

# High Volume Manufacturing of Clean Cookstoves

**Dr. Bryan Willson  
Peter Letvin**



**Global Innovation Center for  
Energy, Environment & Health**

# Global Innovation Center: (1/3) Mission

The Global Innovation Center for Energy, Environment, and Health, is a . . .

- . . . partnership between the College of Engineering and College of Business . . .
- . . . to develop and disseminate solutions . . .
- . . . to global problems . . .
- . . . using a self-sustaining, entrepreneurial approach.



# Global Innovation Center: (2/3) History

Direct-Injection Retrofit Program  
for 2-Stroke Tricycles

Brock Silvers, Dr. Bryan Willson  
EnviroFit International, Ltd.



**Envirofit**

## Engines & Energy Conversion Lab (EECL)

1992

Now one of the world's most active R&D programs for internal combustion engines.

## Envirofit International

2003

A joint effort of the EECL & College of Business to (initially) disseminate a technology solution to pollution from 2-stroke engines in Asia. Now an independent non-profit 501(c)(3) corporation.

## Global Innovation Center

2005

Further EECL / College of Business partnership to promote commercial solutions to large global problems.

**Colorado  
State  
University**

# Global Innovation Center: (3/3) Initiatives

## Household Energy / Stoves

- Stoves Laboratory
- Stove design (BrightLights)
- High volume stove manufacturing
- Village power
- CEIHD / Shell China Prize for Stoves

## Clean Vehicle Technology

- Retrofit solutions for 2-stroke engines
- Retrofit solutions for “dirty diesels”
- “Alternative” fuels: natural gas, “Hythane”
- Biomass fuels: gasification, algae



# Outline

- Global need for clean stoves
- Current manufacturing practice
- Low-cost manufacturing options
- The modular factory approach
- Design implications
- Implementation strategy

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# Need for Improved Cookstoves

- Health impacts
  - 1.5 million – 2+ million annual deaths
  - Leading cause of death for children under 5
  - 2<sup>nd</sup> leading cause of death for women
  - Significant contributing factor to many other causes of premature death: water quality, disease, etc.
- Deforestation
- Climate Change



# Global Need

- Almost half of the world's population use solid fuels for household energy:
  - ≈ 2 billion utilize biomass
  - ≈ 1 billion utilize coal
- With 4 people / stove, the “global need” is ≈500 million biomass cookstoves



# EECL Involvement Began through Measurement



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# Global Manufacturing Status

- Many excellent stoves programs
- Cumulative production quantities of 10,000 – 100,000 are exceptional
- China instituted a high production program for coal stoves, with 120+ million units produced
- No established high-production paradigm for biomass stoves



# Great Innovation! Now we Need Production!



# AHDESA Stove Models



EcoLenca, \$10



EcoFogon, \$90



EcoTortillero, \$113



EcoHorno, \$120



EcoBarril



**EcoLenca**  
Fogón decorativo, portátil y super eficiente. Caliente agua en minutos. Ahorre barbaridad de leña cocinando frijoles, sopas, guisados y arroz...  
Precio Lps. 200





**EcoFogón**  
Ahorre leña, proteja su salud y embellezca su hogar mientras cocina todo de un solo. Plancha amplia y duradera de 22" x 22"  
Precio Lps. 1,750



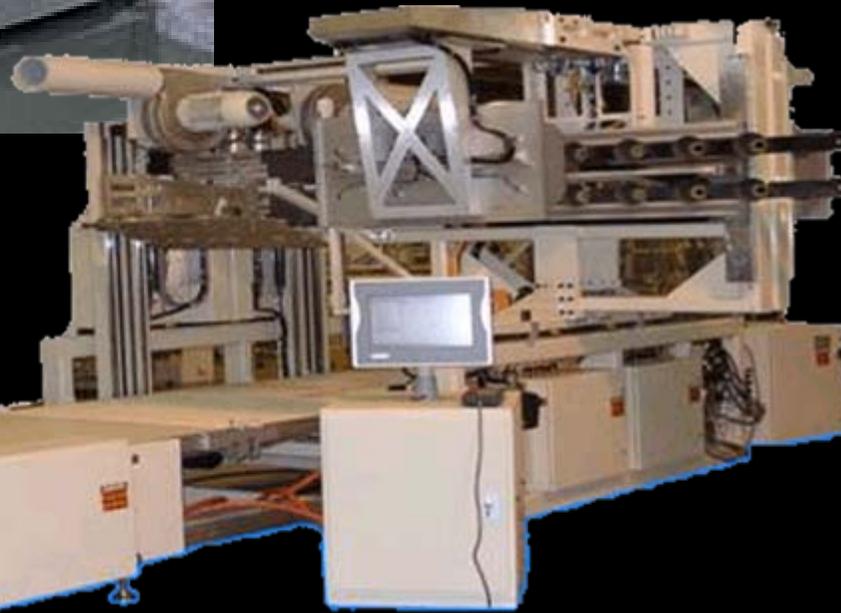
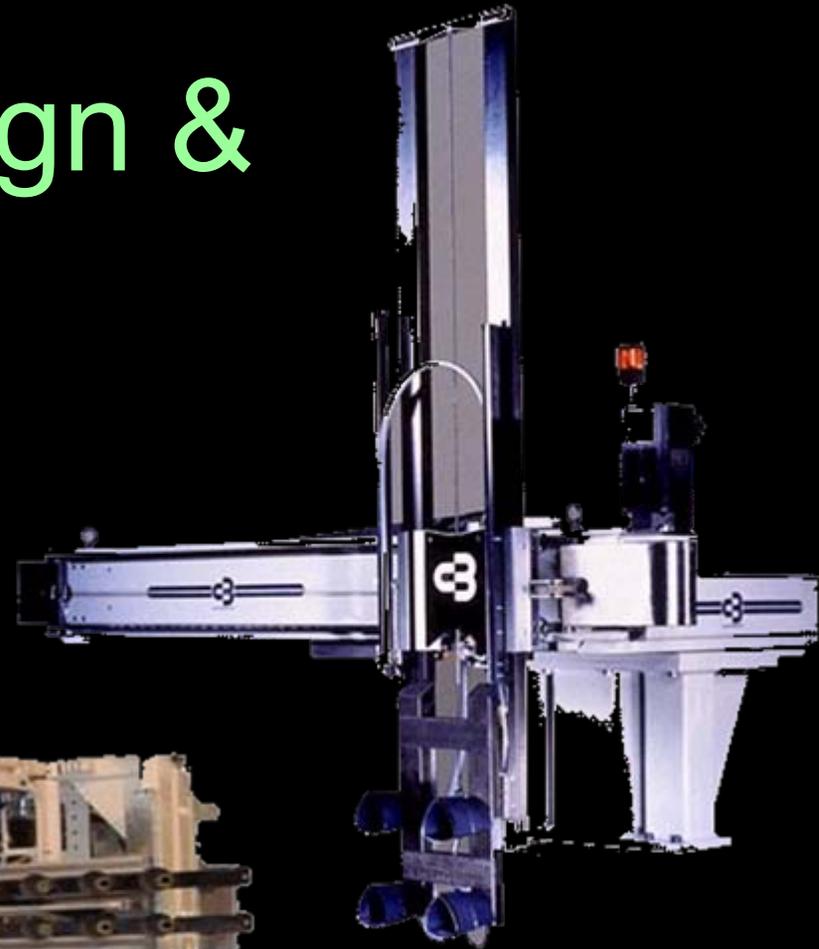
**EcoHorno**  
Cocine en plancha de hierro mientras hornea con el mismo combustible. Plancha amplia y duradera de 16" x 30".  
Precio Lps. 2,350



**EcoTortillero**  
Para su negocio o hogar- coben hasta seis ollas a la vez-ideal para pupusas, tortillas, y más. Vera ahorros desde su primer uso. Plancha amplia y duradera de 20" x 32". Precio Lps. 2,200

Pida el suyo en AHDESA 227-9224

# Background: Design & Manufacturing



# Elements of a Clean Stove: AHDESA EcoHorno Stove, Honduras

Chimney

“Plancha” (griddle) for tortillas

“Rocket”  
combustion chamber  
for high efficiency &  
low emissions

“Horno” (oven)  
for bread



# AHDESA Stoves

- The Ecohorno stove has an oven
- The Ecofogon does not
- There is also a model with an extended plancha and no oven for tortilla makers (largest source of income for low-income women)



**EcoFogon**



**EcoHorno**

# Stove Factory in Tegucigalpa, Honduras



# “Batch” Production



# Manual Marking & Cutting



# Manual Cutting



# Sheet Metal Bending



# Measuring



# Drilling



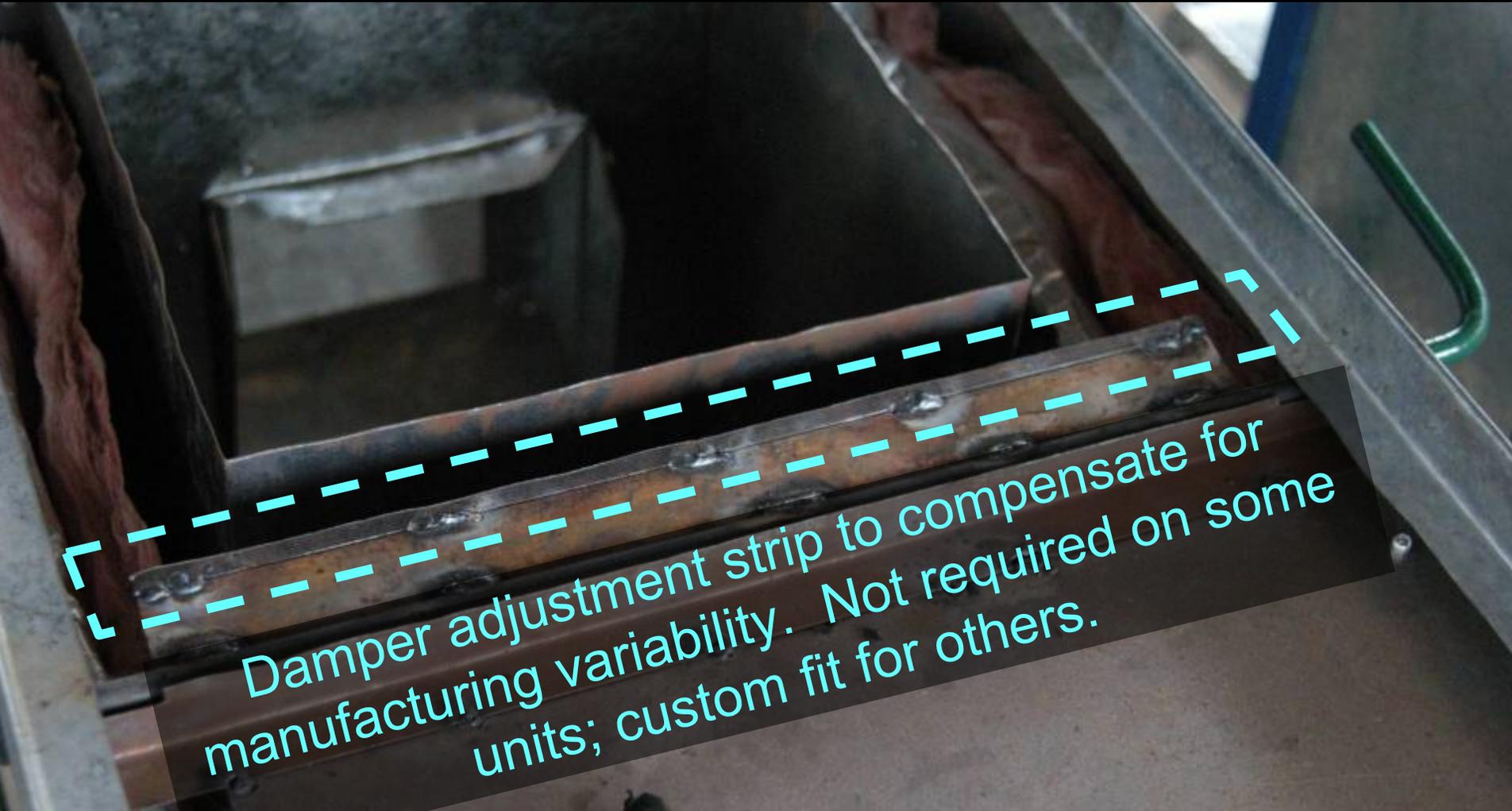
# Sheet Metal Transition Pieces for Chimney Attachment



# Welding of Planchas



# Material Rework



Damper adjustment strip to compensate for manufacturing variability. Not required on some units; custom fit for others.

# Customers



# Satellite Stove<sup>27</sup> Factory #1



# Satellite Stove Factory #2



# Satellite Stove Factory #3



# Satellite Stove Factory #4



**CENTRO DE CAPACITACION DON BOSCO**  
**"TALLERES VOCACIONALES"**

**CURSOS DE APRENDICES:**

- EBANISTERIA-REDES
- SOLDADURA-INFORMATICA
- MECANICA
- TAPICERIA-AUTOMOTRIZ

**CURSOS DE OBREROS:**

- EBANISTERIA
- ELECTRODOMESTICOS
- AUTOMOTRIZ
- ELECTRICIDAD

**DE LA SANA EDUCACION DE LA JUVENTUD  
DEPENDE EL FUTURO DE LAS NACIONES**

**DON BOSCO**



# Ceramic Factory



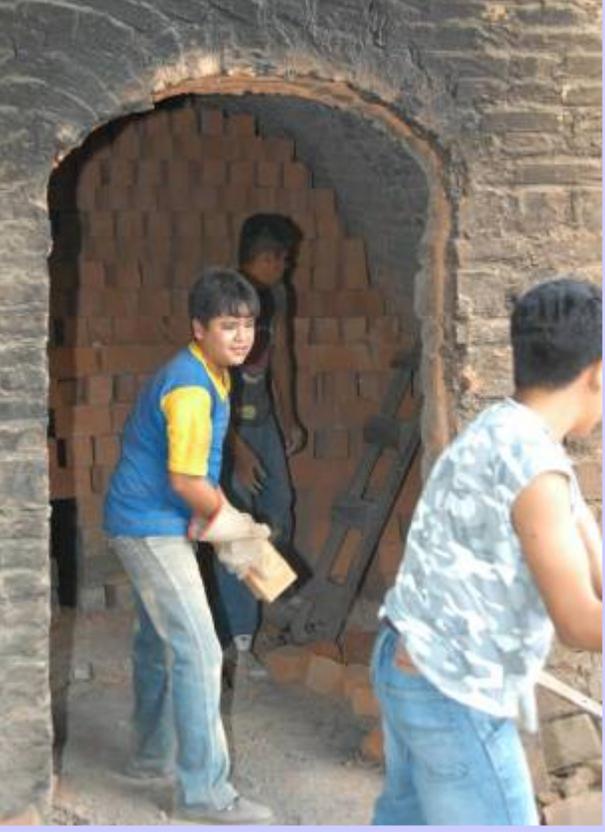
# Ceramic Manufacturing



# Ceramic Manufacturing: An Amateur at Work. . .



# Firing Kiln



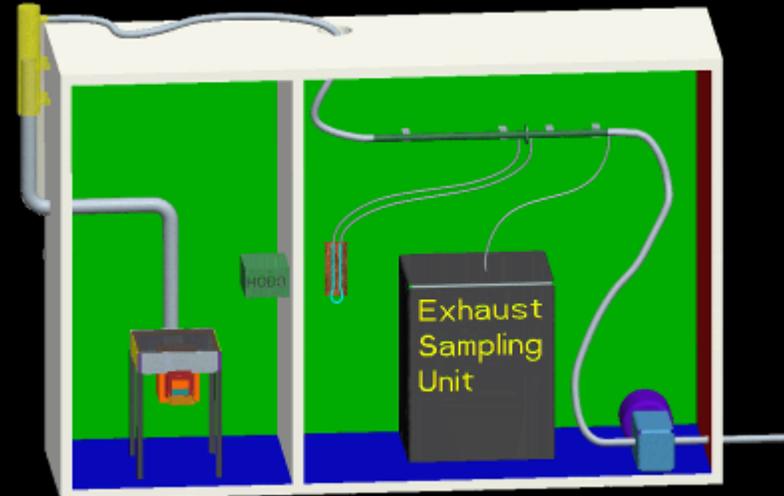




Flame  
deflector

# A Note on China

- China has a history of mass production of stoves – for coal
- Could transform industry to quickly ramp up for wood stove production
- But officially, wood no longer used as a fuel; compressed crop briquettes used



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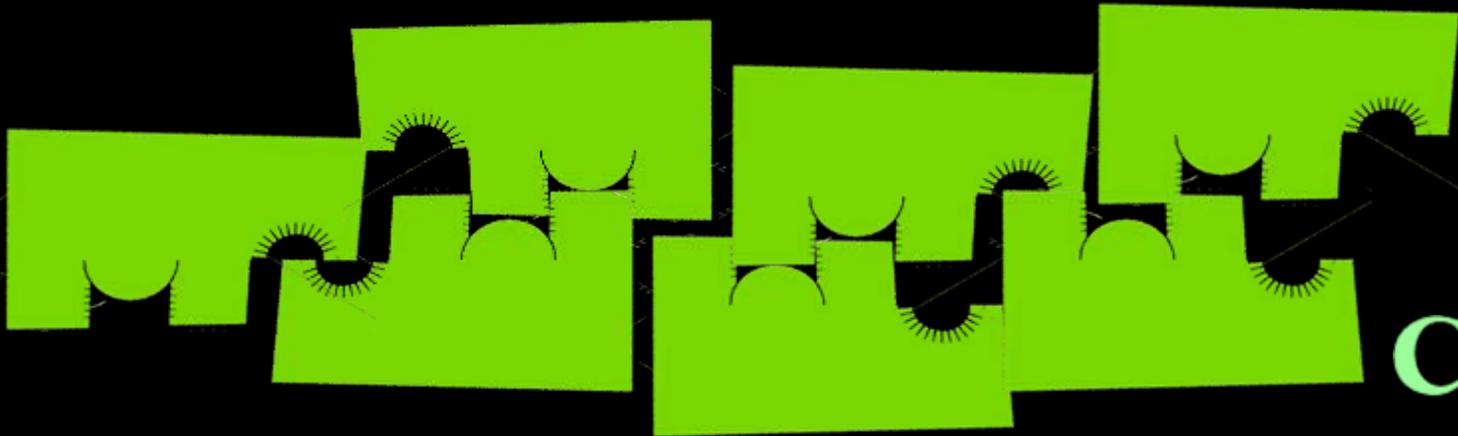
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# The Importance of Cutting

- Cutting is the key operation in high-quality, high-volume manufacturing (of metal stoves)
  - Establishes the quality of the product
  - Determines whether specialized “downstream” equipment can be used
  - Allows the use of high precision nesting to minimize material use



# Cutting Options

## Die-stamping (“blanking”)

- Large up front cost, but lowest cost for high volumes
- Challenge to maximize “nesting” (minimize material)
- Little flexibility for design adaptations

## CNC “nibbling”

## Plasma cutting

- 1 layer, best for mid-weight steels

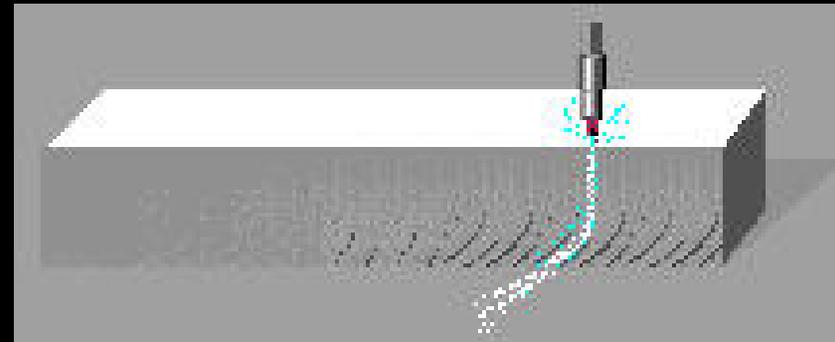
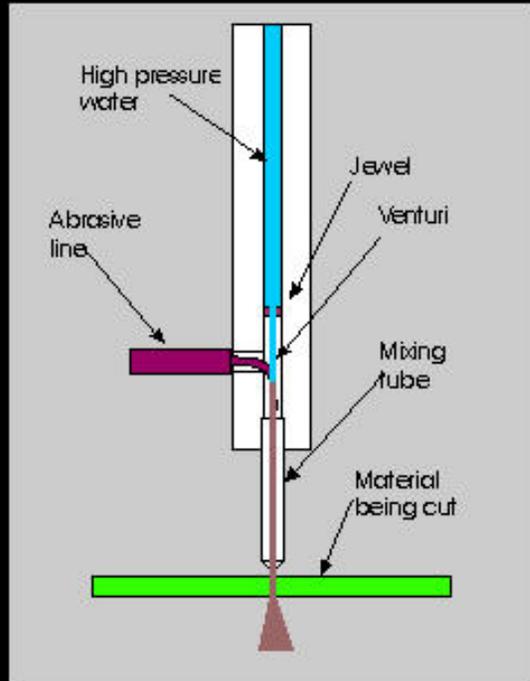
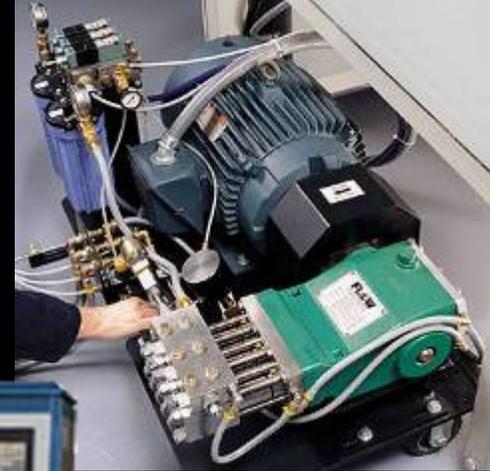
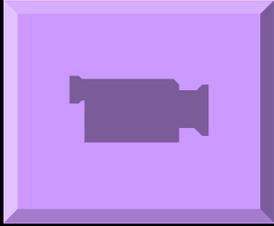
## Laser cutting

- Fast for thin steel
- Comparable cost to water-jet

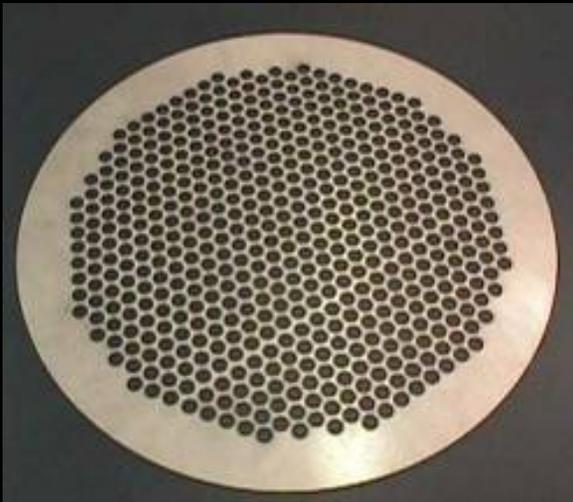
## Water-jet cutting

- Multiple layers
- Ceramics & steel
- Modest training for maintenance / operation

# Water-Jet Cutting



# Waterjet-Cut Parts



# Commercial Machines



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# Outline

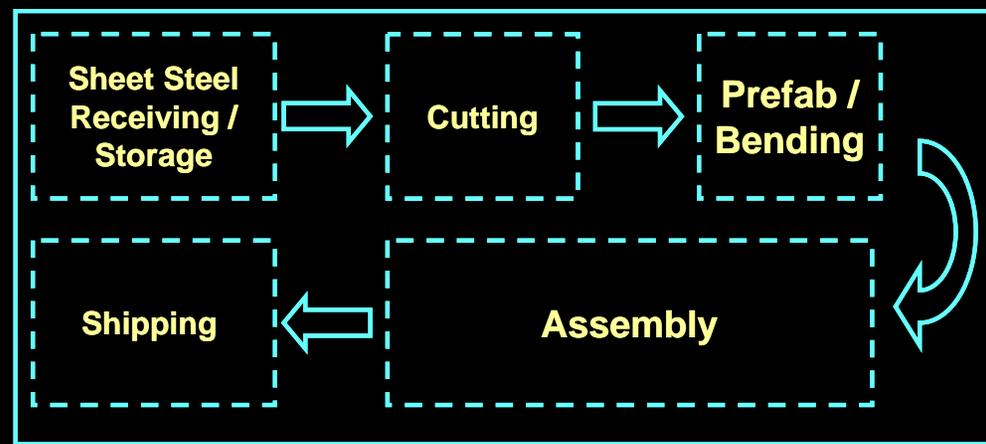
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# Self-Replicating Factory Concept



Water-jet cutter first used to produce the “rest of the factory” – the downstream production equipment:

- “Indexed” bending Brakes
- Jigs & fixtures



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# Manufacturing Considerations

If a proven design exists:

- Re-examine design for efficient cutting:
  - Maximize nesting (reduce waste)
  - Minimize cuts (use existing & common edges)
- Include features for efficient downstream operation:
  - Cut all holes, as well as edges
  - Indexing features for bending & joining
  - Marking & perforations

# Principles

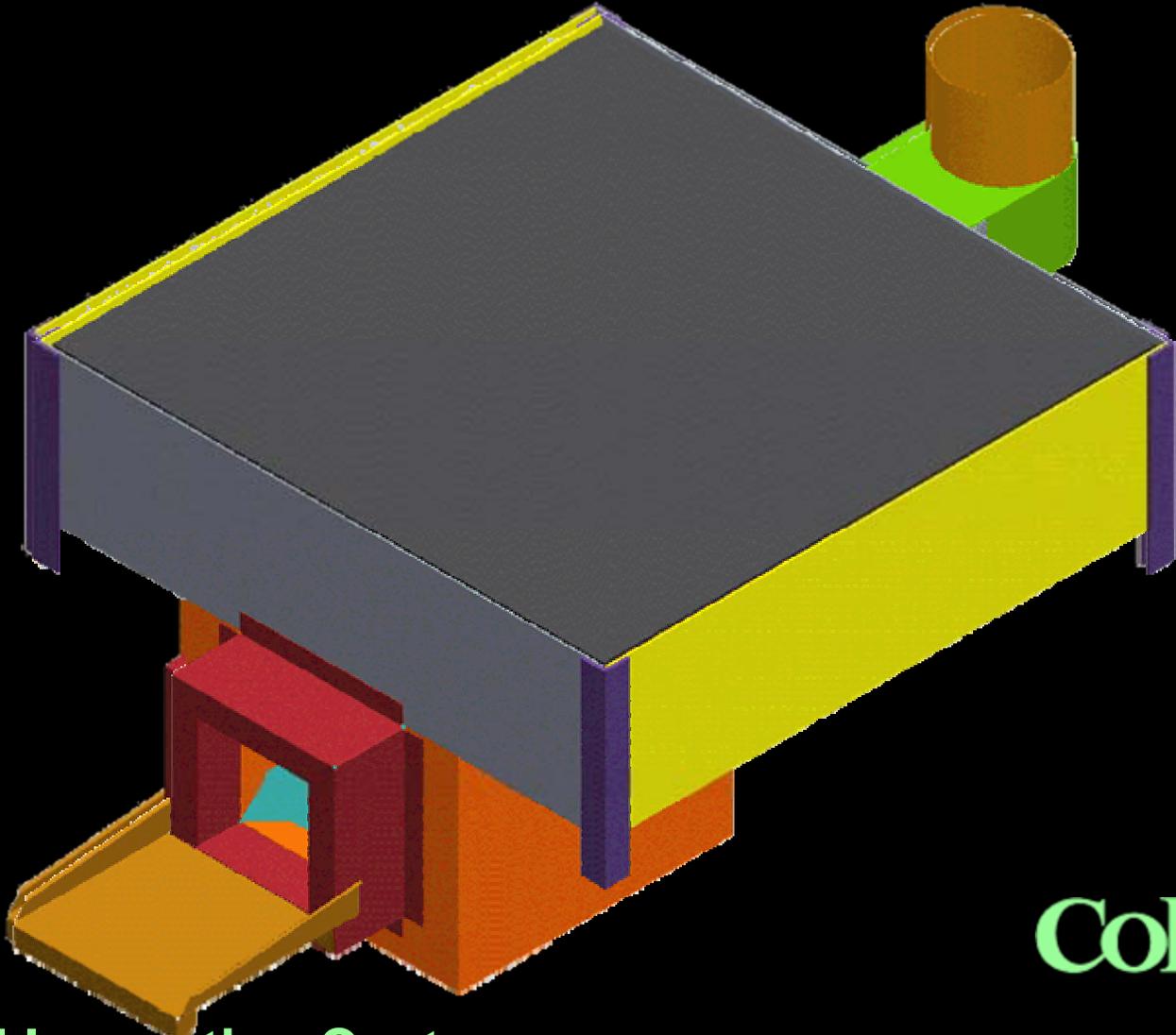
Consistent, Clean, Efficiency, Affordable,  
Durable, Desirable

AHDESA motto:

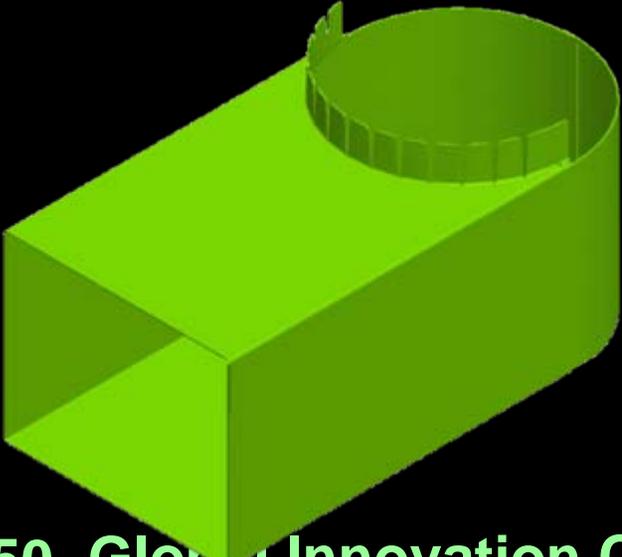
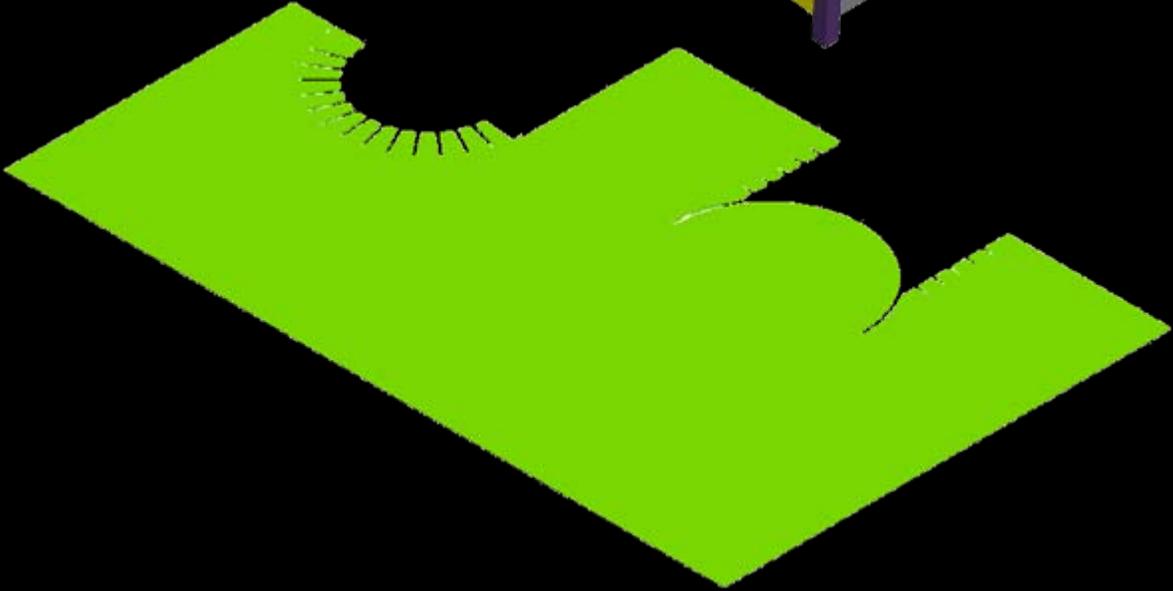
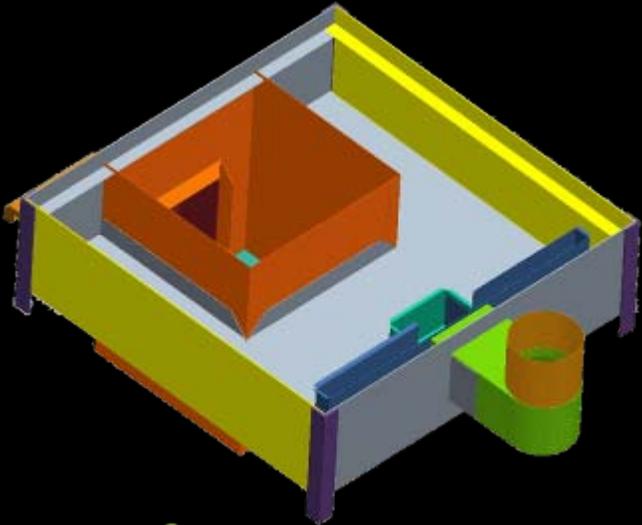
*A stove must be:*

- *Bueno* (Functional)
- *Barato* (Affordable)
- *Bonito* (Beautiful)

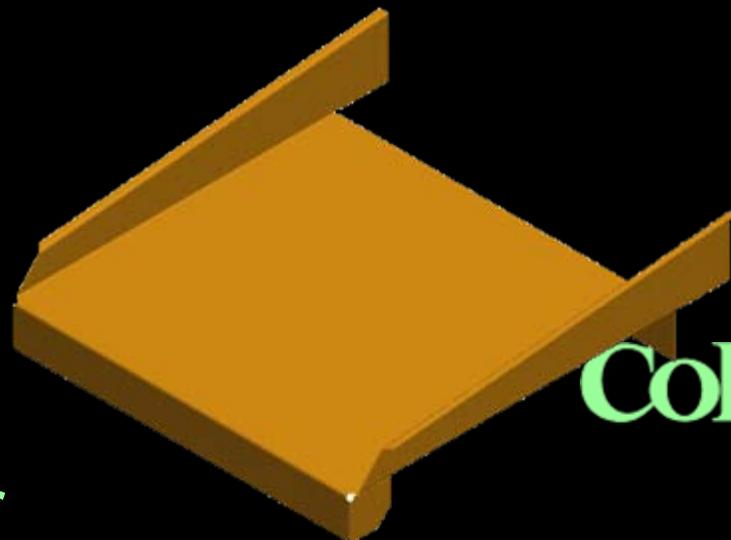
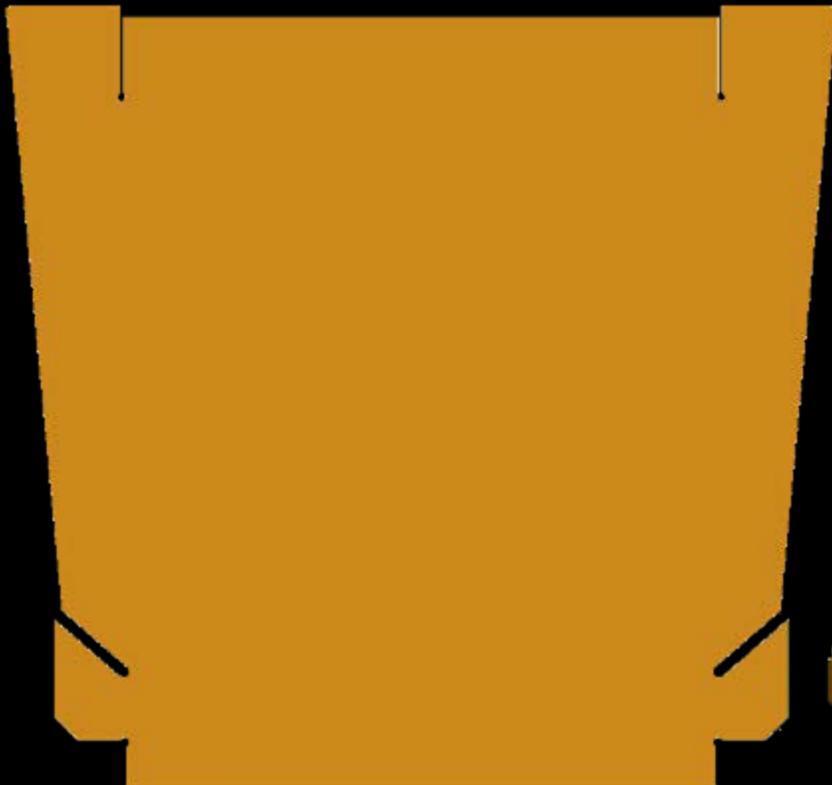
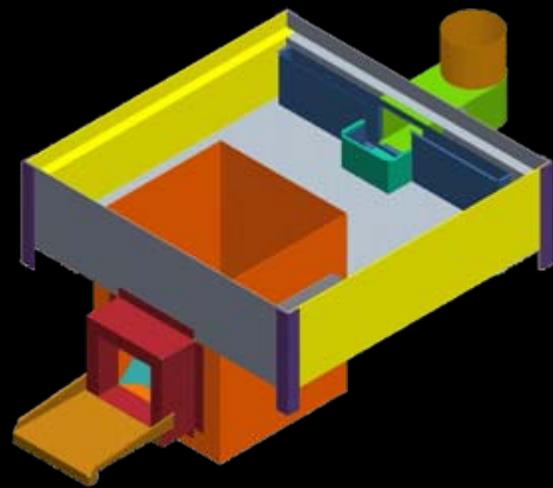
# EcoFogon Stove



# Exhaust Elbow



# Feeder Tray



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# Throughput

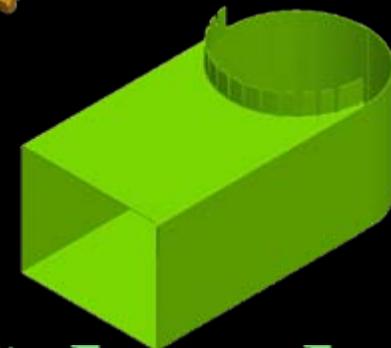
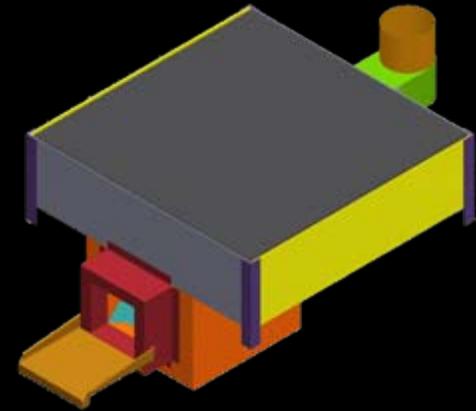
- With stacking & optimization, potential to average cutting of 1 stove every 2 minutes:
  - 30 / hour
  - 2 shifts: 500 / day
  - 5 days / week: 100,000 / year
- Downstream production line can match this throughput, but may exceed purchasing capacity of immediate area
- Suggests regional assembly at satellite shops
  - Will require duplicate downstream production equipment
  - Downstream equipment easily replicated

# EcoFogon Costs

Current Production Cost  $\approx$ \$80

Target Cost for High Production  $\approx$ \$20

- Cost of cutting & capital \$2
- Steel cost reduction to \$12
  - High volume purchasing
  - Improved material nesting
  - Reduced rejection rate
- Ceramics, paint, materials \$3
- Labor costs reduced to \$3
  - Reduced cutting time
  - Improvement in downstream production
  - Elimination of rework
  - Efficient material flow



# Marketing

- Must be approached both regionally & locally
- Significant uncertainty in market projections
- Indications are that a high-quality \$30 plancha stove would sell well w/o financing
- Possible to meet with a \$20 manufacturing cost, but a relatively tight margin for marketing & distribution

## MANUAL DEL USUARIO

**ECOFOGON**  
*La Mejor de las Cocinas Mejoradas*

ECONOMIA Y SALUD PARA SU NEGOCIO Y SU CASA.



EXCELENTE PARA EL USO DOMESTICO Y PEQUEÑOS NEGOCIOS  
**ECOFOGON**

# Potential Market Prioritization

## Phase I - Honduras

- Established products & production w/ 3 models

## Phase II – Central America

- Expand focus to include El Salvador, Nicaragua, Guatemala, Panama, Costa Rica

## Phase III – Other Markets

- South America: Brazil
- Asia: India, Nepal, China
- Africa: East, Central, Highlands



# Candidate Organizational Elements

- AHDESA / TWP Elements
  - Local market knowledge
  - Product developed for local needs
- Envirofit-like Elements:
  - Top-notch technology & manufacturing
  - High production business approach
- Financial Targets
  - Must at least be sustainable
  - Goal is profitability



# Recent Partner Recognition

