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Plastofuel™:
Automating & Commercializing this EfW process

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"Discarded plastic is not trash - It's a previously used resource!"

To be covered today:

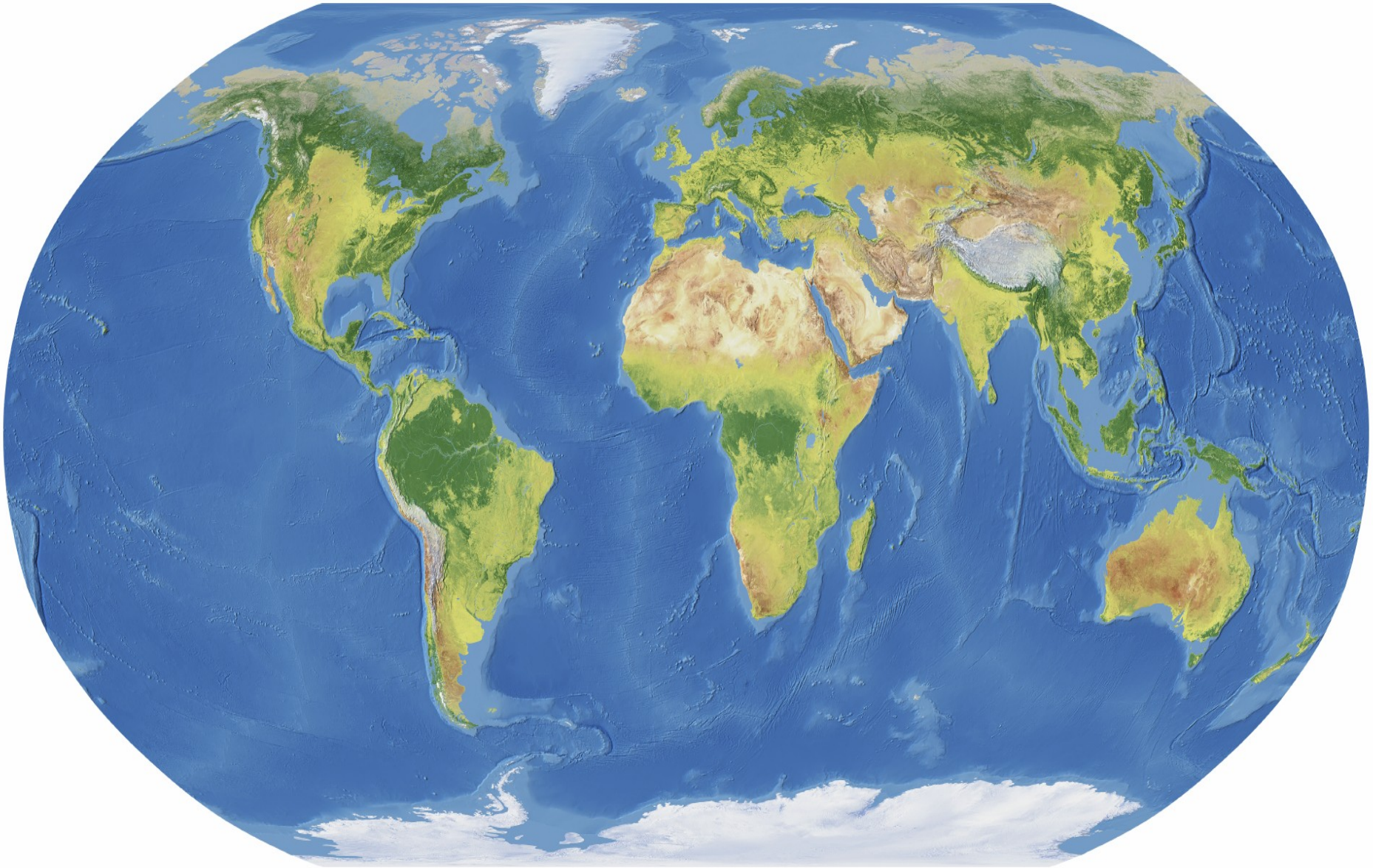
- The product: Plastics
- The waste: Plastics
- The energy source: Plastics
- Making plastic-derived fuel efficiently: Plastofuel™
- Burning plastic-derived fuel cleanly: Eco-Clean Burners

The product: Plastics

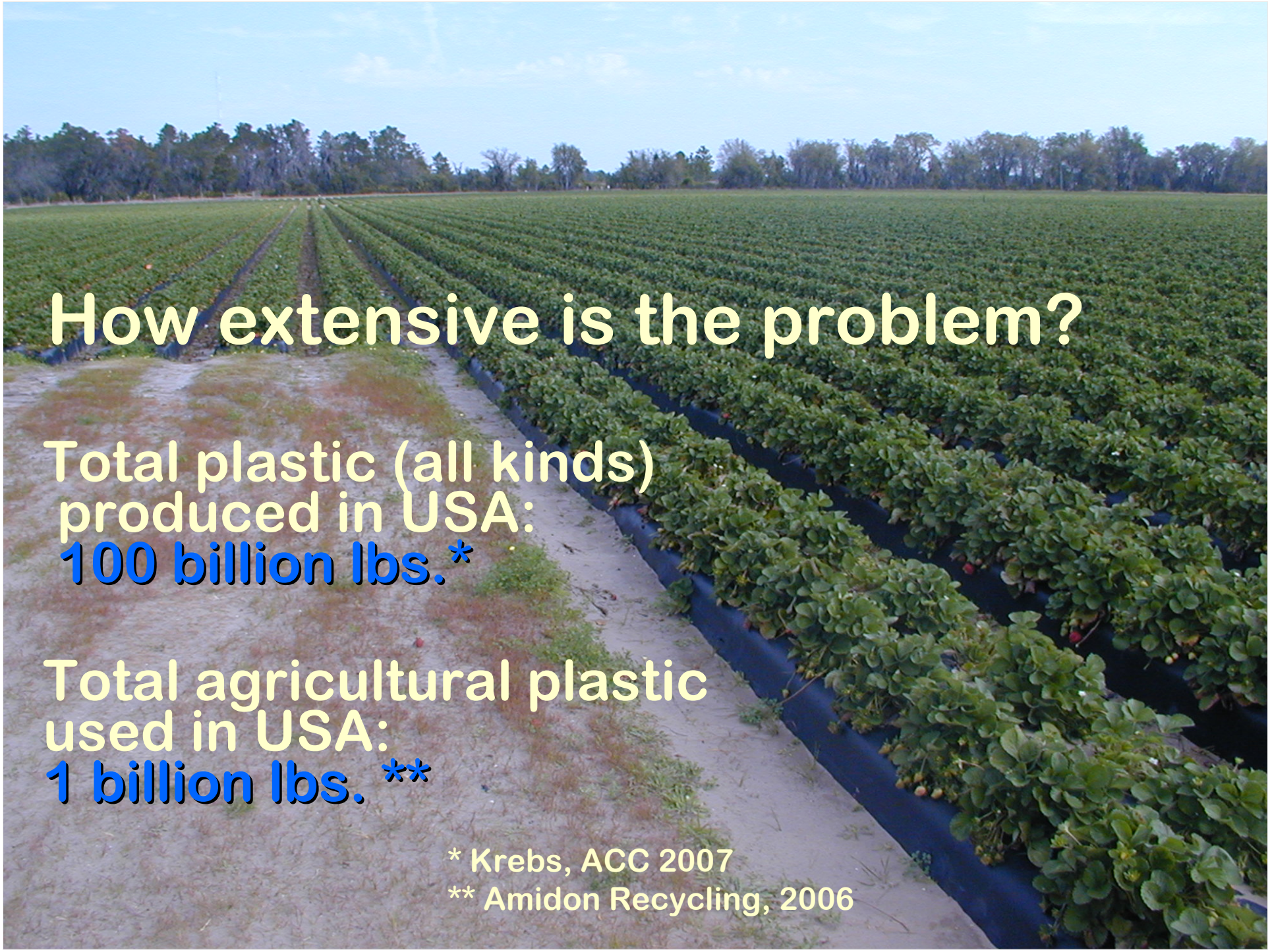
Our first target has been *plasticulture*


Plasticulture is the use of
plastics in agriculture

Plasticulture is a multi-billion dollar industry!



Plasticulture is worldwide!



How extensive is the problem?

Total plastic (all kinds) produced in USA:
100 billion lbs.*

Total agricultural plastic used in USA:
1 billion lbs. **

* Krebs, ACC 2007
** Amidon Recycling, 2006

Also, we've targeted many wasted household products:

#2 HDPE (buckets, tubs, toys)
#4 LDPE (plastic sheeting, tubing)
#5 PP (bottle lids & labels, tubs, cases)
#6 PS (dinnerware, plates, clamshells, cups)

The waste: Plastics

Mismanaged resources


Open burning

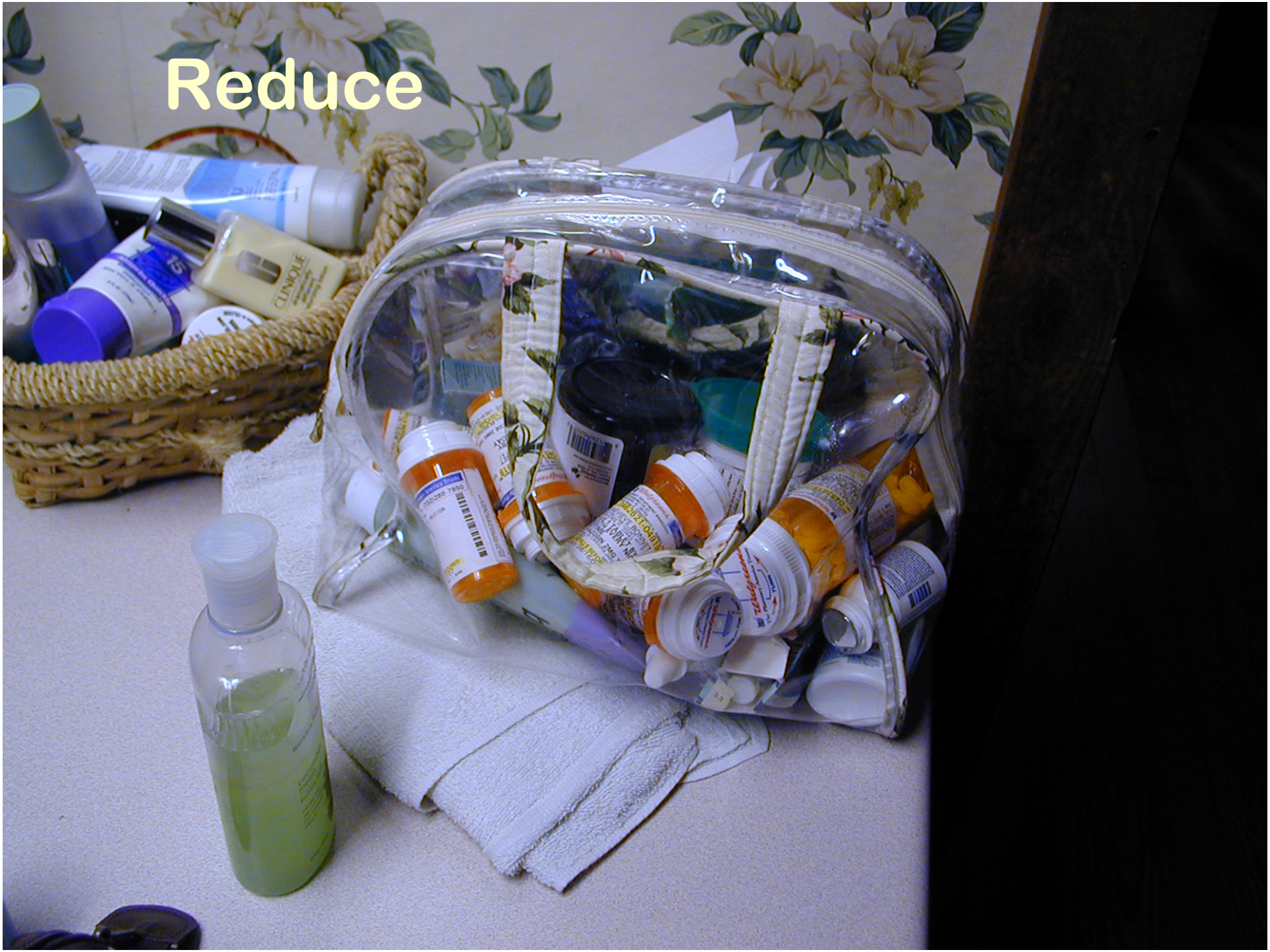

Burying

Littering

Management options

Sending to landfill

Reduce




Reuse


Recycle

Thermal recovery

No air
pyrolysis

Partial air
gasification

Excess air
combustion

The energy source: Plastics

At Penn State, our belief is to recycle whenever possible.

If recycling is not an option…

…why not capture the high heat content of plastic?

Material	Heating value, MJ/kg (Btu/lb)
Fuel Oil	48.6 (20,900)
Polyethylene (pots, tubs, sheeting)	46.3 (19,900)
Polypropylene (rope, lids, tubs)	46.2 (19,850)
Cross-linked PE (PEX tubing)	46.0 (19,780)
Gasoline	44.6 (19,200)
Polystyrene (inserts, Styrofoam)	41.4 (17,800)
PA Kittanning coal	32.3 (13,900)
Wyoming coal	22.3 (9,600)
Wood	19.3 (8,300)
Newspaper	18.6 (8,000)
Textiles	16.0 (6,900)
Municipal waste (dry)	16.2 (7,000)
Yard waste	7.0 (3,000)
Food waste	6.0 (2,600)

There are 2 technologies we are striving to marry

First Technology –

Making plastic-derived fuel efficiently: Plastofuel™

Plastofuel™ extrusion concept is simple…

- Forces rigid & film plastic through a heated die
- Electric band heaters melt only a thin jacket
- Locks dirt & plastic pieces inside

Benefits of the process

- Works with common thermoplastics
- Low energy input (1/10th that of pellets)
- Can stockpile seasonal ag supplies
- #3, #4 - #7 have little value
- Market for MRF rejects

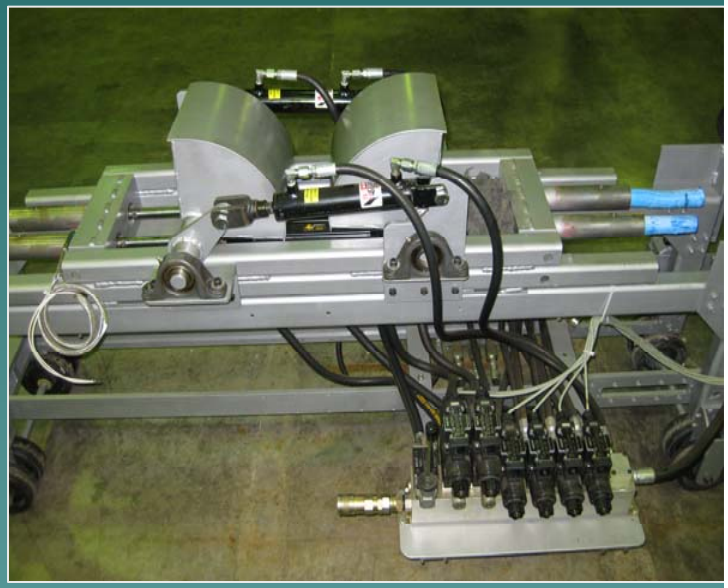
Benefits of combustion

- Densified for easy storage, transport and metering
- Clean burning when co-fired with coal
- 2000°F temperatures eliminate black smoke
- Dirt and debris managed with ash

Combustion testing

- Conducted at PSU's Energy Institute
- A stoker simulator was used
- Emissions results were favorable

Prototype machinery development …



Mid-1990's --
Ram extrusion,
1½ inch diameter


Mid-2000's --
Linear grid extrusion,
1½ x 1½ inch square

Calculations for linear grid system…

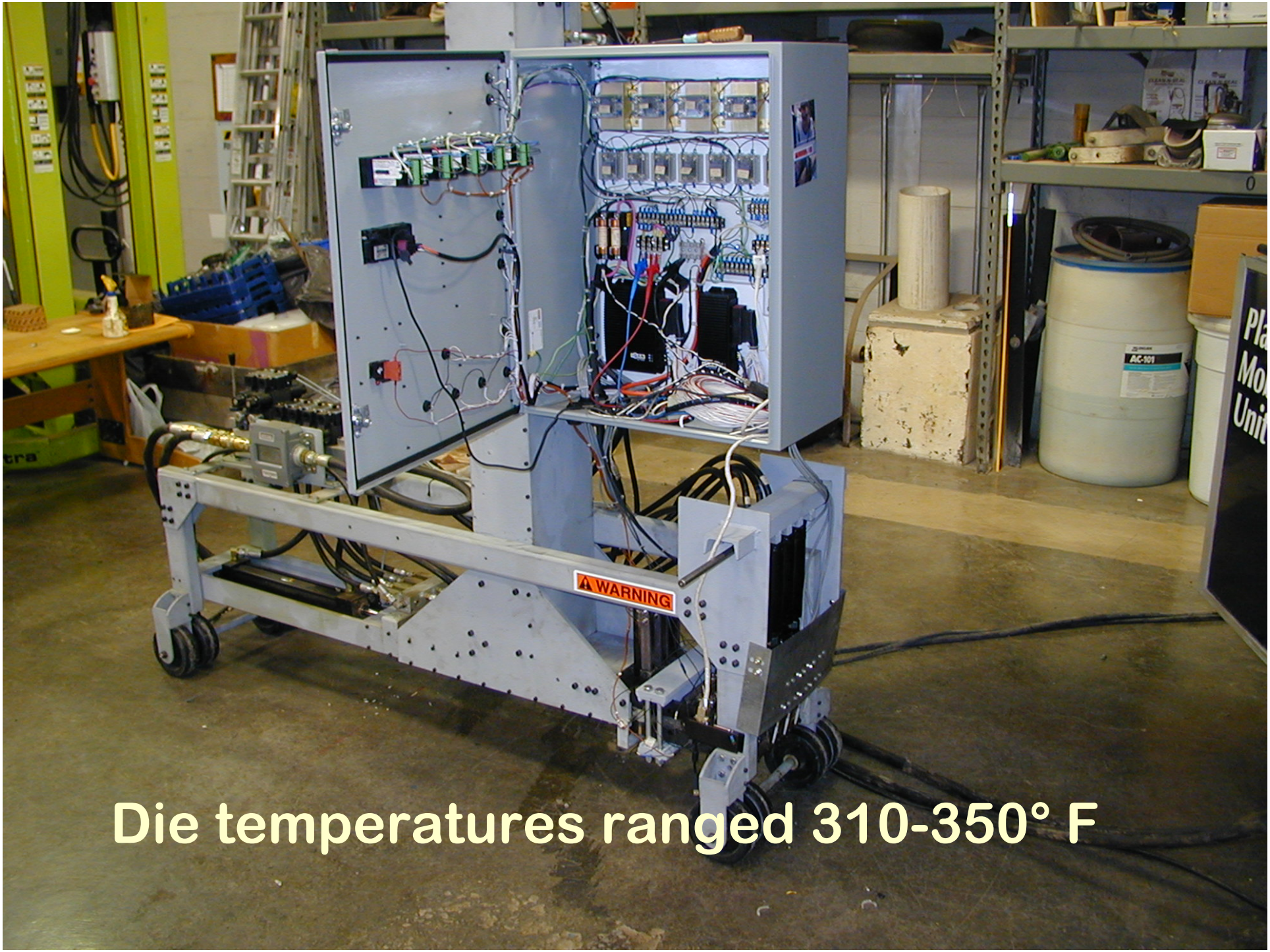
- 1:100 energy balance
- 500 lbs/hr throughput

Linear grid design spec's…

Costs: Not yet determined

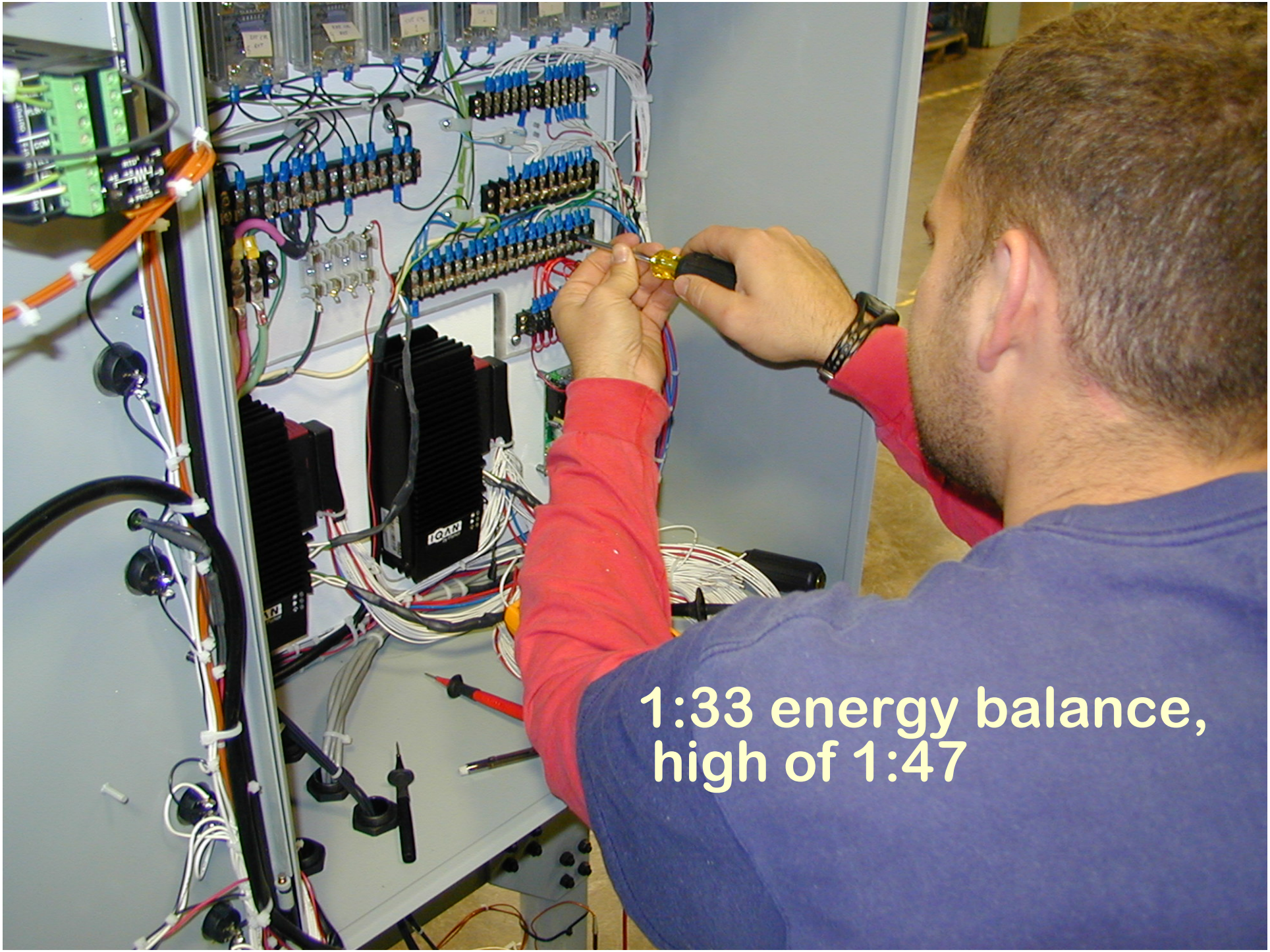
Power: 40 hp. diesel engine / generator

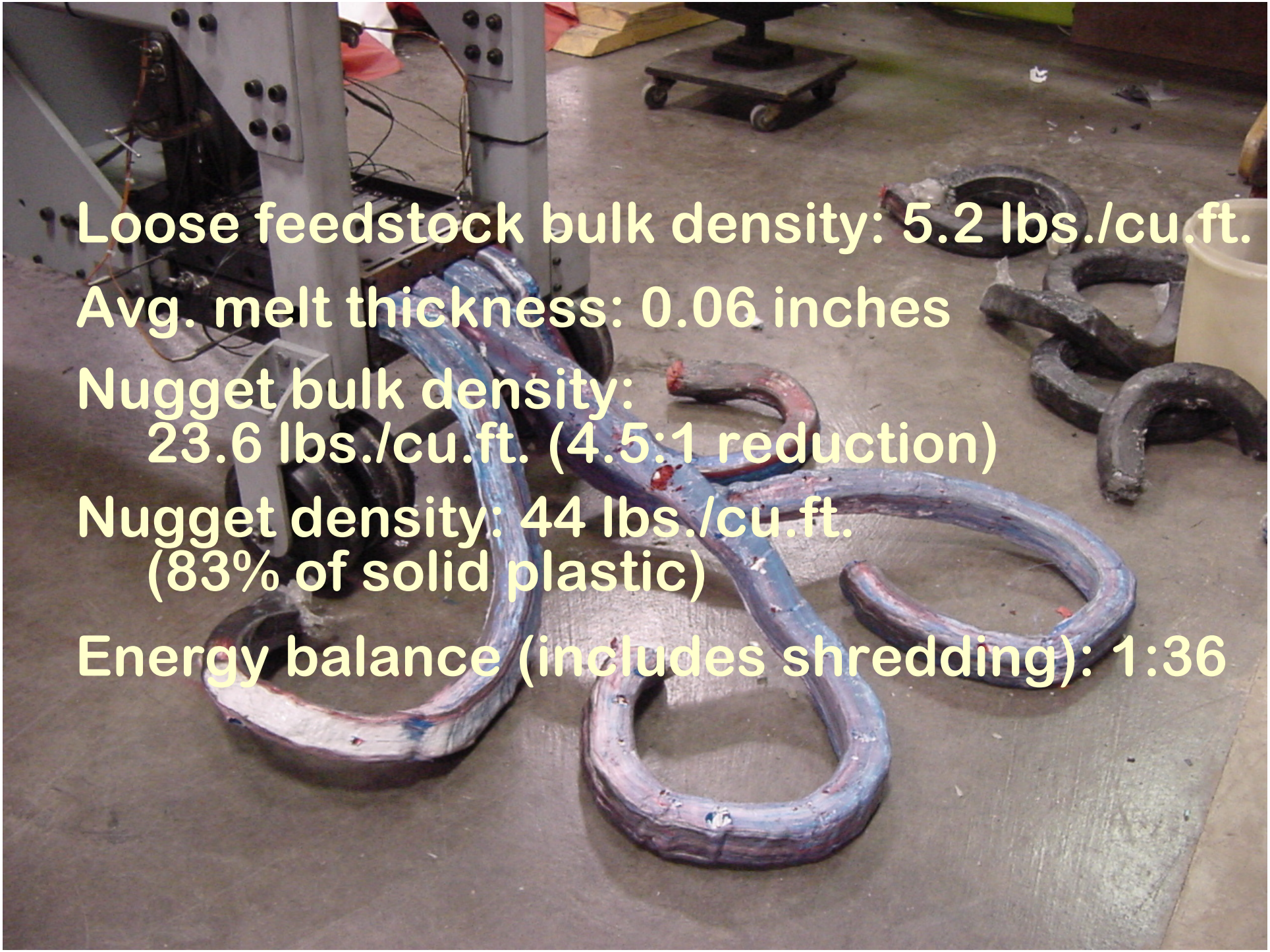
Hydraulics: 20 gpm, variable displ., load-sensing piston pump



Die temperatures ranged 310-350° F

Throughput averaged 46 lb/hr.


1:33 energy balance,
high of 1:47



Loose feedstock bulk density: 5.2 lbs./cu.ft.

Avg. melt thickness: 0.06 inches

Nugget bulk density:
23.6 lbs./cu.ft. (4.5:1 reduction)

Nugget density: 44 lbs./cu.ft.
(83% of solid plastic)

Energy balance (includes shredding): 1:36


Today, back to
ram extrusion,
3 inch diameter

Latest prototype is still under development…


…whimsically called
“80 mm Plastocannon”

Commercialization?


Partnering with pulp and paper industry
(One plant: 50-80 tons waste / day, year round)


Plan is to have manufacturer design
for commercialization

So there you have it – a process to efficiently make a high-energy fuel …Plastofuel™

Now, let's peek at the 2nd technology* to cleanly burn plastic pellets

*Note this technology cannot feed large Plastofuel™ but someday will

Second Technology –
Eco-Clean Burners, LLC

Eco-Clean Burners concept

- Sustains combustion at 1100 °C (2000 °F)
- Hot water boiler system
- Fueled on pellets or granules

Horticulture Research Farm emissions testing…

2005: Clean pellets tested with great results

2007: Dirty mulch film tested with great results up to 17% dirt!

In 2005 & 2007, tested for 3 primary emissions:

- Particulates
- Acid gases
- Furans / dioxin

Demonstration site at Iannetti's Garden Center near Pittsburgh…

- Test in production greenhouses
- Assure system is failsafe
- Verify fuel supply system

Eco-Clean Burners, LLC
(Shown installed at Iannetti's)


Iannetti's Garden Center

What's next?

Our design and research ideas include…

- Commercializing the Plastofuel™ machine
- Modifying feed device for Korean burner to accept large pieces / Plastofuel™
- Pilot testing Plastofuel™ combustion in large greenhouse or power producer setting

In summary, we know…

…we can make plastic fuel energy efficiently
…we can burn plastic very cleanly
…trash is a resource.

So, what are we waiting for?


Thank you. Any questions?