# Clean Water

## The Problem:

- 45 m in Bangladesh drink water laced with arsenic
- Arsenci levels are high...even up to 1000 ppb. Bangladesh standard: 50 ppb to be safe
- Competing methods of arsenic removal
  - **Expensive, or**
  - **Harder to manage, or**
  - **Ineffective in case of high arsenic**

## The Solution: ARUBA

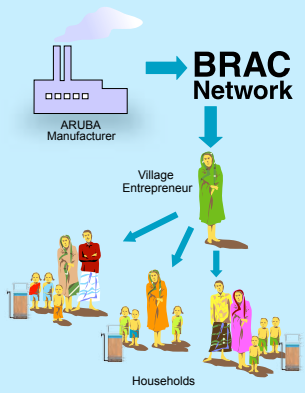
- Technically sound
- Financially viable
- Organizationally, socially, and environmentally sustainable
- Replicable and can be scaled up

# Arsenic Removal Using Bottom Ash (ARUBA)

Developed by Lawrence Berkeley National Laboratory (LBNL)
Licensed to CleanWater LLC

## Financial Viability:

- Annual cost to consumer is $1.40 per person
- Cost to retailing-entrepreneur is $0.70 per person
- Retailing entrepreneurs make $700/year by serving 1,000 people
- Manufacturing facility can be profitable at $0.70 per year per person based on reasonable volume assumption

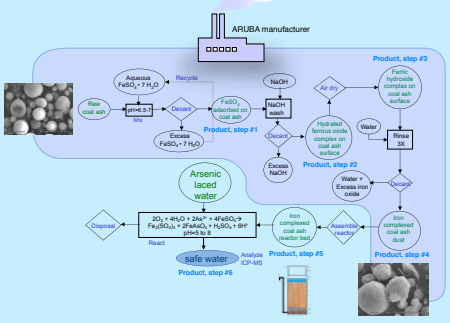



## Replicability and Scaling up:

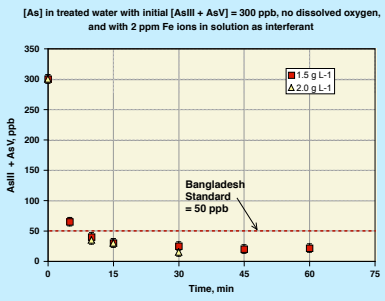
- BRAC (Bangladesh Rural Advancement Committee) is present in virtually all 68,000 villages in Bangladesh
- Self sustaining at the micro level, each entrepreneur makes respectable profits by per capita GDP standards
- Manufacturing operation is profitable and scalable

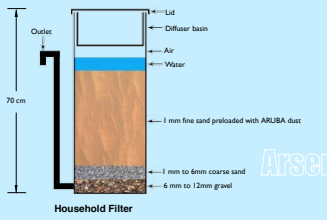
## Technology Innovation:

- Inexpensive substrate (coal ash) coated with ferric hydroxide (patent pending)
- Can be manufactured in the factory inexpensively for household use
- Absorbs and removes arsenic to below 50 ppb rapidly
- Environmentally friendly




## Results:




## The Strategy:

- Manufacture in Bangladesh
- Distributed by the BRAC microcredit network (where village entrepreneurs market and sell ARUBA to their neighbors), replicating the GrameenPhone model
- ARUBA supplier will also service as information disseminators on arsenic problems

## The Progress:

- Exclusive license by LBNL to CleanWater LLC for ARUBA manufacture and distribution in Bangladesh
- Negotiated MOU (Memoradum of Understanding) with BRAC to carry out field tests in 250 households in Bangladesh
- Identified engineering firms interested in manufacturing plant in Gangladesh
- Identified interested U.S. investors

## Sustainability:

**Organizational**
ARUBA is affordable in rural Bangladesh for the consumer and profitable for the manufacturer, BRAC, and village entrepreneurs

**Social**
Avoided cost of arsenic poisoning is much larger ($40 per month per household) than price of ARUBA

**Environmental**
Spent ARUBA media can be disposed of as municipal waste in the landfill, per U.S. EPA standards

# Energy Efficiency in Western Utility Resource Plans

## Tracking Energy Efficiency as a Resource: Spreadsheet Tool


Nicole Hopper[1], Charles Goldman[1] and Jeff Schlegel[2]
[1]Lawrence Berkeley National Laboratory (LBNL)
[2]Independent consultant


### Data Input: Energy Efficiency Impacts

* summer-peak capacity savings
NOTE: Savings measured at the customer meter should be adjusted to produce "generation-equivalent" values.

| Program Year | Strategy | 2006 GWh | 2006 MW* | 2007 GWh | 2007 MW* | 2008 GWh | 2008 MW* | 2009 GWh | 2009 MW* | 2010 GWh | 2010 MW* | 2011 GWh | 2011 MW* | 2012 GWh | 2012 MW* | 2013 GWh | 2013 MW* | 2014 GWh | 2014 MW* | 2015 GWh | 2015 MW* | 2016 GWh | 2016 MW* | 2017 GWh | 2017 MW* | 2018 GWh | 2018 MW* | 2019 GWh | 2019 MW* | 2020 GWh | 2020 MW* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2006 | EE Programs | 500 | 28 | 500 | 28 | 500 | 28 | 500 | 28 | 500 | 28 | 500 | 28 | 500 | 28 | 500 | 28 | 500 | 28 | 500 | 28 | 400 | 22 | 400 | 22 | 400 | 22 | 400 | 22 | 400 | 22 |
| | Building codes | 175 | 10 | 175 | 10 | 175 | 10 | 175 | 10 | 175 | 10 | 175 | 10 | 175 | 10 | 175 | 10 | 175 | 10 | 175 | 10 | 140 | 8 | 140 | 8 | 140 | 8 | 140 | 8 | 140 | 8 |
| | EE standards | 75 | 4 | 75 | 4 | 75 | 4 | 75 | 4 | 75 | 4 | 75 | 4 | 75 | 4 | 75 | 4 | 75 | 4 | 75 | 4 | 60 | 3 | 60 | 3 | 60 | 3 | 60 | 3 | 60 | 3 |
| | Total | 750 | 42 | 750 | 42 | 750 | 42 | 750 | 42 | 750 | 42 | 750 | 42 | 750 | 42 | 750 | 42 | 750 | 42 | 750 | 42 | 600 | 33 | 600 | 33 | 600 | 33 | 600 | 33 | 600 | 33 |
| 2007 | EE Programs | | | 550 | 31 | 550 | 31 | 550 | 31 | 550 | 31 | 550 | 31 | 550 | 31 | 550 | 31 | 550 | 31 | 550 | 31 | 550 | 31 | 440 | 24 | 440 | 24 | 440 | 24 | 440 | 24 |
| | Building codes | | | 193 | 11 | 193 | 11 | 193 | 11 | 193 | 11 | 193 | 11 | 193 | 11 | 193 | 11 | 193 | 11 | 193 | 11 | 193 | 11 | 154 | 9 | 154 | 9 | 154 | 9 | 154 | 9 |
| | EE standards | | | 83 | 5 | 83 | 5 | 83 | 5 | 83 | 5 | 83 | 5 | 83 | 5 | 83 | 5 | 83 | 5 | 83 | 5 | 83 | 5 | 66 | 4 | 66 | 4 | 66 | 4 | 66 | 4 |
| | Total | | | 825 | 46 | 825 | 46 | 825 | 46 | 825 | 46 | 825 | 46 | 825 | 46 | 825 | 46 | 825 | 46 | 825 | 46 | 825 | 46 | 660 | 37 | 660 | 37 | 660 | 37 | 660 | 37 |
| 2008 | EE Programs | | | | | 605 | 34 | 605 | 34 | 605 | 34 | 605 | 34 | 605 | 34 | 605 | 34 | 605 | 34 | 605 | 34 | 605 | 34 | 605 | 34 | 484 | 27 | 484 | 27 | 484 | 27 |
| | Building codes | | | | | 212 | 12 | 212 | 12 | 212 | 12 | 212 | 12 | 212 | 12 | 212 | 12 | 212 | 12 | 212 | 12 | 212 | 12 | 212 | 12 | 169 | 9 | 169 | 9 | 169 | 9 |
| | EE standards | | | | | 91 | 5 | 91 | 5 | 91 | 5 | 91 | 5 | 91 | 5 | 91 | 5 | 91 | 5 | 91 | 5 | 91 | 5 | 91 | 5 | 73 | 4 | 73 | 4 | 73 | 4 |
| | Total | | | | | 908 | 50 | 908 | 50 | 908 | 50 | 908 | 50 | 908 | 50 | 908 | 50 | 908 | 50 | 908 | 50 | 908 | 50 | 908 | 50 | 726 | 40 | 726 | 40 | 726 | 40 |
| 2009 | EE Programs | | | | | | | 666 | 37 | 666 | 37 | 666 | 37 | 666 | 37 | 666 | 37 | 666 | 37 | 666 | 37 | 666 | 37 | 666 | 37 | 666 | 37 | 532 | 30 | 532 | 30 |
| | Building codes | | | | | | | 233 | 13 | 233 | 13 | 233 | 13 | 233 | 13 | 233 | 13 | 233 | 13 | 233 | 13 | 233 | 13 | 233 | 13 | 233 | 13 | 186 | 10 | 186 | 10 |
| | EE standards | | | | | | | 100 | 6 | 100 | 6 | 100 | 6 | 100 | 6 | 100 | 6 | 100 | 6 | 100 | 6 | 100 | 6 | 100 | 6 | 100 | 6 | 80 | 4 | 80 | 4 |
| | Total | | | | | | | 999 | 55 | 999 | 55 | 999 | 55 | 999 | 55 | 999 | 55 | 999 | 55 | 999 | 55 | 999 | 55 | 999 | 55 | 999 | 55 | 799 | 44 | 799 | 44 |
| 2010 | EE Programs | | | | | | | | | 732 | 41 | 732 | 41 | 732 | 41 | 732 | 41 | 732 | 41 | 732 | 41 | 732 | 41 | 732 | 41 | 732 | 41 | 732 | 41 | 586 | 33 |
| | Building codes | | | | | | | | | 256 | 14 | 256 | 14 | 256 | 14 | 256 | 14 | 256 | 14 | 256 | 14 | 256 | 14 | 256 | 14 | 256 | 14 | 256 | 14 | 205 | 11 |
| | EE standards | | | | | | | | | 110 | 6 | 110 | 6 | 110 | 6 | 110 | 6 | 110 | 6 | 110 | 6 | 110 | 6 | 110 | 6 | 110 | 6 | 110 | 6 | 88 | 5 |
| | Total | | | | | | | | | 1,098 | 61 | 1,098 | 61 | 1,098 | 61 | 1,098 | 61 | 1,098 | 61 | 1,098 | 61 | 1,098 | 61 | 1,098 | 61 | 1,098 | 61 | 1,098 | 61 | 878 | 49 |
| 2011 | EE Programs | | | | | | | | | | | 805 | 45 | 805 | 45 | 805 | 45 | 805 | 45 | 805 | 45 | 805 | 45 | 805 | 45 | 805 | 45 | 805 | 45 | 805 | 45 |
| | Building codes | | | | | | | | | | | 282 | 16 | 282 | 16 | 282 | 16 | 282 | 16 | 282 | 16 | 282 | 16 | 282 | 16 | 282 | 16 | 282 | 16 | 282 | 16 |
| | EE standards | | | | | | | | | | | 121 | 7 | 121 | 7 | 121 | 7 | 121 | 7 | 121 | 7 | 121 | 7 | 121 | 7 | 121 | 7 | 121 | 7 | 121 | 7 |
| | Total | | | | | | | | | | | 1,208 | 67 | 1,208 | 67 | 1,208 | 67 | 1,208 | 67 | 1,208 | 67 | 1,208 | 67 | 1,208 | 67 | 1,208 | 67 | 1,208 | 67 | 1,208 | 67 |
| 2012 | EE Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Building codes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EE standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2013 | EE Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Building codes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EE standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2014 | EE Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Building codes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EE standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2015 | EE Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Building codes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EE standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2016 | EE Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Building codes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EE standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2017 | EE Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Building codes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EE standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2018 | EE Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Building codes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EE standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2019 | EE Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Building codes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EE standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2020 | EE Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Building codes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EE standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cumulative Effects in Each Year | EE Programs | 500 | 28 | 1,0 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Building codes | 175 | 10 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | EE standards | 75 | 4 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Total | 750 | 42 | 1,4 | | | | | | | | | | | | | | | | | | | | | | | | | | | |

### Data Input: Load Forecast

| | | 2006 GWh | 2006 MW* | 2007 GWh | 2007 MW* | 2008 GWh | 2008 MW* | 2009 GWh | 2009 MW* | 2010 GWh | 2010 MW* | 2011 GWh | 2011 MW* | 2012 GWh | 2012 MW* | 2013 GWh | 2013 MW* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Total Resource Requirements[1] | 100,000 | 5,000 | 101,500 | 5,075 | 103,023 | 5,151 | 104,568 | 5,228 | 106,136 | 5,307 | 107,728 | 5,386 | 109,344 | 5,467 | 110,984 | 5,549 |
| 2. | EE Programs | 500 | 28 | 1,050 | 58 | 1,655 | 92 | 2,321 | 129 | 3,053 | 170 | 3,858 | 214 | 4,744 | 264 | 5,718 | 318 |
| 3. | Building codes | 175 | 10 | 368 | 20 | 579 | 32 | 812 | 45 | 1,068 | 59 | 1,350 | 75 | 1,660 | 92 | 2,001 | 111 |
| 4. | EE standards | 75 | 4 | 158 | 9 | 248 | 14 | 348 | 19 | 458 | 25 | 579 | 32 | 712 | 40 | 858 | 48 |
| 5. | Total EE Strategies (2+3+4) | 750 | 42 | 1,576 | 88 | 2,483 | 138 | 3,481 | 193 | 4,579 | 254 | 5,787 | 321 | 7,115 | 395 | 8,577 | 476 |
| 6. | Program-adjusted forecast (1-2)[2] | 99,500 | 4,972 | 100,450 | 5,017 | 101,368 | 5,059 | 102,247 | 5,099 | 103,084 | 5,137 | 103,871 | 5,172 | 104,601 | 5,204 | 105,267 | 5,232 |
| 7. | Net Resources for Load (1-5)[3] | 99,250 | 4,958 | 99,925 | 4,988 | 100,540 | 5,013 | 101,087 | 5,035 | 101,558 | 5,052 | 101,942 | 5,065 | 102,229 | 5,072 | 102,408 | 5,073 |
| 8. | Planning Reserve Multiplier[2] | -- | 15% | -- | 15% | -- | 15% | -- | 15% | -- | 15% | -- | 15% | -- | 15% | -- | 15% |
| 9. | Planning Reserves (6x7) | -- | 744 | -- | 748 | -- | 752 | -- | 755 | -- | 758 | -- | 760 | -- | 761 | -- | 761 |
| 10. | Capacity Requirements (6+8)[3] | -- | 5,702 | -- | 5,736 | -- | 5,765 | -- | 5,790 | -- | 5,810 | -- | 5,825 | -- | 5,833 | -- | 5,834 |

| | | 2014 GWh | 2014 MW* | 2015 GWh | 2015 MW* | 2016 GWh | 2016 MW* | 2017 GWh | 2017 MW* | 2018 GWh | 2018 MW* | 2019 GWh | 2019 MW* | 2020 GWh | 2020 MW* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Total Resource Requirements[1] | 112,649 | 5,632 | 114,339 | 5,717 | 116,054 | 5,803 | 117,795 | 5,890 | 119,562 | 5,978 | 121,355 | 6,068 | 123,176 | 6,159 |
| 2. | EE Programs | 6,790 | 377 | 7,969 | 443 | 9,166 | 509 | 10,482 | 582 | 11,930 | 663 | 13,523 | 751 | 15,276 | 849 |
| 3. | Building codes | 2,376 | 132 | 2,789 | 155 | 3,208 | 178 | 3,669 | 204 | 4,176 | 232 | 4,733 | 263 | 5,347 | 297 |
| 4. | EE standards | 1,018 | 57 | 1,195 | 66 | 1,375 | 76 | 1,572 | 87 | 1,790 | 99 | 2,029 | 113 | 2,291 | 127 |
| 5. | Total EE Strategies (2+3+4) | 10,185 | 566 | 11,953 | 664 | 13,748 | 764 | 15,723 | 874 | 17,896 | 994 | 20,285 | 1,127 | 22,914 | 1,273 |
| 6. | Program-adjusted forecast (1-2)[2] | 105,860 | 5,265 | 106,370 | 5,274 | 106,888 | 5,294 | 107,313 | 5,307 | 107,631 | 5,315 | 107,832 | 5,316 | 107,900 | 5,310 |
| 7. | Net Resources for Load (1-5)[3] | 102,465 | 5,067 | 102,386 | 5,053 | 102,306 | 5,039 | 102,072 | 5,016 | 101,666 | 4,984 | 101,070 | 4,941 | 100,262 | 4,886 |
| 8. | Planning Reserve Multiplier[2] | -- | 15% | -- | 15% | -- | 15% | -- | 15% | -- | 15% | -- | 15% | -- | 15% |
| 9. | Planning Reserves (6x7) | -- | 760 | -- | 758 | -- | 756 | -- | 752 | -- | 748 | -- | 741 | -- | 733 |
| 10. | Capacity Requirements (6+8)[3] | -- | 5,827 | -- | 5,811 | -- | 5,795 | -- | 5,769 | -- | 5,731 | -- | 5,682 | -- | 5,619 |

* summer-peak demand

### Output: Efficiency Resource Summary Tables

**Energy Efficiency Strategy Summary**
**Cumulative Impacts of EE Strategies Implemented Starting in 2006**

| | 2010 GWh | 2010 MW* | 2015 GWh | 2015 MW* | 2020 GWh | 2020 MW* |
|---|---|---|---|---|---|---|
| **EE Strategy Impacts** | | | | | | |
| Cumulative EE Strategy Impacts[1] | 4,579 | 254 | 11,953 | 664 | 22,914 | 1,273 |
| Forecast Total Resource Requirements (TRR)[2] | 106,136 | 5,307 | 114,339 | 5,717 | 123,176 | 6,159 |
| EE Strategies as Percent of TRR | 4% | 5% | 10% | 12% | 19% | 21% |
| EE Strategies as Percent of TRR Growth (since 2006) | 75% | 83% | 83% | 93% | 99% | 110% |
| **Impact of EE strategies on forecast load growth** | | | | | | |
| Average Annual growth in TRR (since 2006) | 1.5% | 1.5% | 1.5% | 1.5% | 1.5% | 1.5% |
| Net Resources for Load (NRL)[3] | 101,558 | 5,052 | 102,386 | 5,053 | 100,262 | 4,886 |
| Average Annual Growth in NRL | 0.6% | 0.5% | 0.3% | 0.2% | 0.1% | -0.1% |
| Percentage reduction in growth rate | 62% | 69% | 77% | 86% | 95% | 107% |

← WGA goal

* summer-peak capacity

**Energy Efficiency Program Summary**
**Cumulative Impacts of Programs Implemented Starting in 2006**

| | 2010 GWh | 2010 MW* | 2015 GWh | 2015 MW* | 2020 GWh | 2020 MW* |
|---|---|---|---|---|---|---|
| **EE program Impacts** | | | | | | |
| Cumulative EE Program Impacts[1] | 3,053 | 170 | 7,969 | 443 | 15,276 | 849 |
| Forecast Total Resource Requirements (TRR)[2] | 106,136 | 5,307 | 114,339 | 5,717 | 123,176 | 6,159 |
| EE Programs as Percent of TRR | 3% | 3% | 7% | 8% | 12% | 14% |
| EE Programs as Percent of TRR Growth (since 2006) | 50% | 55% | 56% | 62% | 66% | 73% |
| **Impact of EE programs on forecast load growth** | | | | | | |
| Average Annual growth in TRR (since 2006) | 1.5% | 1.5% | 1.5% | 1.5% | 1.5% | 1.5% |
| Program-adjusted foreast (PAF)[3] | 103,084 | 5,137 | 106,370 | 5,274 | 107,900 | 5,310 |
| Average Annual Growth in PAF | 0.9% | 0.8% | 0.7% | 0.7% | 0.6% | 0.5% |
| Percentage reduction in growth rate | 41% | 45% | 50% | 56% | 61% | 69% |

* summer-peak capacity

LBNL has developed a spreadsheet tool that can be used by utilities and states to track energy-efficiency resources over time. Two data input forms collect detailed information on energy-efficiency impacts and load forecasts. These data are aggregated into summary tables that provide key energy-efficiency metrics.

The spreadsheet is available at http://eetd.lbl.gov/ea/EMS/rplan-pubs.html

## For More Information…

- Download the report and spreadsheet tool at http://eetd.lbl.gov/ea/EMS/rplan-pubs.html
- Contact Nicole Hopper 510-495-2370, nchopper@lbl.gov

## Acknowledgements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Environmental Energy Technologies Division