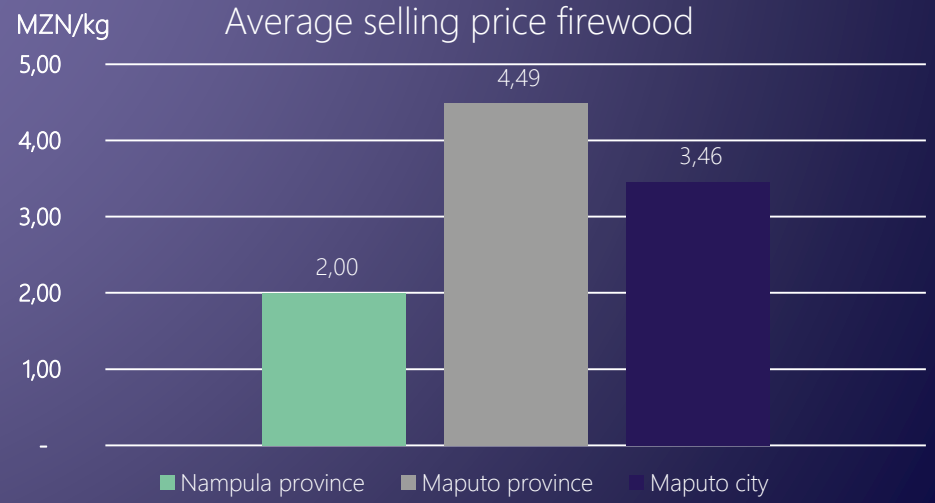
- **Nampula:** Up to 29,000 MT/year produced → could supply industry, bakeries and collective kitchens

  A nova fábrica de cimento de Nacala vai absorber toda a produção atual

- **Maputo:** Only up to 3,000 MT/year to be produced (Macia, Gaza) → could supply part of the bakeries

- **The cost of cake production is 0** (as it is a by-product from shell after CNSL extraction).
- The profit for the cashew shell processor depends on the proximity to the customer (transport ←→ profit)
- The selling price of cake can be lower or equal to the price of firewood: the final value depends on the quality (residual oil content, density)
- It would be possible to negotiate a more advantageous price with clients ready to pay for environmental services.



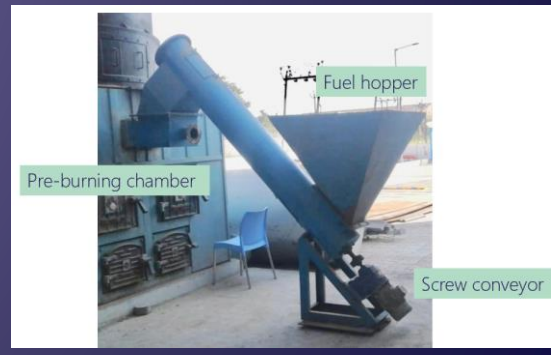


Results of pilot project 1: substitution of firewood by shell cake in an industrial boiler in Nampula

- **Replacement of 95% of the daily consumption of wood** in the boiler tested, equivalent to 1,400 MT of avoided wood consumption annually.

- If extrapolated over the 3 boilers operating together, this corresponds to **~4,000 MT/year of avoided fuelwood consumption**. This single industry could absorb ~4,000 MT of cake per year, i.e. the equivalent of the entire cake production of an 8,000 MT cashew processing unit equipped with a CNSL extraction unit.

- **Environmental and economic benefits for the industry:**
  - **Preservation of the Miombo forests** in Nampula province;
  - **Reduction of carbon emissions: estimated 800 TCO_2 eq** (Gold Standard Methodology);
  - **Financial viability of investing in an automatic cake feeding system for the boilers** (strong impact on the cake transportation costs).



Cake: conclusions, positioning

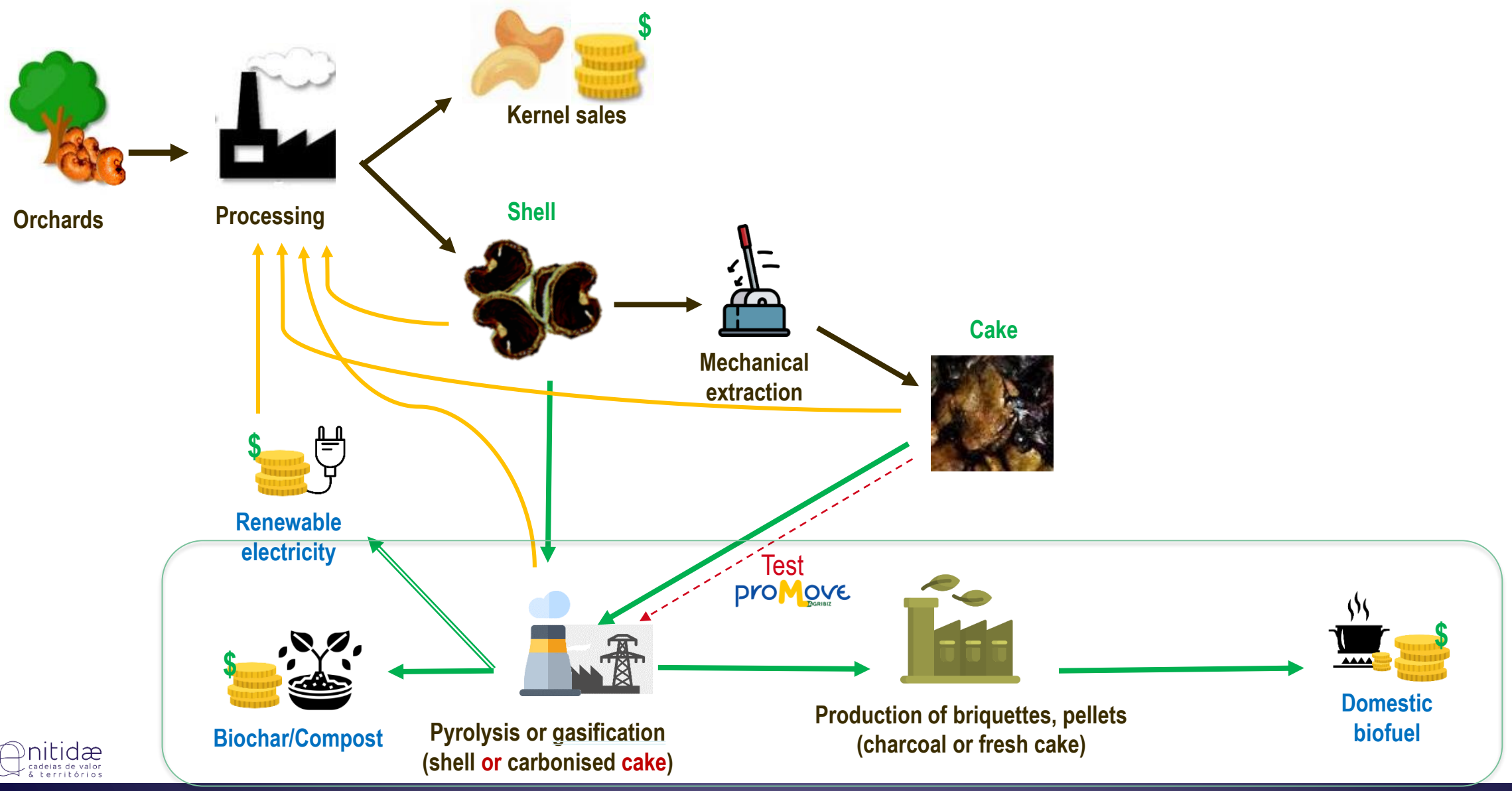
- In India and Vietnam, it is customary to burn cake, mixed or not with other biomasses (peanut shells, rice shells, etc.)

- The exemplary case of pilot test No. 1 could be the case for many other industrial actors: Thousands of tons of firewood or hectares of fragile miombo woodland can be saved every year.
  - Large firewood consumers get ROIs of only 2 years
  - In the case of SME consumers (bakeries, collective kitchens): The current very low price of firewood might not achieve important savings to quickly compensate the investment of changing the equipment.

- Going to scale: users need technical support
  - Adjustments of the operating parameters of the current combustion device, changing the grates…
  - Small productive users need new burners in order to integrate cake.
  - An incentive policy would help to quickly generalize cake use

- Financing opportunities through carbon finance

Carbonized cashew shell/cake: Opportunity to set up an industrial process of green charcoal for biofuel or agronomic use



Charcoal users in Mozambique

Demand:

Consumers profile

- Communal kitchens: hospitals, refugee centres, educational centres, military structures
- Wood charcoal is one of the fuels used, along with firewood

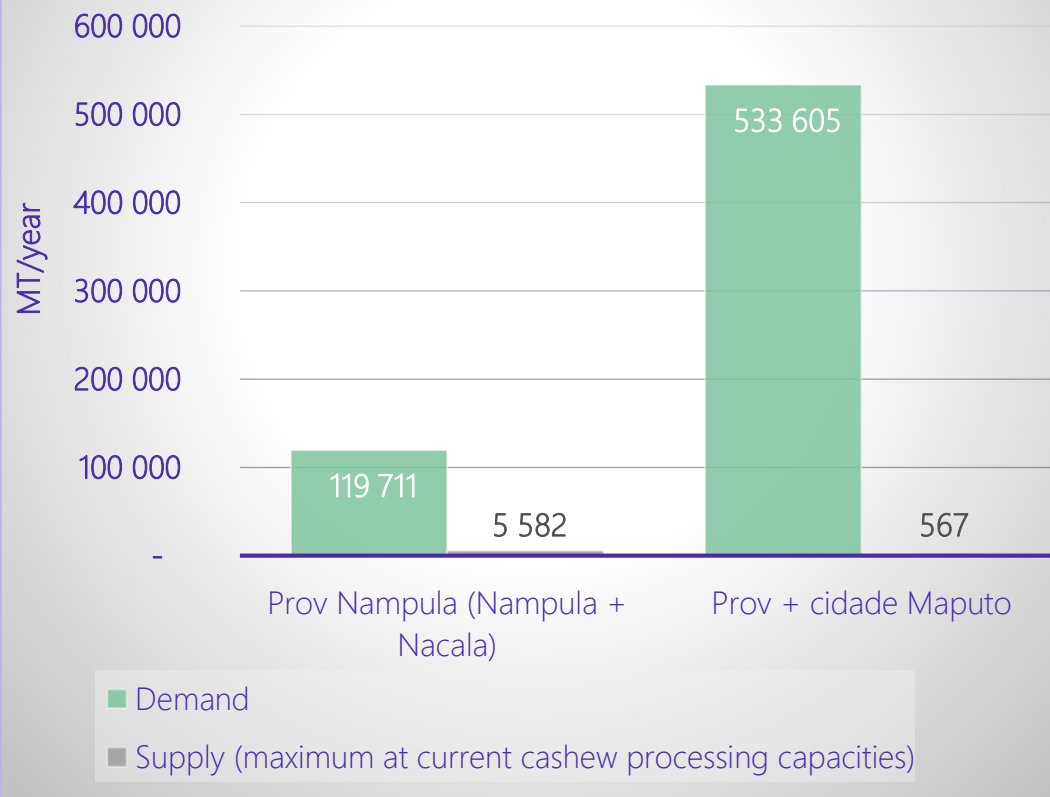
- Nampula:
  - Estimated consumption of collective kitchens and restaurants ~1,100 MT/year (n=36)
  - Estimated industry consumption (*mineral coal, not considered) 4,500 MT/year (n=2)
- Maputo (city and province):
  - Estimated consumption of collective kitchens and restaurants ~4,900MT/year (n=152)
  - The poultry sector consumes wood charcoal, ~1,000 MT/year
  - Heavy industry (Mozal) does not consume charcoal but mineral coal (*not considered here)

Supply: Potential production of charcoal from shell/cake:

- Nampula
  - Up to 5,582 MT/year produced → could supply collective kitchens, industry and restaurants
- Maputo
  - Only up to 567 MT/year produced → could supply part of the collective kitchens

Demand vs potential green charcoal from cashew shell, per province [tons/year]

*Includes extrapolation of data from domestic consumption [source: Study of biomass use (MIREME, 2022) and RGPH (INE, 2017)]



Results of pilot project 2: Production and testing of a pyrolysis furnace for Biochar production in Nampula






- First (2) pyrolysis furnaces built in Mozambique at the Instituto Polivante de Marrere (IPOMA, Nampula)
- **18 professionals** from the industry and AICAJU were trained in the construction of the furnaces
- Installation and testing of the furnaces at CNCAJU and ADPP: **successful coal/Biochar production**
- **Testing of cashew charcoal briquettes** (made in Quelimane).
- **Quality test:** cooking test (Enabel, Greenlight) and laboratory test (Endev)

On Quality of shell charcoal

1. Physico-chemical characterization of briquettes in lab

Moisture 5%, Volatile matter 15%, Fixed carbon 76%, Ash 17%, Heating value 23,5 MJ/kg.

⚠ Very high Ash content ; Low Fixed carbon

2. Testing with users & focus groups

(+) slow combustion, possibility of reuse, economical

(-) dirty, smelly smoke at the start of combustion only

2. Combustion assessment

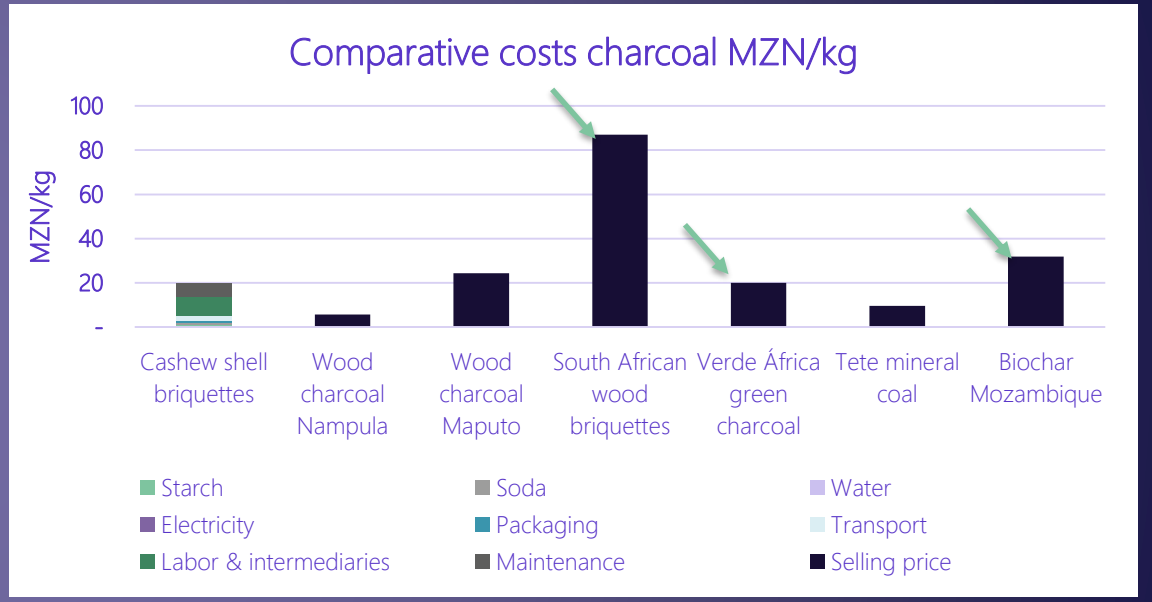
Standard comparative Water Boiling Tests (WBT) + emissions assessment :

- Specific consumption [g/liter water]: shell briquettes > wood charcoal
- Global efficiency (high power) [%]: shell briquettes > wood charcoal
- CO emissions [ppm]: wood charcoal > shell briquettes
- Particulate matter [ppm]: shell briquettes > wood charcoal ⚠

Results of pilot project 2: Production and testing of a pyrolysis furnace for Biochar production in Nampula

Assessment of the production costs shell charcoal: very high

- The main cost is labour: the carbonisation operation is slow and needs surveyance (process not automatized)
- Maintenance and additives (binders) are important costs but necessary
- Transport: determines the type of market to be reached



- The study identified three initiatives of green charcoal producers (2 in Maputo and 1 in Quelimane), only one is still active in Maputo.

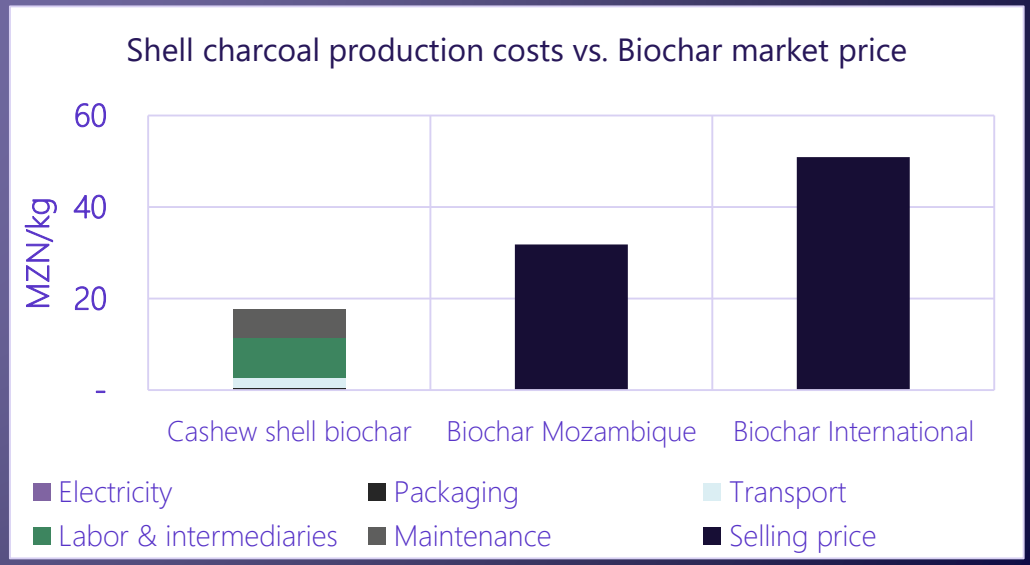
Raw materials	Market approached
Coconut shells	Domestic
Coconut shell, peanut, rice	Supermarket sale, premium price
Wood charcoal powder	Poultry SMEs

- Hard to compete → alignment with wood charcoal prices → It is not viable **TODAY** to invest in shell/cake carbonisation in Nampula, but it looks promising in Maputo province (investigate premium market).

Results of pilot project 2: Production and testing of a pyrolysis furnace for Biochar production in Nampula

- The use of renewable charcoal as an agricultural input (biochar) starts to be considered in the global market
  - The benefits of Biochar depend a lot on the type of soil.
  - At the same time, it is a solution considered as a carbon sink, **so it can be remunerated as avoided emissions**

- Selling price : international prices are high, up to 800 USD/MT
- Under the project, a cashew processor (ADPP) received support to negotiate a commercial agreement for the supply of cashew shell biochar
- Nitidæ is to undertake agricultural testing with this biochar, in the frame of a new partnership

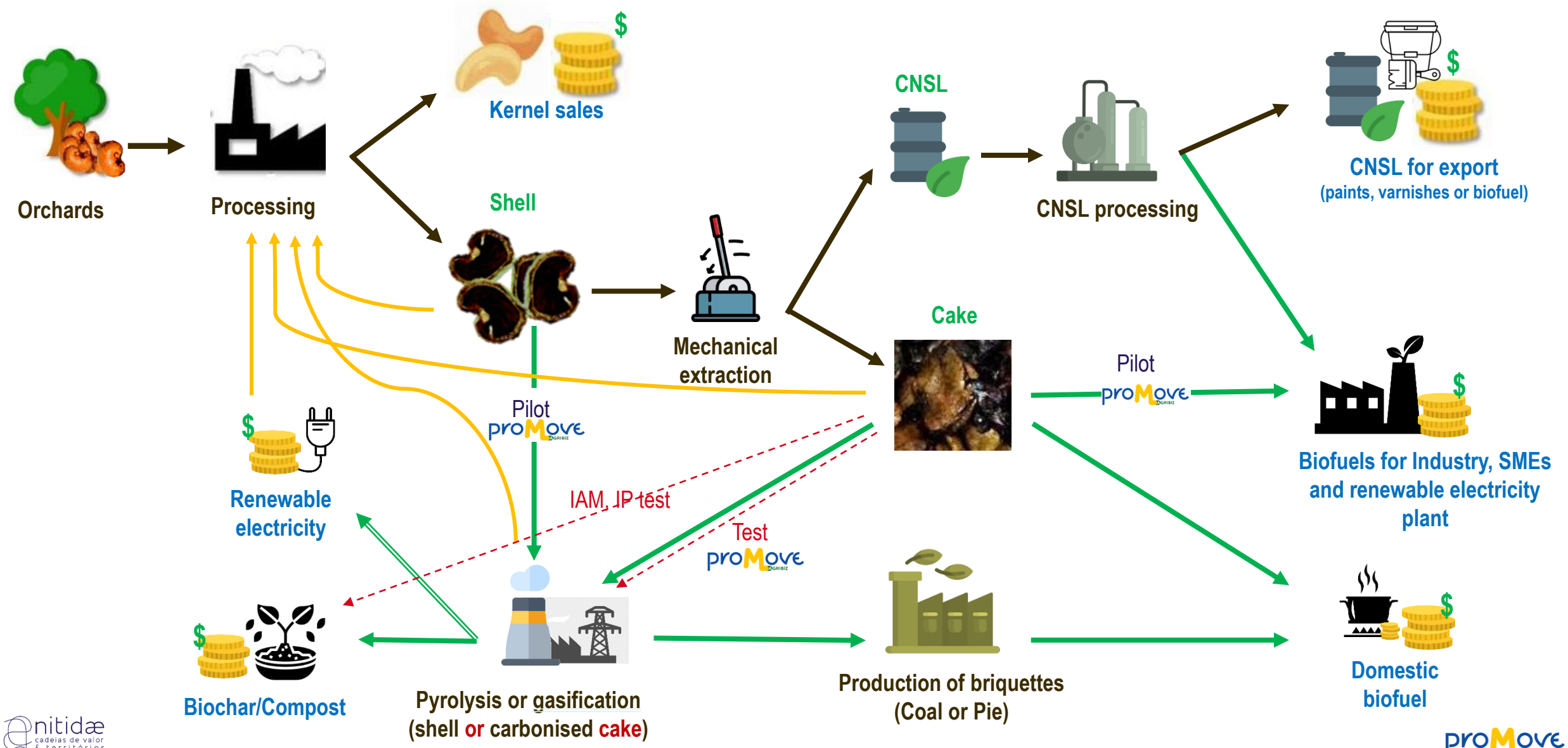


Charcoal: conclusions, positioning

- The demand for charcoal is sufficient to absorb all potential shell/cake coal production.
- The collective kitchen sector and SMEs should be prioritised.
- Difficult to compete in the domestic market → alignment with wood charcoal prices → It is not viable TODAY to invest in shell/cake carbonisation in Nampula, it looks promising in Maputo province (seek premium market).
  - The household sector is evolving slowly, Greenlight (2022) indicates low household sensitivity to the adoption of improved cookers. E.g in Maputo, only 3% of households use improved cookers for charcoal;
  - Need to raise awareness among users about the quality of shell charcoal (smoke, smell when lighting);
  - There is little experience in Mozambique in the carbonisation of shells/cake, experiments must continue in order to achieve an acceptable quality

- Biochar market in development: some players in favour of offering a premium price for fertilisation → need for experimentation to confirm that quality is appropriate.
  - Nitidæ is to conduct pilot testing in application of biochar in cashew orchards

Our vision : Complete chain for the energy valorisation of cashew shell by-products in Mozambique



Overall conclusions / Outlook

How to finance the rising of the cashew shell sector?

- Climate finance can be an appropriate solution to facilitate the quick launch of this renewable biomass sector, contributing to the neutrality of the cashew sector and the circular economy in Mozambique.
- Funds such as carbon credits, climate change adaptation schemes, green investment funds, green tax/ incentives… are valid examples for this sector

Overall conclusions / Outlook

- There is a great opportunity to improve competitiveness and sustainability of cashew processing in Mozambique, through value addition of shell byproducts and launching a circular economy.
  - The sales profit would bring in an additional turnover ranging from 5% to 11% the real cost of cashew nut

- The ideal scenario for valorisation of the shell by-products, today in Mozambique, consists of the extraction and sale of CNSL and the direct use of the cake as a solid fuel:
  - It maximises economic & environmental benefits and grants optimal energy use of byproducts;
  - There is an important market at international and national level (national demand CNSL 26,000 MT, Cake 66,000 MT) for actors with high unit consumption;
  - Business case demonstrated at industrial level through provious experiences (Indo Metal for CNSL) and through the pilot to replace firewood with cake.

The first action should be the investment for CNSL extraction (today, only 1/3 of the potential volumes are extracted), which is the main bottleneck for complete value addition of all shell byproducts.

Overall conclusions / Outlook

- For charcoal, difficult to compete with wood charcoal prices in the domestic market → It does not seem viable today to invest in carbonisation of shell/cake in Nampula, looks promising in Maputo province.
- There are still important players and markets to investigate (CFM, oil & gas, cement).
- Need to support actors, whether large industries or SMEs, in the introduction of adapted technologies and experimentation to integrate shell fuels and scale up.
- What role, strategies and actions could be developed by the key actors in the sector?
  - Fuel users, how to make their queries and needs on clean biofuels heard?
  - MIREME: integrating cashew shell byproducts in the National Strategy for Biofuels and incentive mechanisms, promoting renewable and endogenous biofuels.
  - AICAJU: What strategy to position upon the identified opportunities in this work with the respective partners?
  - IAM, IP: How shall cashew shell byproducts be strategically integrated through the new Master Plan?
  - Cooperation partners and the banking sector: sought to help leveraging access to finance (credit, climate finance, payments for environmental services, carbon markets)

Thank you very much

Presentation of the study results

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