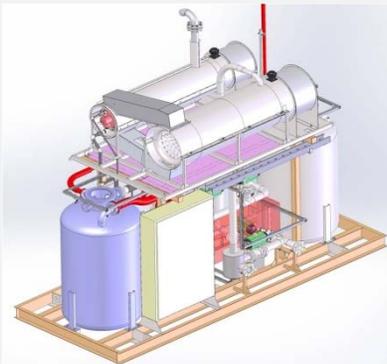


Presentation to:



U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



Quadrogen Gas Clean-up Technology for Fuel Cell Applications

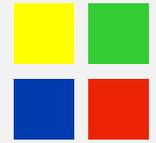
Presented by: Alakh Prasad, President & CEO

Quadrogen Power Systems, Inc.

7 March 2014

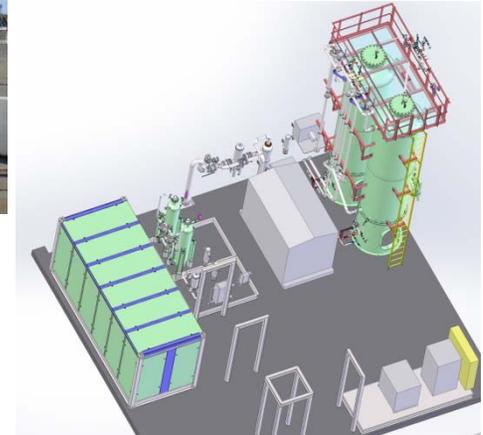
Quadrogen®

Quadrogen Overview

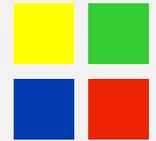


Developed proprietary gas clean-up technology for fuel cell applications

- First demonstration unit using biogas in operation for more than 2 ½ years
- Second unit using biogas operational by Q3/2014
- Third unit using landfill gas operational by Q1/2015
- Working on associated gas applications



The Problem



Biogas

50 - 60% Methane
35 - 40% Carbon Dioxide
0-11% Nitrogen

Contaminants:

Siloxanes
Sulfur Species
Halogen Species
Volatile Organic Compounds
Water
Oxygen

Associated Petroleum Gas (APG)

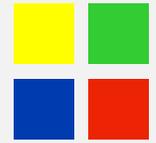
50 - 80% Methane
20 – 50% Higher hydrocarbons
20 - 40% Carbon Dioxide
0 - 5% Nitrogen

Contaminants:

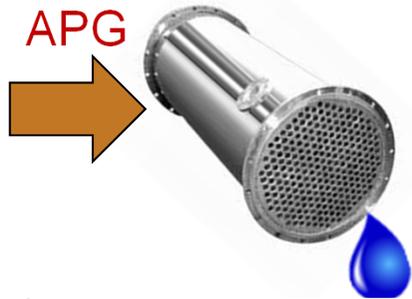
Sulfur Species
Volatile Organic Compounds
Water

High maintenance, reduced revenues, reduced possibilities

C³P Technology

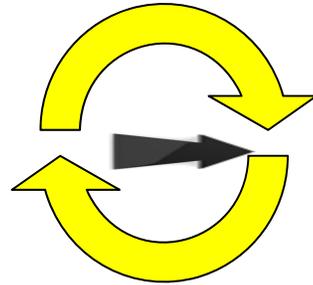


Biogas
or
APG



Condensing

Water and contaminants separated via cooling
- uses no adsorption media



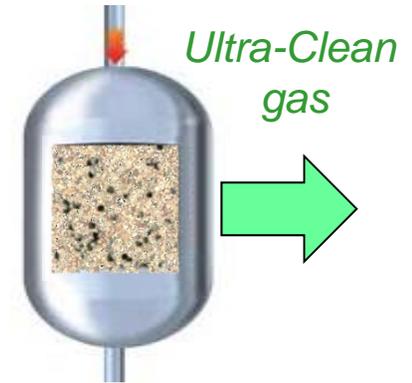
Conversion

Organic sulfur and other species converted to known set of compounds



Capture

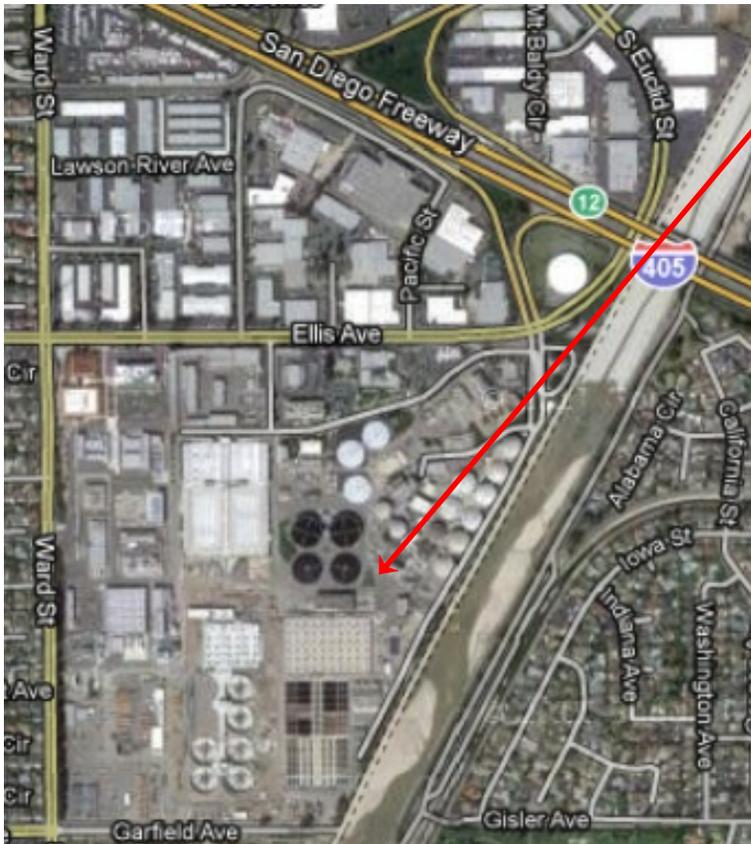
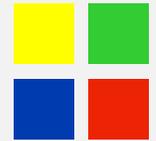
Known species adsorbed on unique high-capacity media



Polishing

Final chemisorption step polishes contaminants to trace levels (< 30 ppbv)

Quadrogen System at Orange County WWTP, California



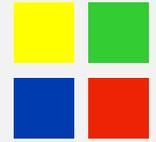
Quadrogen Gas Clean-up System Installed

A joint venture between:



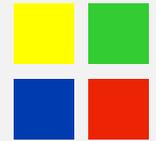
Orange County Sanitation District (OCSD)

Biogas Clean-up system at OCSD WWTP in California

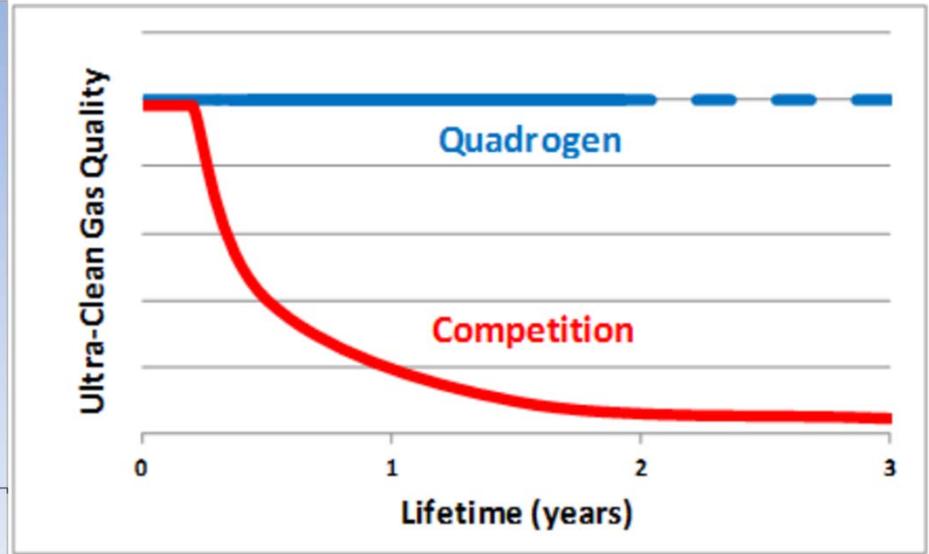
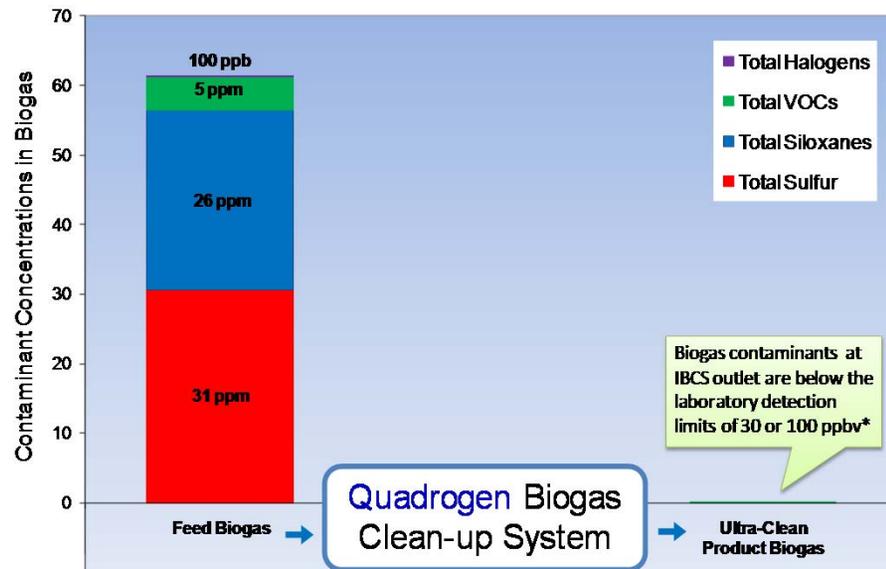


The Air Products and FuelCell Energy team selected C³P technology through a competitive bidding process and the installed unit is in operation since June , 2011

Biogas Clean-up System Performance at OCSD WWTP



Quadrogen Biogas Clean-up System Performance



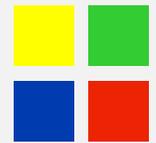
* Volume basis; siloxane species analyzed: D4, D5, D6, L2, and L3 to 100 ppbv detection limit

ppb_v level clean-up

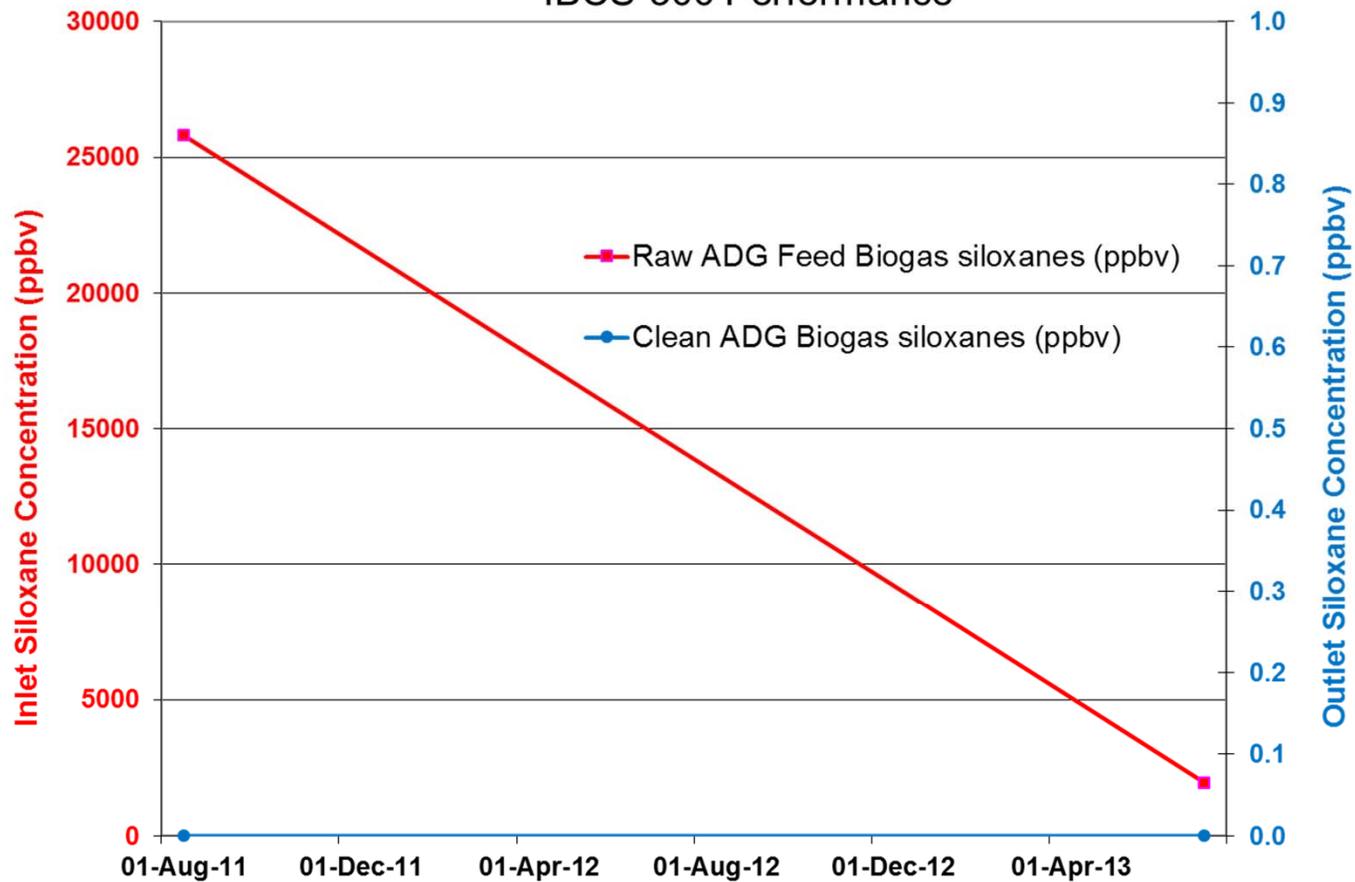
Longer life

Reliable ultra-clean and lower O&M cost

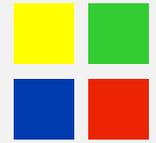
Siloxane Removal after 15,000+ hours of operation



Digester Gas Clean-Up Performance (Siloxane)
IBCS-300 Performance

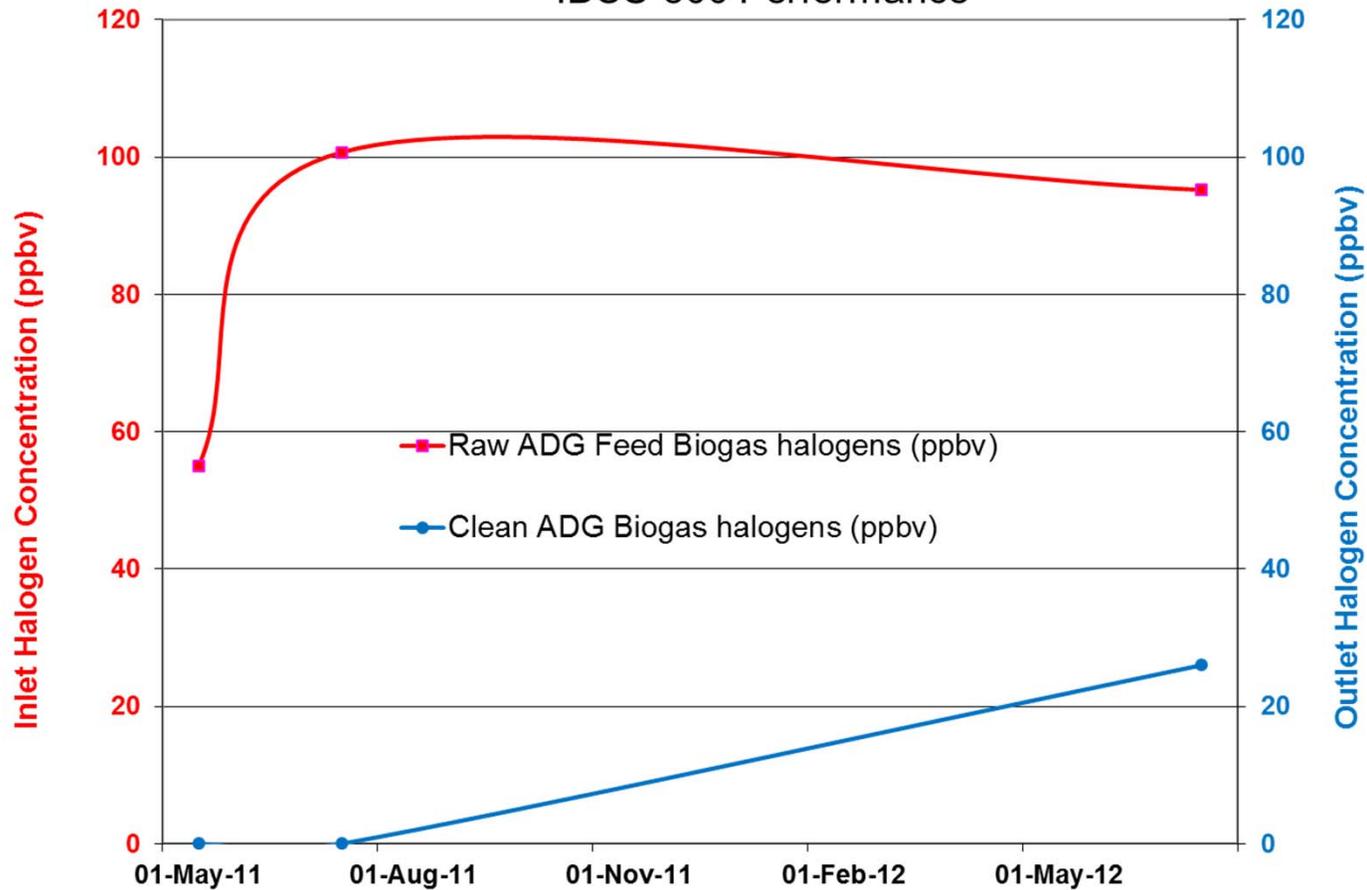


Halogen Removal after 15,000+ hours of operation

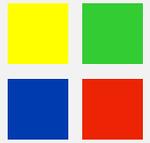


Digester Gas Clean-Up Performance (Halogens)

IBCS-300 Performance

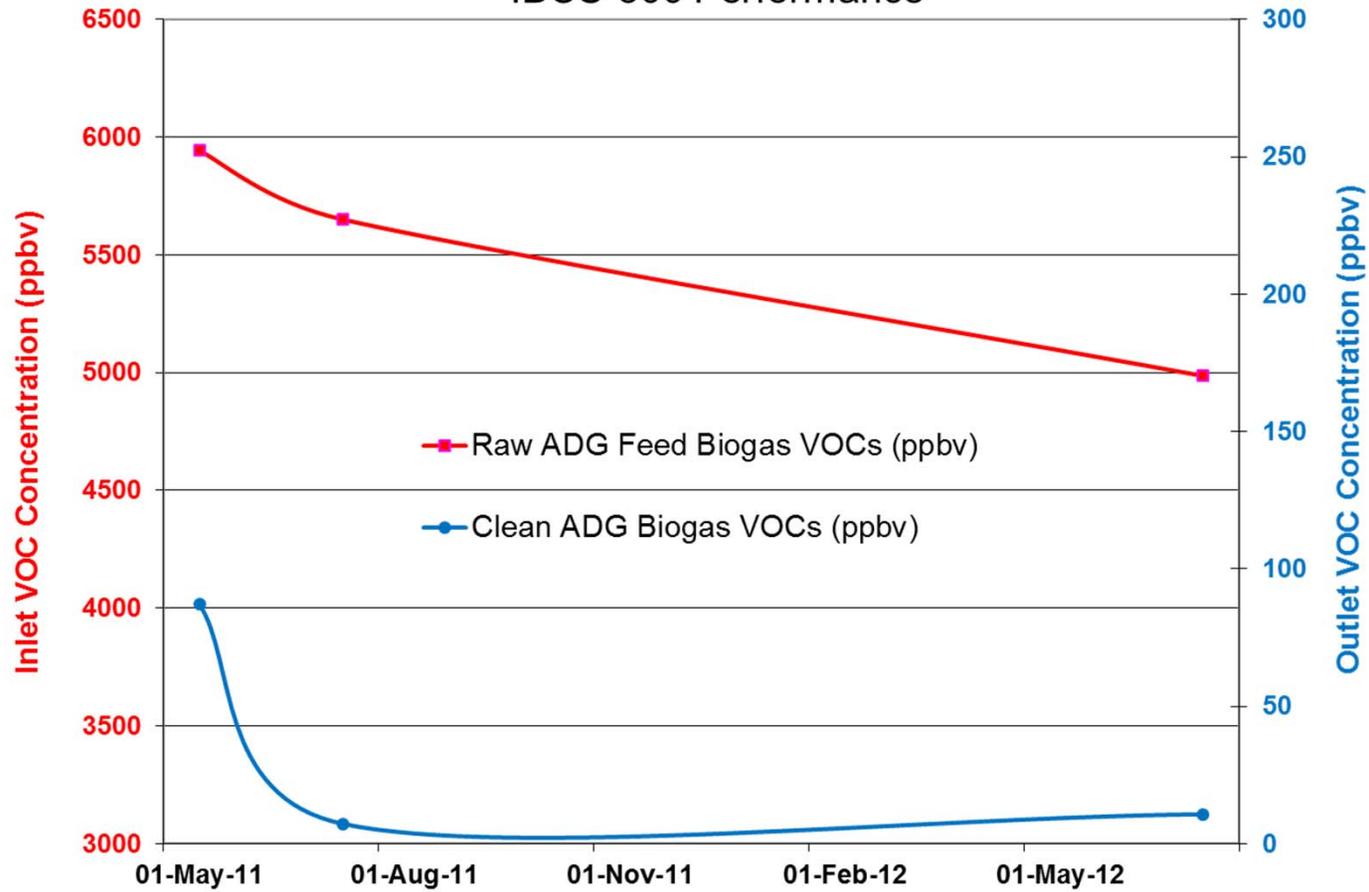


VOC Removal after 15,000+ hours of operation



Digester Gas Clean-Up Performance (VOC)

IBCS-300 Performance



Sulfur Removal after 15,000+ hours of operation

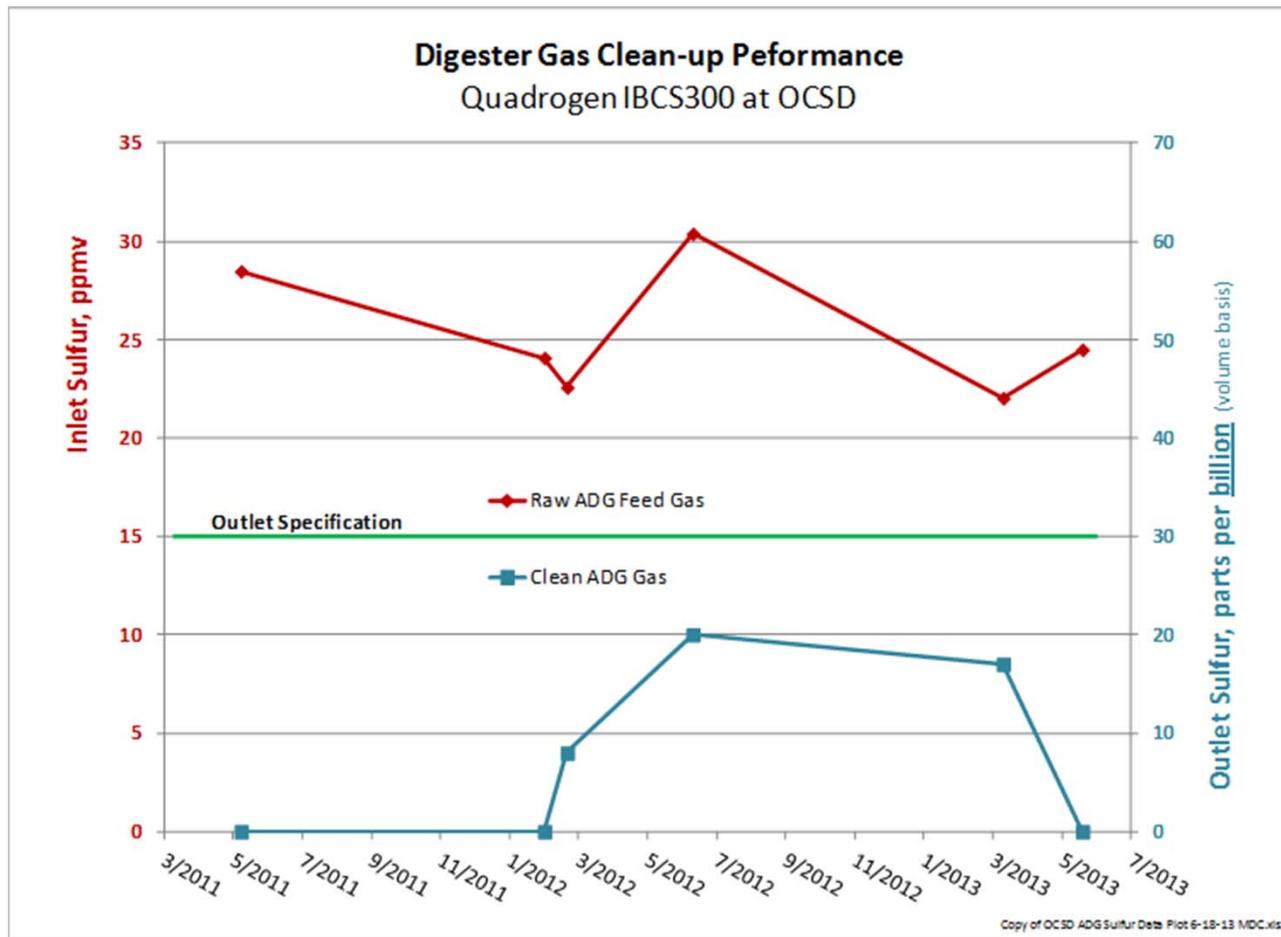
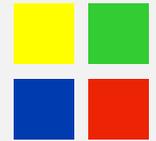
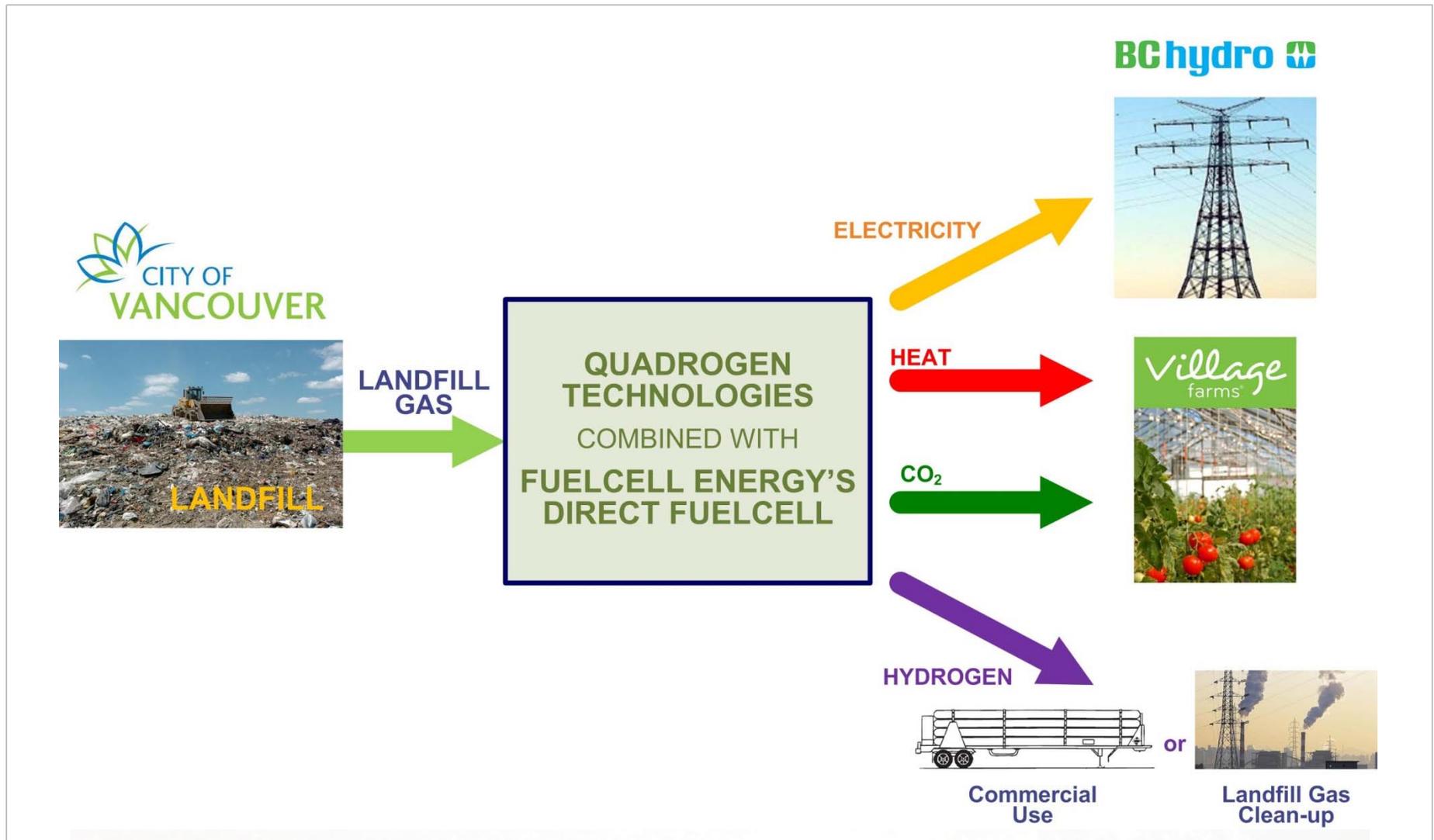
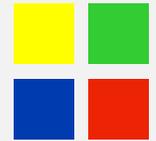


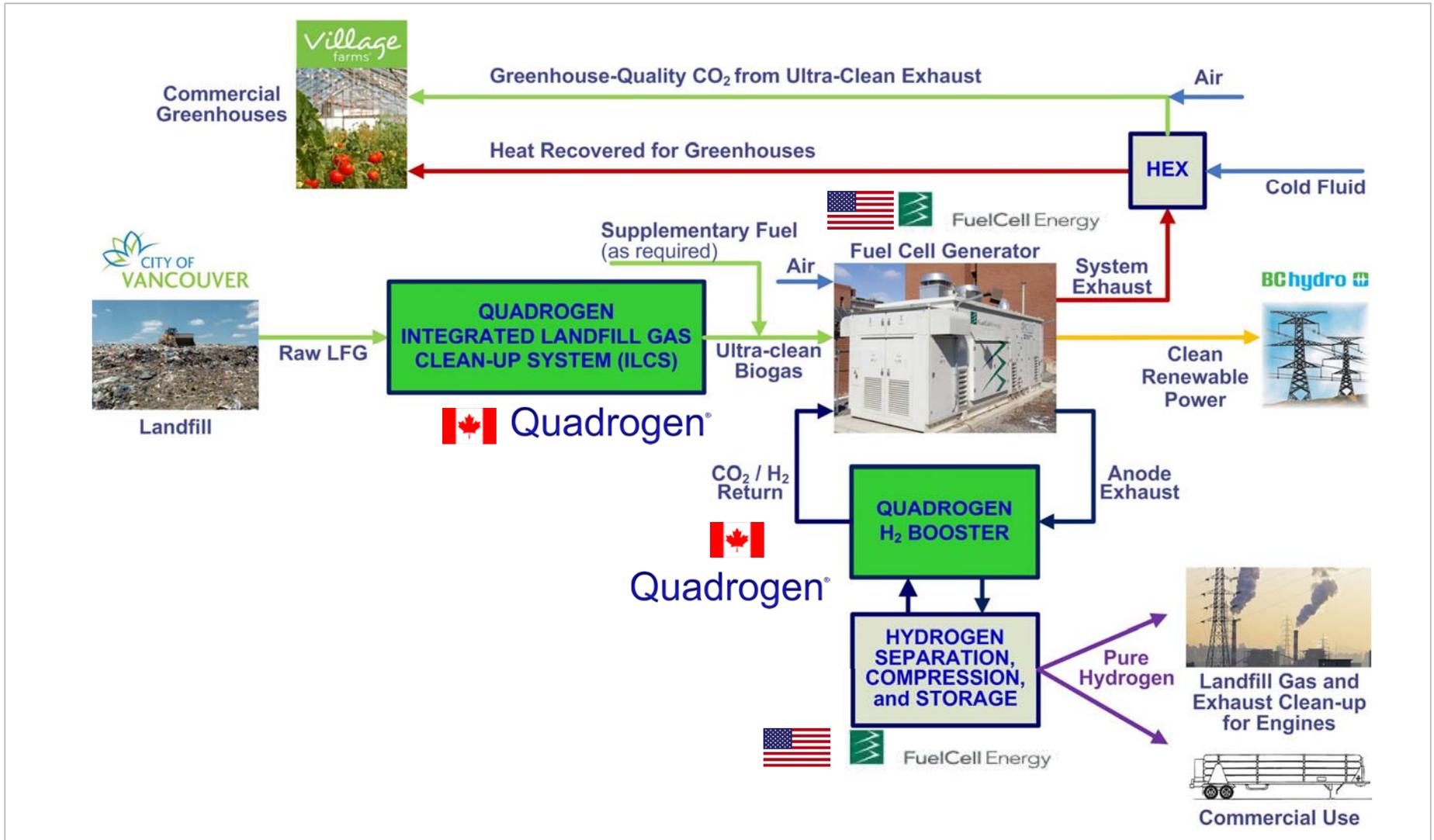
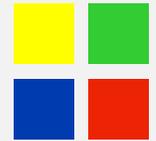
Chart courtesy of Fred Jahnke, Sr. Manager Hydrogen Programs, FuelCell Energy, Inc.

Highly Reliable, No breakthrough yet and no maintenance required

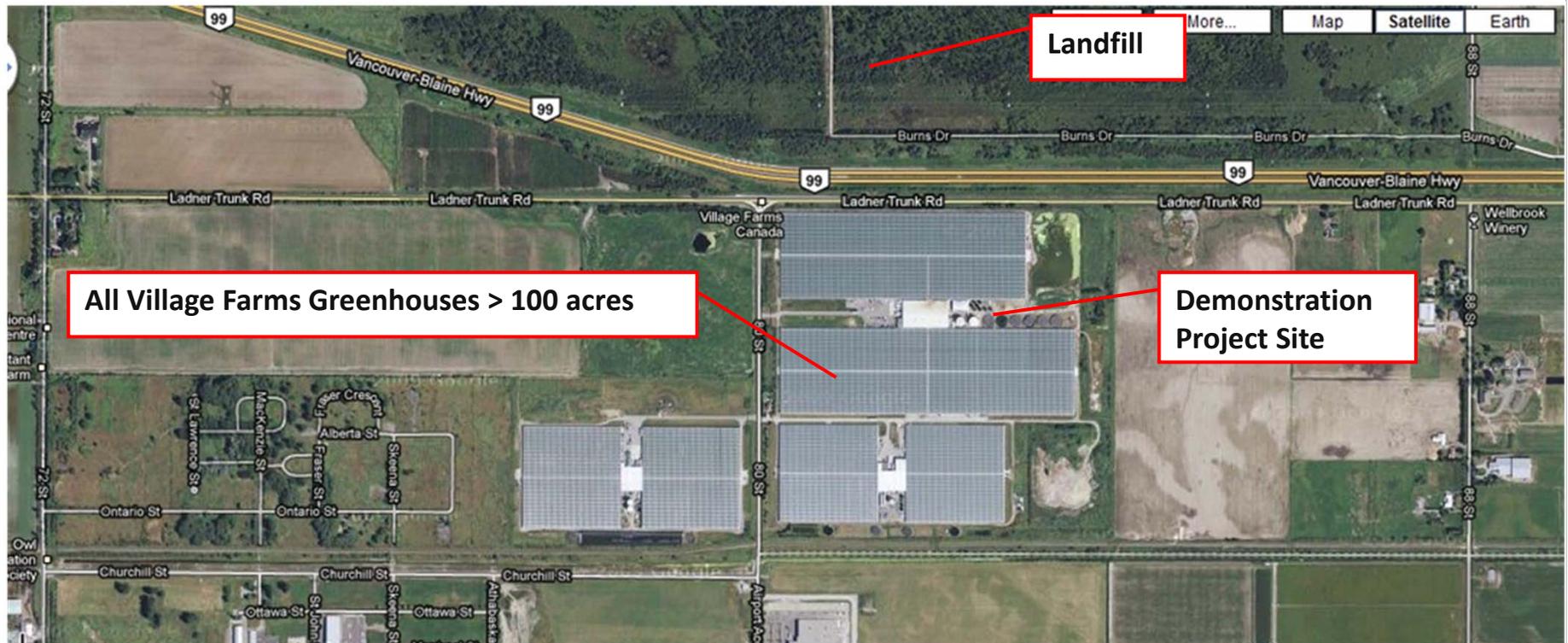
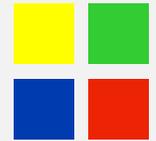
Quad-generation Demo Project in Delta, BC



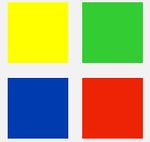
Quadrogen Technologies for Quad-generation Demo Project



Quad-generation Demonstration Project in BC, Canada

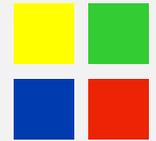


Conclusion



- Biogas system cost reduction
 - System simplification
 - Fuel flexible design and development

- Demonstrate technology for APG applications
 - Performance validation
 - Lifetime evaluation
 - Validate design for ease of deployment



THANK YOU



FuelCell Energy



SUSTAINABLE DEVELOPMENT
TECHNOLOGY CANADA™



BRITISH
COLUMBIA



Funding provided by:



Investment
Agriculture
Foundation
of British Columbia



Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada



Quadrogen Power Systems, Inc.
www.quadrogen.com
Phone: (604) 221 7170