

# Bio-coal from Groundnut Shells - An Example for Sustainable Bio-energy Use



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## Introduction

- ◆ Factor 4 Energy Projects GmbH, Wismar (Germany)
  - ▶ small consulting firm specialized in renewable energies (RE)
  - ▶ wind energy, biomass/household energy, solar energy
  - ▶ training in the Field of RE
  - ▶ energy Master Plans
- ◆ Current Projects
  - ▶ capacity building for wind energy engineers (P.R. of China)
  - ▶ planning of a 50 MW Wind Park (Ethiopia)
  - ▶ installation of wind parks in parallel with Island Grids – a total of 21 wind turbines 300 kW each (Azores, Portugal)
  - ▶ wind energy utilization in CARICOM countries (Jamaica)
  - ▶ dissemination of fuel-saving cook stoves (Ethiopia)
  - ▶ energy from household waste (Jamaica)



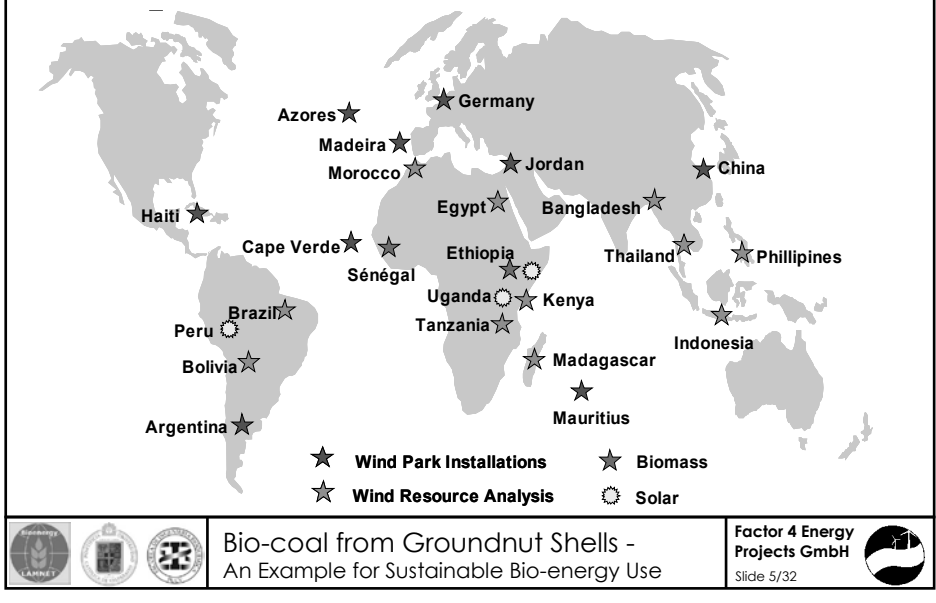
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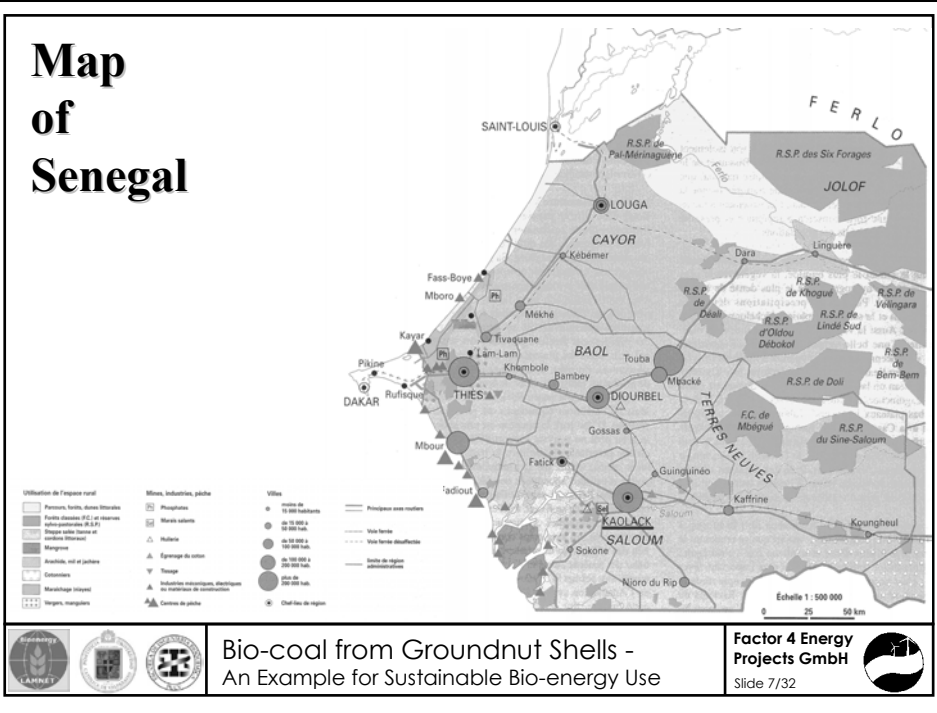
## World-wide Activities since 1985



## Household Energy Project Senegal

- ◆ carried out by Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, since 1997
- ◆ a combination of an energy (household energy) and forestry project (community forest)
- ◆ one project component: energy master plan of a regional province capital
- ◆ Kaolack, centre of groundnut production and processing in Senegal
- ◆ the energy master plan aimed at identifying suitable areas for large-scale intervention in the field of energy

# Map of Senegal



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## Major Results of Energy Master Plan

- ◆ an average per capita consumption of 230 kgoe
- ◆ roughly 1/3 household energy for cooking
- ◆ fossil fuels nearly 50 % - practically exclusively for transport and electricity
- ◆ kerosene and LPG with 6 % (increasing)

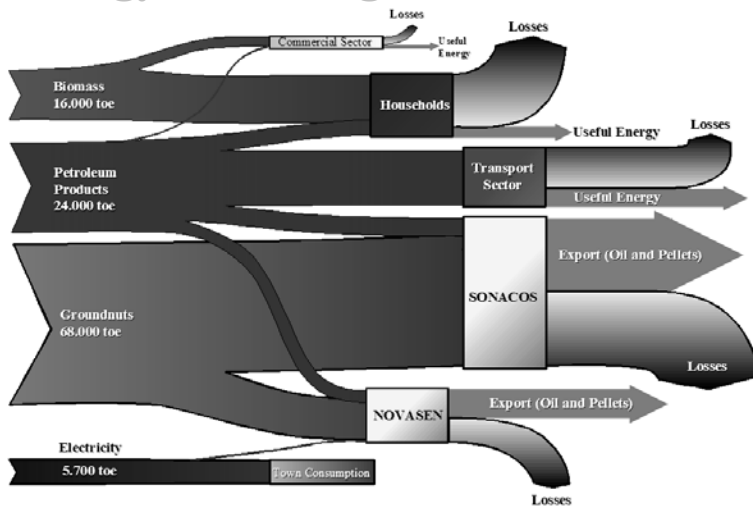
Fossil Fuels	107 kgoe	47 %
Household Energy	67 kgoe	29 %
Kerosene, LPG	14 kgoe	6 %
Commercial Energy	8 kgoe	3 %
Others and Losses	34 kgoe	15 %



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## Energy Flow Diagram of Kaolack



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## Summary of Master Plan

- ◆ largest energy input to Kaolack through agricultural residues (ground nuts – a total of 68,000 toe per year)
- ◆ largest amount of losses in ground nut processing, followed by household sector
- ◆ commercial energy sector insignificant
- ◆ two industrial groundnut processing plants (mills)
  - ▶ government owned SONACOS
  - ▶ private owned NOVASEN
- ◆ very difficult to cut down on losses at household level
- ◆ technical possible to reduce losses in the ground nut processing plants



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## Comparison SONACOS – NOVASEN 1

	<i>SONACOS</i>	<i>NOVASEN</i>
Property	Government	Private
Employees	600 + 500 temporary workers	90 + 250 temporary workers
Annual Capacity	130.000 t	40.000 t
Annual Production	46.000 t Groundnut Oil 50.000 t Pellets	60.000 t Groundnut Oil 60.000 t Pellets
Energy Input	15.000 MWh from Combustion of Groundnut Shells	4.400 MWh Diesel Generator (heavy fuel)
Specific Energy Consumption	210 kWh per ton of Oil 80 kWh per ton of Pellets	37 kWh per ton of Oil 37 kWh per ton of Pellets
Grid Connection SENELEC	none	yes, illumination only
Stand-by Generator	2 x 600, 1 x 1.200 MW	no, only 1 MW main electric generator
Residues of Production	none	30.000 tons Groundnut Shells
theoretical Biocoal Potential	33.000 t per year	10.000 tons per year
technical Biocoal Potential		10.000 tons per year



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## Comparison SONACOS – NOVASEN 2

### ◆ SONACOS factory

- ▶ not flexible, government structures
- ▶ not interested in energy efficiency
- ▶ low efficiency boilers for ground nut shell combustion
- ▶ two stage oil extraction: mechanical (80 %), chemical using Hexane (10 %)

### ◆ NOVASEN

- ▶ private company, using modern equipment
- ▶ highly efficient oil extraction without chemicals (conditioners = rotary hearth furnaces), extraction efficiency 92 %
- ▶ no uses for groundnut shells – dumped, or sold to SONACOS



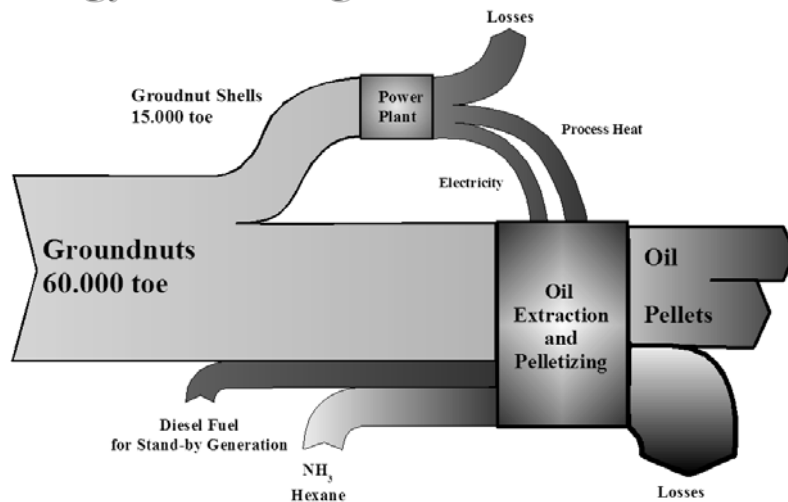
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## Energy Flow Diagram SONACOS



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## Proposed Intervention

- ◆ installation of a pyrolysis plant at NOVASEN, intending to generate
  - ▶ bio-coal from groundnut shells
  - ▶ flue gasses for the running of NOVASEN diesel generator
  - ▶ pyrolysis oil for generation of process heat
- ◆ proposed project structure
  - ▶ private-public partnership with a charcoal (grill-coal) producer from Europe
- ◆ expected result
  - ▶ considerable amount of biocoal produced from groundnut shells
  - ▶ increased efficiency in the NOVASEN factory
  - ▶ reduction of fossil fuel consumption



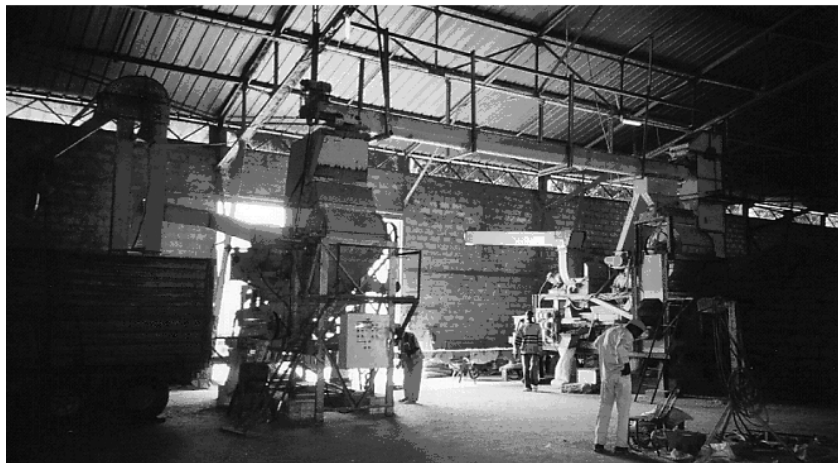
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## Shelling Plants (90 tons/day)



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## Storing Groundnut Shells



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## NOVASEN Rotary Hearth Furnaces



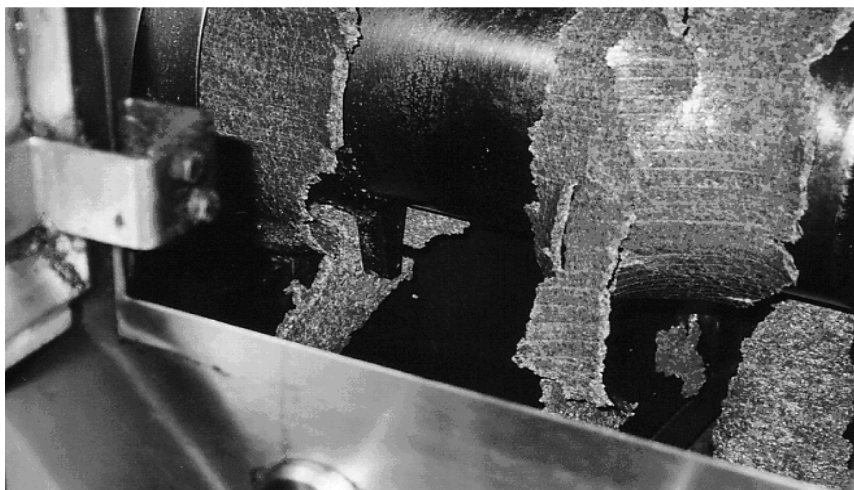
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## Screw Press of “Mechanik Moderne”



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## Diesel Generator 1.25 MVA (1 MW)



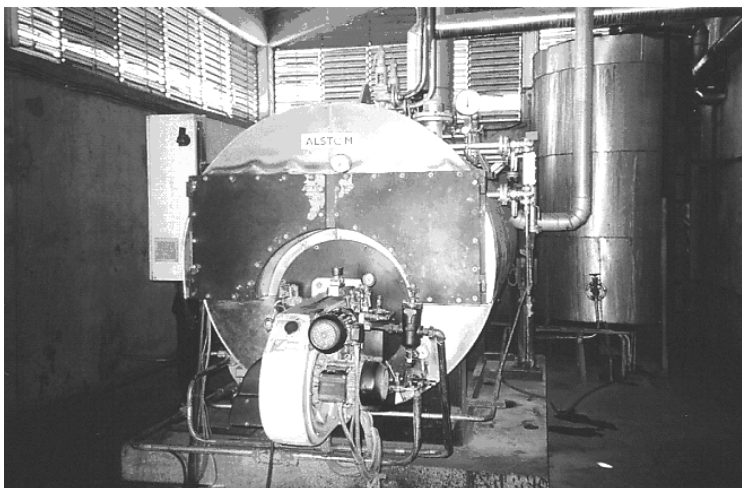
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## Heavy Fuel Boiler for Process Heat



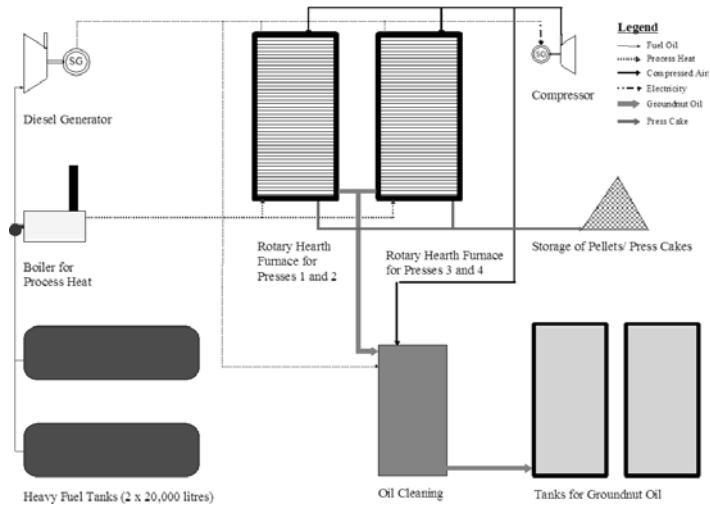
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# Process Flow Sheet NOVASEN (existing)



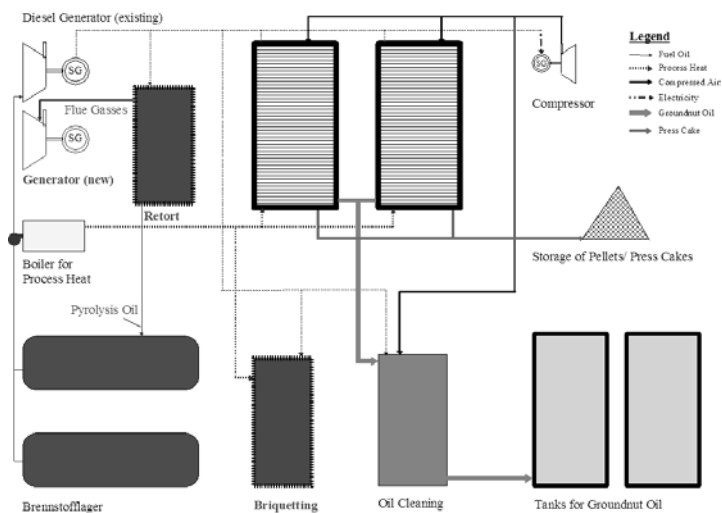
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# Process Flow Sheet NOVASEN (planned)



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## Energy Balance NOVASEN

Input	in t	in toe	Output	in t	in toe	utilized
Groundnuts	30,000	12,000	Groundnut Oi	12,000	4,800	4,800
			Press Cake	18,000	7,200	720
Groundnut Shells	10,000	4,000	Bio-Coal	2,400	1,656	1,656
			Pyrolysis Oil	2,140	449	
			Flue Gasses	2,320	302	
Heavy Fuel	920					
Pyrolysis Oil	-449	471				
Electricity SENELEC 500 MWh		150				
from Flue Gasses		-302				
<b>Total</b>		<b>16,319</b>	<b>Total</b>		<b>14,407</b>	<b>7,176</b>

**Overall Energy Efficiency 44 %**

Note: only 10 % of press cake pelletized (lack of market for fodder in Senegal, lack of pelletizing capacity)



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## Energy Balance NOVASEN max.

Input	in t	in toe	Output	in t	in toe	utilized
Groundnuts	30,000	12,000	Groundnut Oi	12,000	4,800	4,800
			Press Cake	18,000	7,200	720
Groundnut Shells	10,000	4,000	Bio-Coal	4,320	2,981	2,981
			Pyrolysis Oil	4,100	820	
			Flue Gasses	4,200	546	
Heavy Fuel	920					
Pyrolysis Oil	-820	100				
Electricity SENELEC 500 MWh		150				
from Flue Gasses		-546				
<b>Total</b>		<b>15,704</b>	<b>Total</b>		<b>16,347</b>	<b>8,501</b>

**Overall Energy Efficiency 54% (additional pyrolysis of press cake)**

Note: only 10 % of press cake pelletized (lack of market for fodder in Senegal, lack of pelletizing capacity)



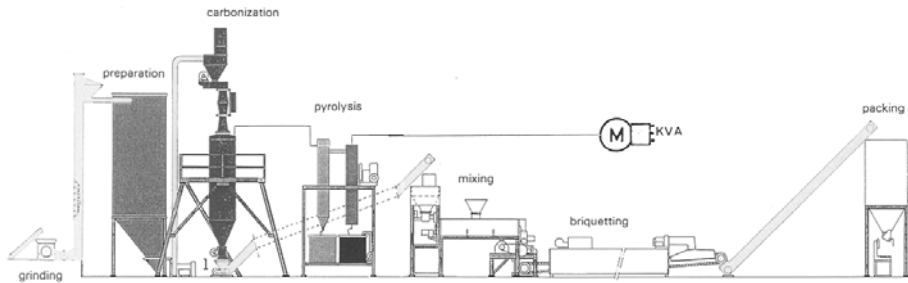
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## First Proposal – Continuous Retort



Source: GENELTEC, Engollon, Switzerland



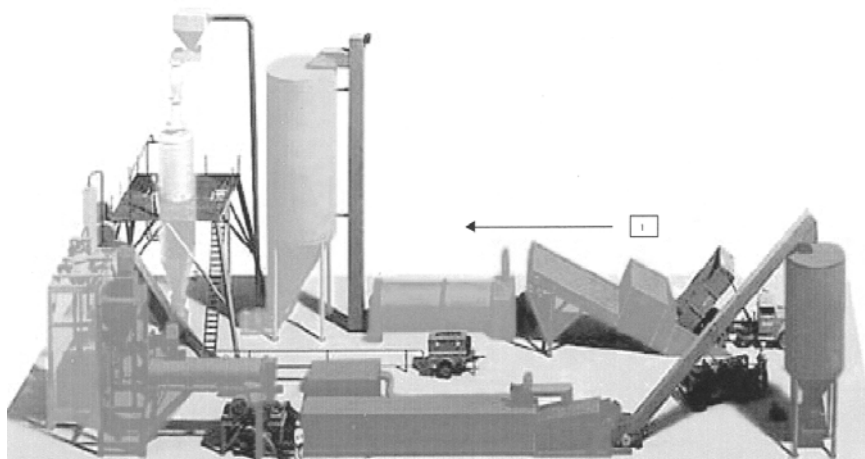
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## Isometric Lay-out incl. Drying & Briquetting



Source: GENELTEC, Engollon, Switzerland



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## Signed Proposal

- ◆ Dutch company Carbo Group B.V. (Amelo, NL) is a major producer of pellets and bio-coal ([info@carbo.nl](mailto:info@carbo.nl), [www.carbo.nl](http://www.carbo.nl))
- ◆ contacted DGIS (Directoraat-Generaal Internationale Samenwerking) General Directorate for International Co-operation, part of the Dutch Foreign Ministry
- ◆ worked out a PPP proposal together with NOVASEN
- ◆ up to 60 % of investment cost can come from DGIS
- ◆ estimated investment ~ 1.5 mill. EUR for complete plant
- ◆ estimated output ~ 4.000 tons bio-coal (= 1 % of Senegal's current consumption)



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## Technology

- ◆ two retorts work in combination
- ◆ batch process
- ◆ for starting, external heating of first retort (fuel)
- ◆ then, flue gasses are directed to the second and incinerated
- ◆ the process is repeated
  
- ◆ for NOVASEN two sets (4 retorts) are planned



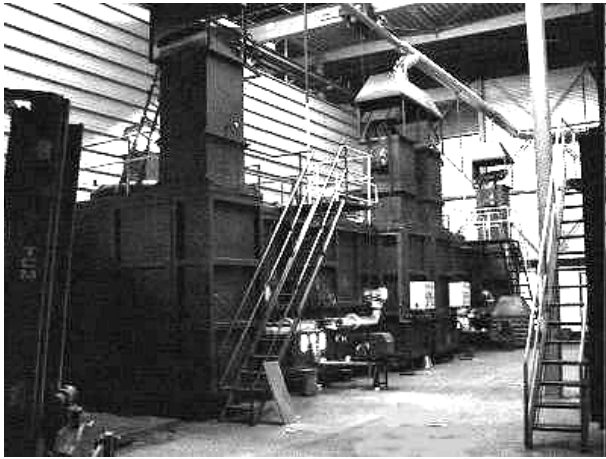
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# Carbonizer CG 2000 Plant (2 retorts)



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# Carbonizer CG 2000 Plant (2 retorts)



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## Summary

- ◆ through using the otherwise wasted groundnut shells, the modern groundnut processing plant NOVASEN can achieve fuel autonomy
- ◆ and, additionally, produce approx. 4,000 tons of bio-coal per year
- ◆ of 14,000 tons charcoal consumption in Kaolack, ~ 28 % can be generated from groundnut shells
- ◆ with ~ 1 mio. tons of groundnut production/a, Senegal has a potential of ~ 100,000 tons of groundnut shell coal
- ◆ other residues, such as biological municipal waste or typha (at the Senegal river) offer additional raw material



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## Outlook

- ◆ through using pyrolysis instead of simple combustion, the overall energy efficiency of a groundnut processing plant can be increased dramatically
- ◆ in addition, pressures from the scarce forest resources in Senegal can be taken
- ◆ this supply-side intervention is much more effective than demand-side measures (such as energy-saving stoves)
- ◆ advantages:
  - ▶ the biomass is collected anyway, no additional transport costs
  - ▶ industrial process guarantees high efficiency (retorts ~ 40 % coal, traditional kilns only ~ 10 ... 15 %)
  - ▶ in using the pyrolysis by-products, the economy of carbonization is improved tremendously



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