Cat® 336E H Hybrid Excavator

Customers, Diversity Drive Innovation

Ken Gray
Director of Innovation
Caterpillar Inc.
336E H Hybrid Excavator: Agenda

- Hybrid Overview & Customer Expectations
- Technology Building Blocks
- Top ten customer benefits
- Lessons Learned
- Q & A
HYBRID OVERVIEW

Conserve  |  Optimize  |  Reuse
CATERPILLAR HYBRID DEFINED:
A machine equipped with a device to collect, store, and release energy during machine operation.
336E H Machine Layout
Greater Fuel Efficiency

Up to 50% Greater fuel efficiency*

* Tons/Liter compared to 336D

*Additional factors such as operator skill and jobsite conditions can also affect fuel economy.
A Customer-Focused Hybrid Solution

- Maintain quality, reliability and durability
- Maintain production and performance
- Reduce owning & operating costs
- Reduce our carbon footprint
“Anything that won’t sell, I don’t want to invent. Its sale is proof of utility, and utility is success.”

Thomas Alva Edison
Massive Collaboration by International Team

DIVERSITY

PEORIA PROVING GROUNDS TEAM

JOLIET DESIGN TEAM

CUSTOMER

AKASHI DESIGN TEAM

ONO PROVING GROUNDS TEAM

INNOVATION

Courtesy of Machine.Market
Hybrid Excavator Product Development Timeline

- First 336 hydraulic hybrid prototype tested in 2009
- First 320 production-intent electric hybrid built and tested in 2010
- Began 336E H New Product Introduction (NPI) program in 2011
- Concluded early prototype phase, selected best hybrid options, dual development paths, and competitive machine evaluation begins in 2012
- Production-level validation for 336E H in 2013
- 336E H launch at bauma in April 2014
- Voice of customer assessed, both electric and hydraulic hybrid programs begin in earnest
- Tier 4 Engine Technology

Courtesy of Machine.Market
Technology Theme - Building Blocks

REUSE
Energy

CONSERVE
Fuel

OPTIMIZE
Performance

HYDRAULIC HYBRID

Courtesy of Machine.Market
Hydraulic Hybrid Swing System

Adaptive Control System (ACS) Valve

Electronic Standardized Programmable (ESP) Main Pump

CONSERVE      OPTIMIZE       REUSE

336E H Machine Layout

Courtesy of Machine.Market
1. Conserve Fuel

Electronic Standardized Programmable (ESP) Pump

- Reduced engine speed for fuel savings and quieter operation
- Higher pump displacement with greater efficiency
- Ensures smooth transition between power sources
- Maximizes efficiency and productivity by matching engine/pump load

Always Conserving
2. Optimize Performance

Adaptive Control System (ACS) Valve

- “Brain” of system
  “Traffic control”

- Algorithms independently control machine functions

- Reduces fuel consumption by reducing pressure losses

- Hydraulic regeneration

- Energy where you need it, precisely when you need it

Always Optimizing
3. Reuse Energy

Hydraulic Hybrid Swing System

- Recovers/reuses otherwise wasted swing braking energy
- Less load on engine results in fuel savings
- Non-flammable pre-charged nitrogen gas accumulator
- Fully serviceable

Always Reusing

Courtesy of Machine.Market
336E H Power Flow Animation (http://youtu.be/Klz50qzM81w)

Courtesy of Machine Market
### Fuel Efficiency – Common Applications*  
### 336D, 336E vs. 336E H

<table>
<thead>
<tr>
<th></th>
<th>336D</th>
<th>336E</th>
<th>336E H</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bench Truck Loading</strong></td>
<td>Baseline</td>
<td>+15%</td>
<td>+68%</td>
</tr>
<tr>
<td><strong>180° Truck Loading</strong></td>
<td>Baseline</td>
<td>+14%</td>
<td>+46%</td>
</tr>
<tr>
<td><strong>90° Truck Loading</strong></td>
<td>Baseline</td>
<td>+23%</td>
<td>+49%</td>
</tr>
<tr>
<td><strong>Trenching</strong></td>
<td>Baseline</td>
<td>+7%</td>
<td>+35%</td>
</tr>
</tbody>
</table>

* Average of multiple operators

*Courtesy of Machine.Market*
## Performance @ Customer Site

<table>
<thead>
<tr>
<th>Bench Truck Loading</th>
<th>336E</th>
<th>336E H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>Baseline</td>
<td>+7%</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>Baseline</td>
<td>-27%</td>
</tr>
<tr>
<td>Fuel Efficiency</td>
<td>Baseline</td>
<td>+46%</td>
</tr>
</tbody>
</table>

**Courtesy of Machine.Market**
Projected Payback

Payback in as little as 1 year*

*Assumes today’s fuel prices and a high-production application. Varies depending on operation and job site condition.
Top Ten Customer Benefits*

1. Reduces O&O costs by burning less fuel
2. Maintains performance
3. Returns hybrid investment in as little as one year
4. Produces less engine exhaust emissions
5. Requires no new or unique skills to operate or service
6. Leverages scale of standard Cat components to keep costs down
7. Operates even if the hybrid system doesn’t
8. Generates lower cab and spectator sound
9. Largest hybrid excavator means more power to get jobs done
10. Backed by Caterpillar’s global dealer network

*as compared to a standard 336E
Lessons Learned for Commercializing Innovation

• Every great innovation begins and ends with the customer.
• Following the herd is not always right.
• Including the experiences, opinions, and ideas of a diverse team is an essential ingredient of innovation.
• Important to support the dissenting voice(s) to the extent required to keep competitive solutions afloat.
• High-level sponsorship is critical.
• Changing the organization direction requires demonstrating the innovation to leaders, one by one.
• Leadership is sometimes knowing when to get out of the way.
Fear of failure is innovation's greatest cultural impediment.
Q&A

Ken Gray, LHEX Global Product Manager
Safety

- Designated emergency caller
- CPR/AED or First Responder Certified
- Take cover
- Evacuation
- Fire
  - Fire extinguisher locations
  - Exit locations and where to meet
- Room hazards
THINK BIG.
Start Small.
ACT FAST.