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Effectively Responding to Humanitarian Crises: The *Berkeley-Darfur Stove Case Study*

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a student design competition for sustainability

SUSTAINABLE PRODUCTS + SOLUTIONS PROGRAM
CENTER FOR RESPONSIBLE BUSINESS

And numerous individual donors, advisors, and the sweat and dedicated efforts of many volunteers (over the years, total now >100)

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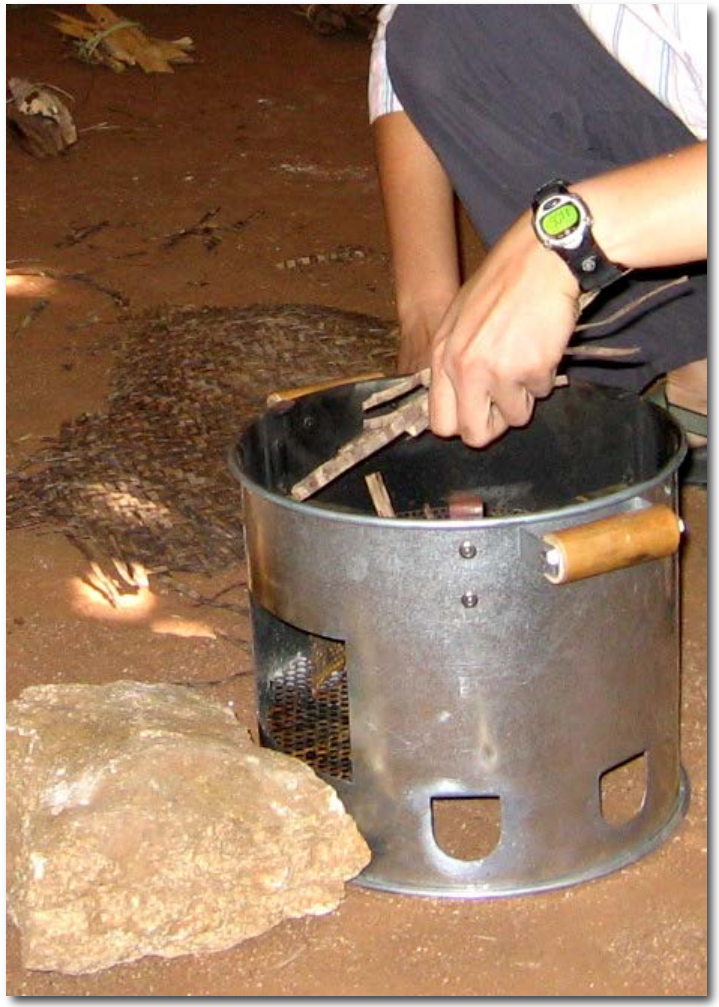
The Plight of Internally Displaced Women in Darfur

- 2.7 million (mostly women and children) driven into crowded IDP camps
- Women and girls travel an average of 7 hours to fetch firewood for cooking
- Wood is almost inaccessible in North Darfur due to firewood depletion

Increase Thermal Efficiency and Reduce Fuel Consumption

- Field tested four different existing stoves in Darfur in 2005
- Indian metal stove (~10 USD) cut the fuel-wood use by 50%, but was unsatisfactory in other ways
- No stove was suitable enough to distribute to the IDP women – because none fit their key needs



Efficient Metal Cookstoves

Improving Metal Cookstoves for Darfur: 2005

Side-by-side testing revealed needs of Darfur cooks and required design improvements to increase user adoption

Finalizing the Berkeley-Darfur Stove (BDS) Design 2007-2009

1. Iteratively improved design based on user feedback

2. Iteratively improved design for local assembly, lower cost, and fewer parts

3. Finalized Design (BDS version 14) ~20 USD

Designing for Performance and Usability

User Requirements

1. High heat output (~5kW)
2. Flame visible to the cook
3. Uses collected firewood
4. Compatible with Darfuri pots and cooking methods

Performance Requirements

1. 50% fuel savings/increased thermal efficiency
2. Not designed with respiratory health as a main goal

First Field Tested Prototype, 2007 (Berkeley-Darfur Stove version 5)

Designing for Manufacturing

Manufacture parts in India

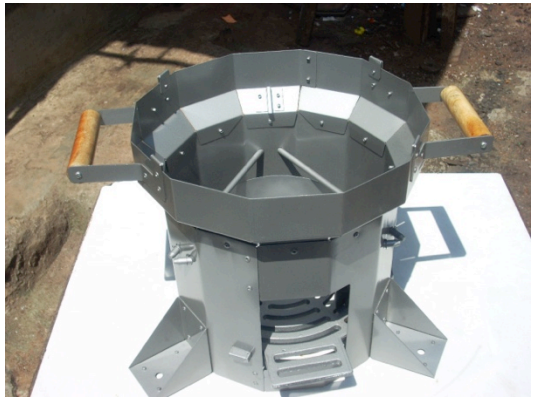
1. Low Cost
2. Reliable supply chain (confirmed by third parties)
3. High quality control and precision
4. Shipped flat to reduce cost

Build in Darfur, Sudan

1. Assembled with hand tools
2. Elevates local skils
3. Increases self-reliance
4. Easy to repair and service
5. Provides employment and income

Designing for Assembly

“Poka-Yoke” flat-kit design to eliminate assembly errors



Assembly capacity of 175 stoves per day

El Haj Adam in a sea of stoves outside El Fasher assembly workshop 2010

Berkeley-Darfur Stove Outcomes

- Built and distributed >45,000 stoves helping ~300,000 women and their dependents
- Each iteration was more user friendly, more stable, and simpler to build
- Could double the disposable income of the refugee woman over its 5-year life
- Worth $80 Million to 45,000 recipients over 5 year life of the stoves
- Performance and use has been thoroughly investigated

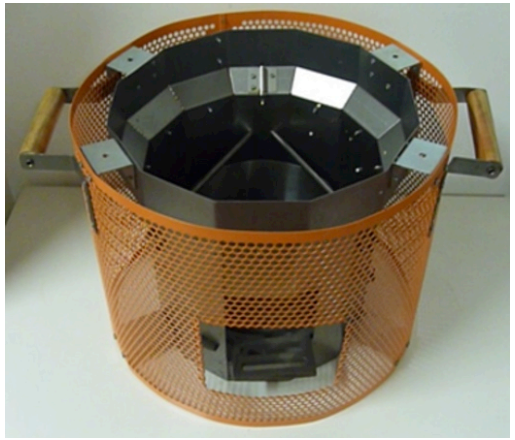
Summary

Lessons Learned

- **Must be accepted and adopted by user**
- **Must identify a robust supply chain with local support**
- Artisanal shops could not meet required production or quality control

Next Steps

- Collaborating with Harvard Global and Tata Trusts to distribute stoves in India
- Exploring outreach possibilities Uganda



SUPPLEMENTAL SLIDES

Designing for Manufacturing: Challenges

Sudan

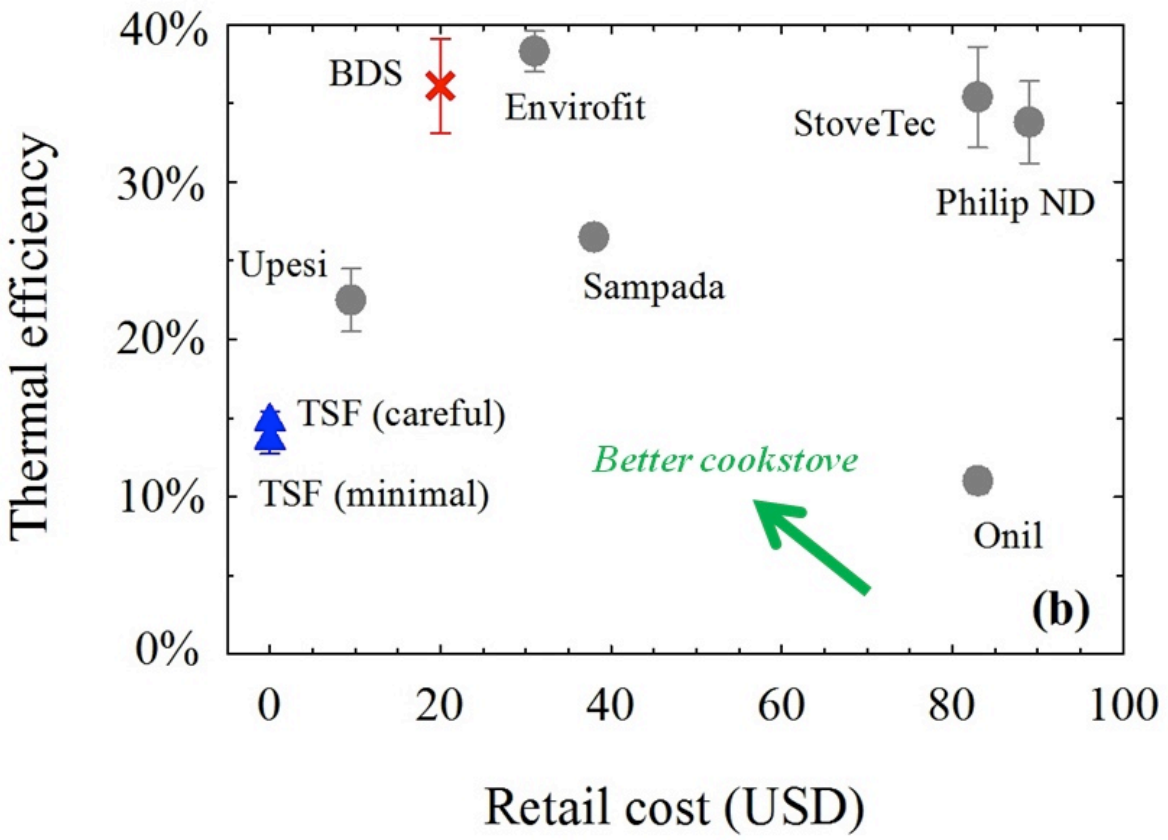
1. High cost (60 USD per stove)
2. Conflicting supply chain (military contractor)
3. Low quality control and precision
4. Low Industrialization
5. Same problem in Egypt and Kenya

India

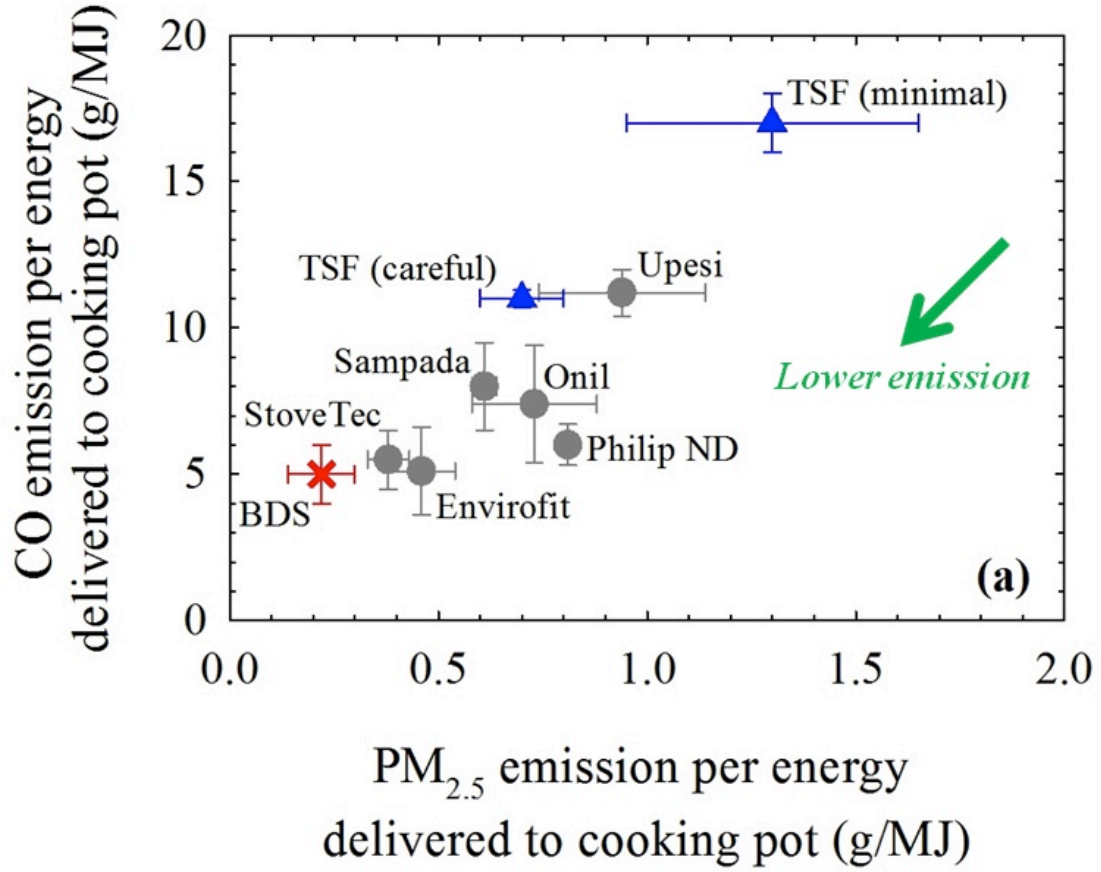
1. Low Cost (20 USD per stove)
2. Reliable supply chain (confirmed by third parties)
3. High quality control and precision
4. Advanced industrialization
5. Scalability

Berkeley Darfur Stove Performance

Thermal Efficiency



Emissions



Jetter et al. (2011) Environmental Science and Technology. V46, pp. 10827-10834
Stove price data collected in 2012 by Dr. Carl Wang, LBNL

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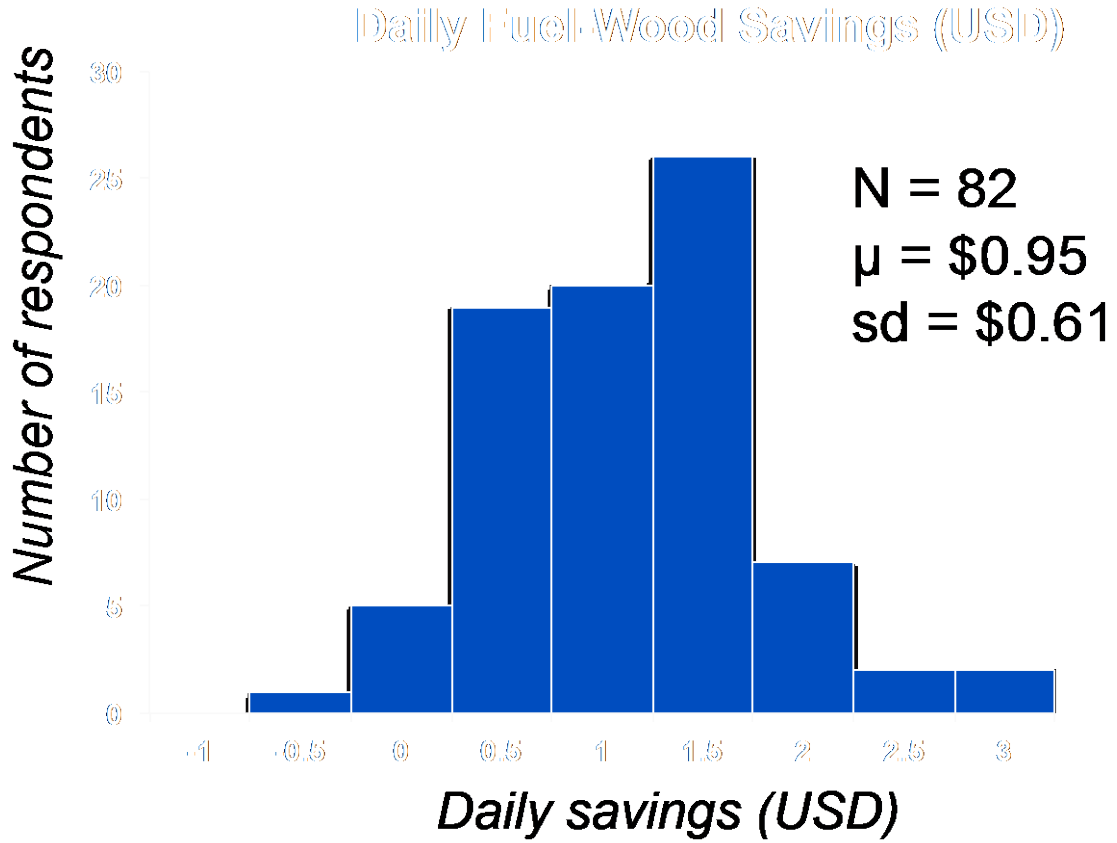
Understanding Impact of BDS: 2010 Field Survey



Baseline: Jan.2010, Follow-up: July 2010

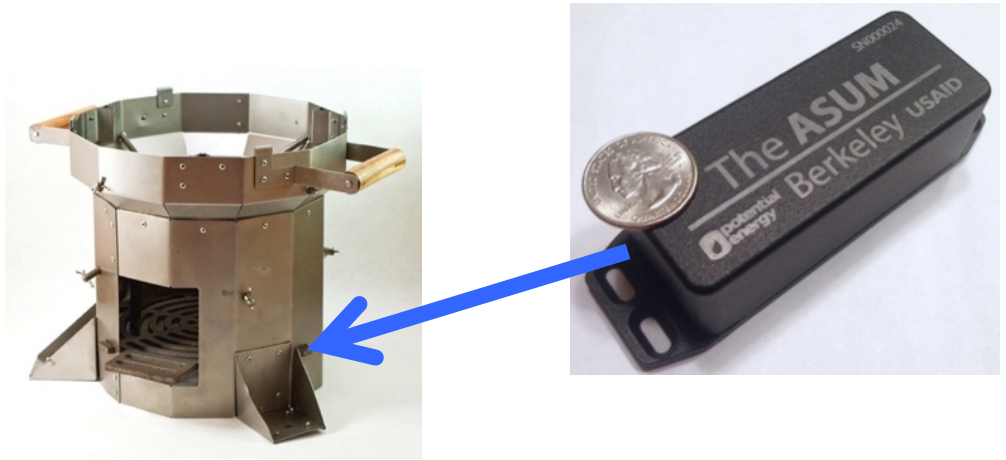
Zam Zam Camp, North Darfur

- Conducted field surveys to assess user adoption and acceptance
- 100 North Darfur households reduced spending on fuel-wood by more than 50%
- Each 20 USD stove saves 345 USD/yr

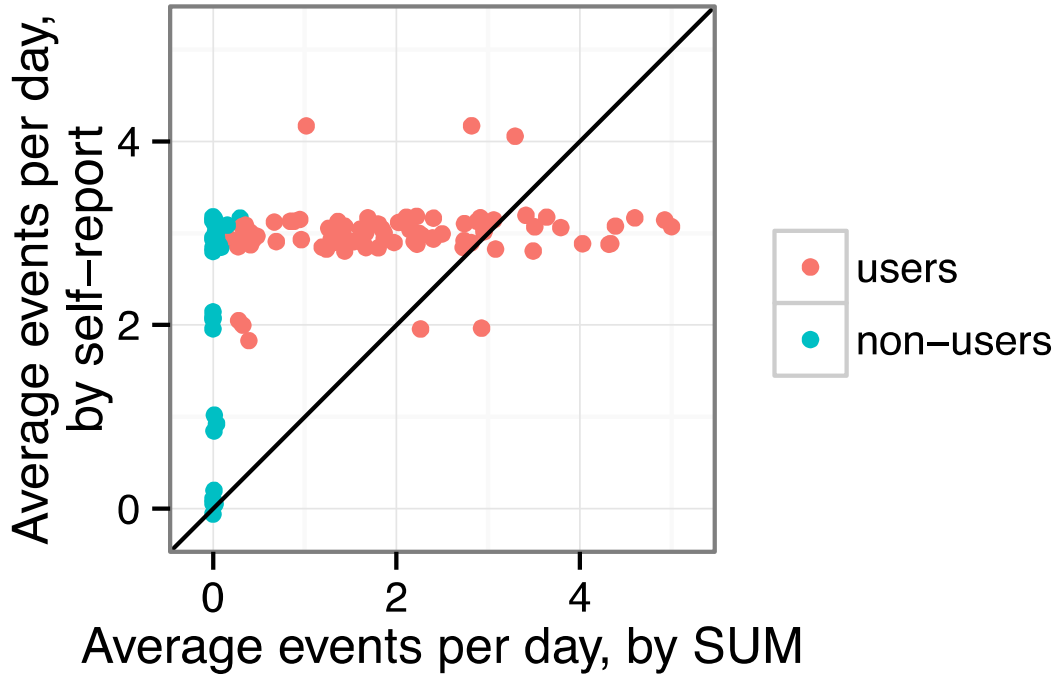
Understanding behavior and adoption

Affordable Advanced Stove Use Monitors (ASUMS)
~$20 for materials, commercial iButton ~$80

- Multiuse device
- 10 month continuous operation
- Temperature & analog ports



Use over-reported by 85%



Wilson et al. (2016) Environmental Science and Technology. V50, pp. 9393-8399