Company Overview
Proprietary De-NOx Solutions
Advanced Coal Utilization
LP Amina at a Glance

LP Amina was established in 2007 with a mission to develop and deploy clean and profitable energy solutions globally.

- **100+** Full time employees on 2 continents
- **5** R&D centers, with activities in the US, Europe and Asia
- **30+** Average experience of core technical team
- **50+** Engineers covering all disciplines
- **10+** Patents focused on coal/biomass conversion and pollution control
- **15GW** Projects completed in the last 5 years

### Emissions Control Solutions

Wide range of proprietary and customized De-NOx solutions that help coal-, gas-fired power plants as well as the industry (cement, paper, steel) meet the emissions regulation at an affordable price.

### Advance Coal Technologies

Family of technologies that enable existing coal-fired power plants to produce valuable chemicals and fuels while generating electricity, all under one roof. Have extraordinary cost and environmental advantages.
LP Amina - Three Innovations in One

LP Amina is underpinned by a unique R&D model and a vast network of partnerships that support the development of the technology.

What is Unique About Our Approach:

1. Market-Disrupting Technology
2. Unique Business and R&D Models

LP Amina plays a constructive role in developing clean energy cooperation between the US and China. Pairing technological know-how from the U.S. with China’s robust infrastructure and drive for economic development, LP Amina’s technology portfolio is a great tangible example of the new age of the US-China Energy Cooperation.
U.S.-China Bi-Lateral Cooperation Shaping Our Markets

LP Amina has formed public sector partnerships, in both U.S. and China, to benefit the provision of sustainable energy in both markets and globally.

Growth Through Innovation

Private Companies
- Bayer Technology Services
- China Huaneng Group
- Gemeng Energy Group

Research Institutions
- University of Wyoming
- West Virginia University
- US-China CERC

Government Entities
- US-China ECP
- US-China CERC
- US TDA
LP Amina’s Completed De-NOx Projects in China

Since 2009, LP Amina has completed over 50 projects in China, achieving superb results and lowering NOx emissions below target levels.
Direct Injection SCR / CO Reactor Design


Solution Comparison

**Traditional**

- CO Cat/AIG/SCR Cat
- Large Distance Between AIG & SCR Cat. (Mixing)
- Fairly Complex AIG
- Difficult to achieve NH3/NOx RMS<10%

**Direct Injection**

- AIG/SCR Cat/CO Cat
- Much more compact design
- CO Cat also reduces NH3 slip
- Simple Reagent injection near turbine exhaust
- High velocities improve mixing
- Easy to achieve NH3/NOx RMS ~ 5%

Growth Through Innovation
In 2014, with the development of the US gas market, LP Amina successfully transferred its latest innovative technologies from China to capture US market share.
Company Overview
Proprietary De-NOx Solutions
Advanced Coal Utilization
Significantly Improving the Economic Viability of a Power Plant

LP Amina’s technology combines the highest value components of several processes to increase efficiency resulting in compelling economics.

Conventional Approach

Coal

Electricity

At a conventional power plant coal is directly oxidized to produce steam and then electricity.

LP Amina’s Technology (BenePlus and Polygen)

Coal

Hydrocarbons/Chemicals

Electricity

CO₂ Ready For Capture

LP Amina’s technology enables existing power plants to co-produce electricity, valuable chemicals and CO₂, which improves efficiency, improves economic return and reduces carbon emissions.
Pilot Plant in San Antonio Texas Started Operation in March 2015

Pilot plant is demonstrating improved yields compared to bench scale results

About SwRI

- Independent non-profit organization
- Over 1,200-acre facility in San Antonio, Texas
- Founded in 1947; Over 3,000 employees
- Revenues ~$600 million per year, 60% gov.
- Chem. Eng: 69 FTEs, 6 PhDs, 7 M.S., 45 B.S.
- Vast experience with liquids handling
- Experience with clean coal technologies

LP Amina’s Pilot Scope & Timing

- Processing capacity: ~1 ton / day continuous
- Timeline:
  - Sept 2014: Started work
  - Jan 2015: Construction complete
  - Feb 2015: Single pass tests
  - Mar - Aug 2015: Range finding
  - Sept – Dec 2015: Continuous operation (24/7)
Reducing Emissions to Near Zero

BenePlus achieves efficient low-cost removal of pollutants from coal enabling cleaner more efficient combustion.

1. Removes Water
   • Can reduce moisture content to 5%
   • Reclaimed water can be purified and reused

2. Reduces Pollutants
   • Reduces mercury content by 50%-80%
   • Reduces sulfur content by 90%+

3. Improves boiler efficiency
   • Up to 6% from burning higher rank coal
   • Use of fuel gas further reduces CO\textsubscript{2} footprint

4. Captures CO\textsubscript{2}:
   • Pure stream of CO\textsubscript{2} as by-product
   • Low cost to capture and compress
BeneficiationPlus™ CO₂ Reduction

CO₂ footprint reduction comes from: (1) upgraded coal & fuel gas efficiency gain (2) co-production credit (3) FGD duty reduction and (4) CO₂ EOR

Effect of BeneficiationPlus™ on a Lignite-fired Power Plant CO₂ Footprint

-10% CO₂ Capture for EOR

100% Baseline CO₂ Emissions

+10% Ben Plus Process

-14% Upgraded Coal & Efficiency

-2% Hydrocarbons Credit

-2% FGD Duty Reduction

-12% CO₂ Capture for EOR

80% Resulting CO₂ Emissions

-8% to -20%
BeneficiationPlus Process

The BenePlus process converts part of the volatile matter to high quality, low sulfur, low tar, light fuels and aromatics.

Van Krevelen Diagram for Tested Coals

Pyrolysis Product Yield for the Tested Coals

Patent Filing

- Patent filed on May 23, 2014
- 7 inventors, including 4 LP Amina staff and 3 Bayer Technology Services staff
- IP legal counsel provided by Foley & Lardner, a long-time partner of LP Amina

- 30 claims; claims structured to provide broad patent coverage of the technology
- Low tars and heteroatoms among the significant advantages over prior art
- Over 200 references examined covering 100 years of prior coal-to-chemicals work
## Beni+ Product Slate with ND lignite at optimized conditions

### Lignite feed, dry basis

<table>
<thead>
<tr>
<th>Property</th>
<th>ND lignite (final data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VM, wt%</td>
<td>43.8</td>
</tr>
<tr>
<td>Ash, wt%</td>
<td>14.5</td>
</tr>
<tr>
<td>Fixed C, wt%</td>
<td>41.8</td>
</tr>
<tr>
<td>Sulfur, wt%</td>
<td>1.7</td>
</tr>
<tr>
<td>Sulfur emissions, lb sulfur/MMBtu lignite burned</td>
<td>1.65</td>
</tr>
<tr>
<td>HHV, Btu/lb, dry</td>
<td>10,103</td>
</tr>
<tr>
<td>HHV, Btu/lb, as received</td>
<td>6,343</td>
</tr>
<tr>
<td>Moisture, wt%</td>
<td>37.2</td>
</tr>
</tbody>
</table>

### Syncoal product

<table>
<thead>
<tr>
<th>Property</th>
<th>ND lignite</th>
</tr>
</thead>
<tbody>
<tr>
<td>VM, wt%</td>
<td>25.4</td>
</tr>
<tr>
<td>Ash, wt%</td>
<td>19.0</td>
</tr>
<tr>
<td>Fixed C, wt% (by difference)</td>
<td>55.6</td>
</tr>
<tr>
<td>Sulfur, wt%</td>
<td>0.7</td>
</tr>
<tr>
<td>Sulfur emissions, lb sulfur/MMBtu syncoal burned</td>
<td>0.69</td>
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<tr>
<td>HHV, Btu/lb</td>
<td>11,016</td>
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<tr>
<td>Moisture, wt%</td>
<td>1.1</td>
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<tr>
<td>Yield, lb/100 lb dry coal feed</td>
<td>57.8</td>
</tr>
<tr>
<td>HHV upgrade, HHV_{syncoal}/HHV_{feedcoal}, as rec'd</td>
<td>1.7</td>
</tr>
<tr>
<td>Reduction in sulfur emissions per MMBtu</td>
<td>58%</td>
</tr>
<tr>
<td>Ash retained, lb / 100 lb ash fed</td>
<td>76</td>
</tr>
</tbody>
</table>

### Product Gas Yield on Dry basis lb gas/lb coal fed Compositions (wt%)

<table>
<thead>
<tr>
<th>Comp</th>
<th>CO2</th>
<th>CO2, wt%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO, wt%</td>
<td>6.67</td>
<td></td>
</tr>
<tr>
<td>H2, wt%</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>METHANE, wt%</td>
<td>2.18</td>
<td></td>
</tr>
<tr>
<td>ETHYLENE, wt%</td>
<td>1.16</td>
<td></td>
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<tr>
<td>ETHANE, wt%</td>
<td>0.43</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Comp</th>
<th>Naphtha Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROPYLENE, wt%</td>
<td>1.35</td>
</tr>
<tr>
<td>N-PROPANE, wt%</td>
<td>0.15</td>
</tr>
<tr>
<td>ISOBUTYLEN, wt%</td>
<td>0.19</td>
</tr>
<tr>
<td>1-BUTENE, wt%</td>
<td>0.10</td>
</tr>
<tr>
<td>1,3-BUTADIENE, wt%</td>
<td>0.08</td>
</tr>
<tr>
<td>TRANS-2-BUTENE, wt%</td>
<td>0.09</td>
</tr>
<tr>
<td>CIS-2-BUTENE, wt%</td>
<td>0.10</td>
</tr>
<tr>
<td>2-METHYL-2-BUTENE, wt%</td>
<td>0.11</td>
</tr>
<tr>
<td>N-HExANE, wt%</td>
<td>0.13</td>
</tr>
<tr>
<td>BENZENE, wt%</td>
<td>1.19</td>
</tr>
<tr>
<td>Toluene, wt%</td>
<td>0.98</td>
</tr>
<tr>
<td>Xylene, wt%</td>
<td>0.16</td>
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</table>

<table>
<thead>
<tr>
<th>Comp</th>
<th>BTX Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2S, wt%</td>
<td>0.84</td>
</tr>
<tr>
<td>OTHER SULFUR, wt%</td>
<td>0.13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comp</th>
<th>Higher HCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total, wt%</td>
<td>26.77</td>
</tr>
</tbody>
</table>
Given the high proportion of BTX and Propylene in the product slate, the hydrocarbons stream may be sold at up to 50% premium to crude
LP Amina has Developed a Consortium in ND to Commercialize BenePlus Technology

### Preliminary Timeline (2014 – 2015)

- **Until February**: Initial discussions with potential strategic partners. Steering Committee established (coal companies, utilities and fineries)
- **March**: Technology readiness review at Pilot Facility, Texas, USA (1st Steering Committee Review)
- **June**: 2nd Steering Committee Review.
- **August**: 3rd party validation, feasibility, permitting, FEL 1.
- **Sept - Dec**: Kick-off to pilot facility validated

#### Partnerships

<table>
<thead>
<tr>
<th>Coal Company</th>
<th>Electric Utility</th>
<th>Refinery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides input coal</td>
<td>Upgraded coal off-take</td>
<td>Hydrocarbon off-take</td>
</tr>
</tbody>
</table>

#### The Phased Deployment Approach

**PMU**
- Timing: 2016
- Coal Input: 1 ton / hour
- Upgraded Coal Produced: 0.45 ton / hour
- Hydrocarbons Output: 2 bbls / hour
- Capital Required: $25M USD
- Simple Payback: NA

**Phase I**
- Timing: 2017-2018
- Hydrocarbons Output: 2 bbls / hour
- Capital Required: $150M USD
- Simple Payback: < 5 years

**Phase II**
- Timing: 2018-2019
- Hydrocarbons Output: 14.5 tons / hour
- Capital Required: $100M USD
- Simple Payback: < 8 years

- **Product Marketing Unit (PMU) will prove product quality and quantity**
- **Phase I results in a product mix of aromatics and light diesel which is well suited for most refineries**
- **Phase II is a fully commercialized system ready for world-scale deployment**

- **Coal Company**
  - **Electric Utility**
  - **Refinery**
Thank You