

Taking Advantage of the Lowest Carbon Fuel and Improving the Environmental Performance of NGVs



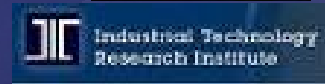
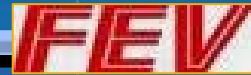
Advanced Transportation Technologies

*Clean Transportation Solutions*SM

John Boesel
President and CEO
NGVA Summit
September 21, 2009

CALSTART Has 130+ Members

(partial list)





NGV Cooperative



- CALSTART has partnered with Sempra Utilities, CNGVP & NG stakeholders to create a **Natural Gas Vehicle Purchase Cooperative**
- Benefits :
 - Coordination of high volume purchases of LD & MD vehicles by public & private fleets
 - Incentivizes manufacturers & dealers to expand the market for these vehicles
 - Makes process of finding & buying NGVs easier for fleets
 - Gives utilities, suppliers & other stakeholders concrete data on NGV market potential



Sign-up Today! www.ngvcoop.org



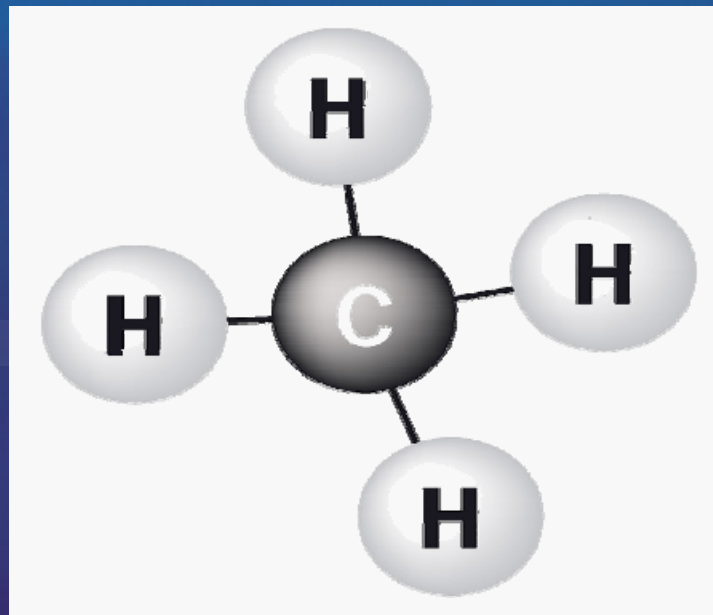
Natural Gas = Biogas But with Some Important Exceptions

Methane

Natural gas

Fossil Fuel

Less GHG
Emissions



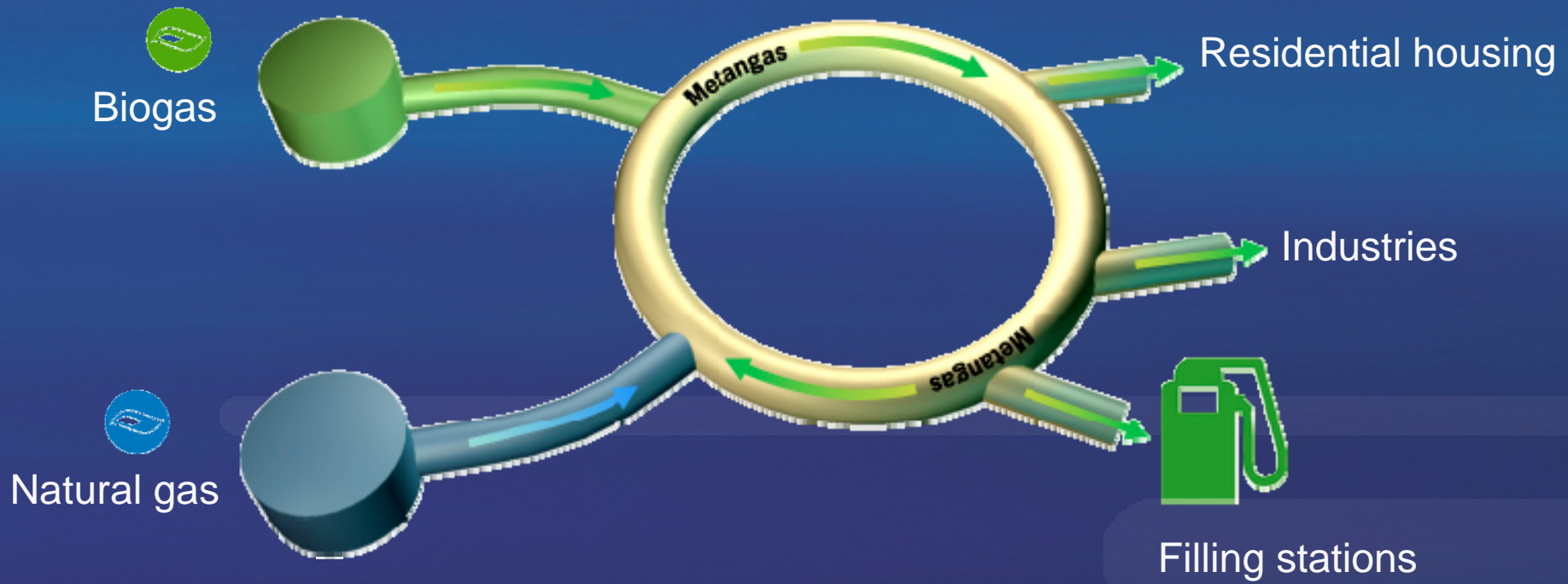
Both Good for
Air Quality!

Biogas

Renewable
Fuel

Net zero or
negative
GHG
Emissions

Green-Gas Principle – “Greening the Gas Pipeline”





Swedish Biomethane Vehicles





Linköping – The Bakersfield of Biomethane



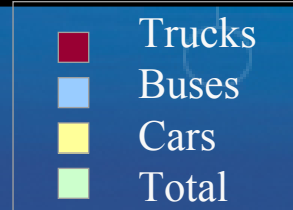
Off-the-Shelf Equipment is Used to Upgrade Digester Gas to Transportation Quality Biomethane



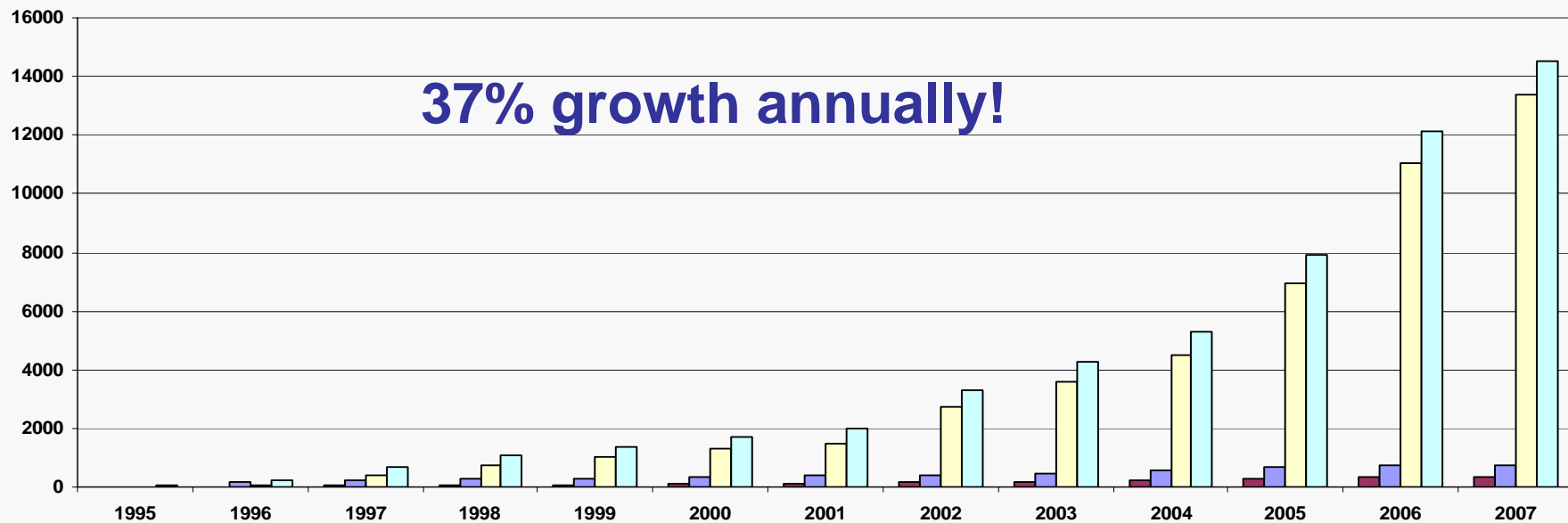
Digester where raw products breaks down and produces methane



Methane Gas Vehicles in Sweden



Number

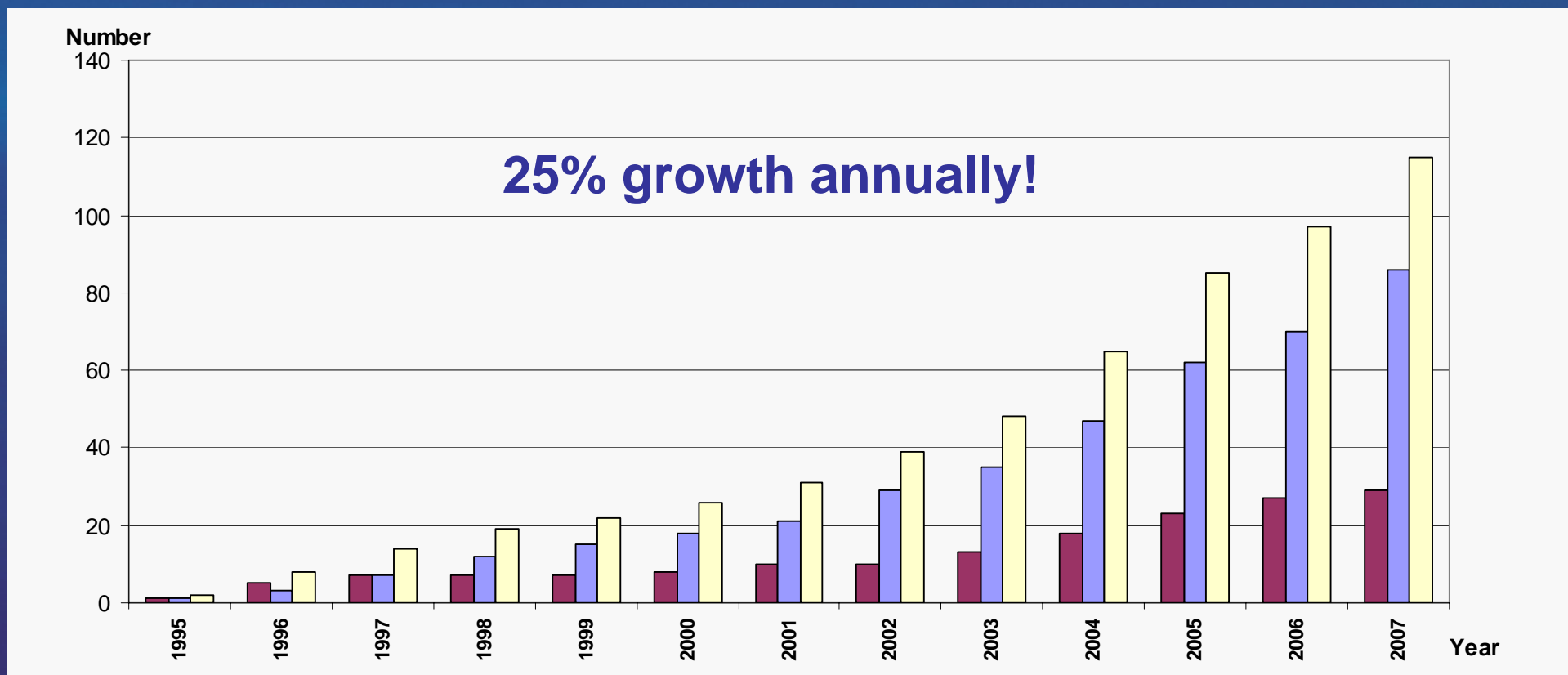


(Source: Svenska Gasföreningen)

Year



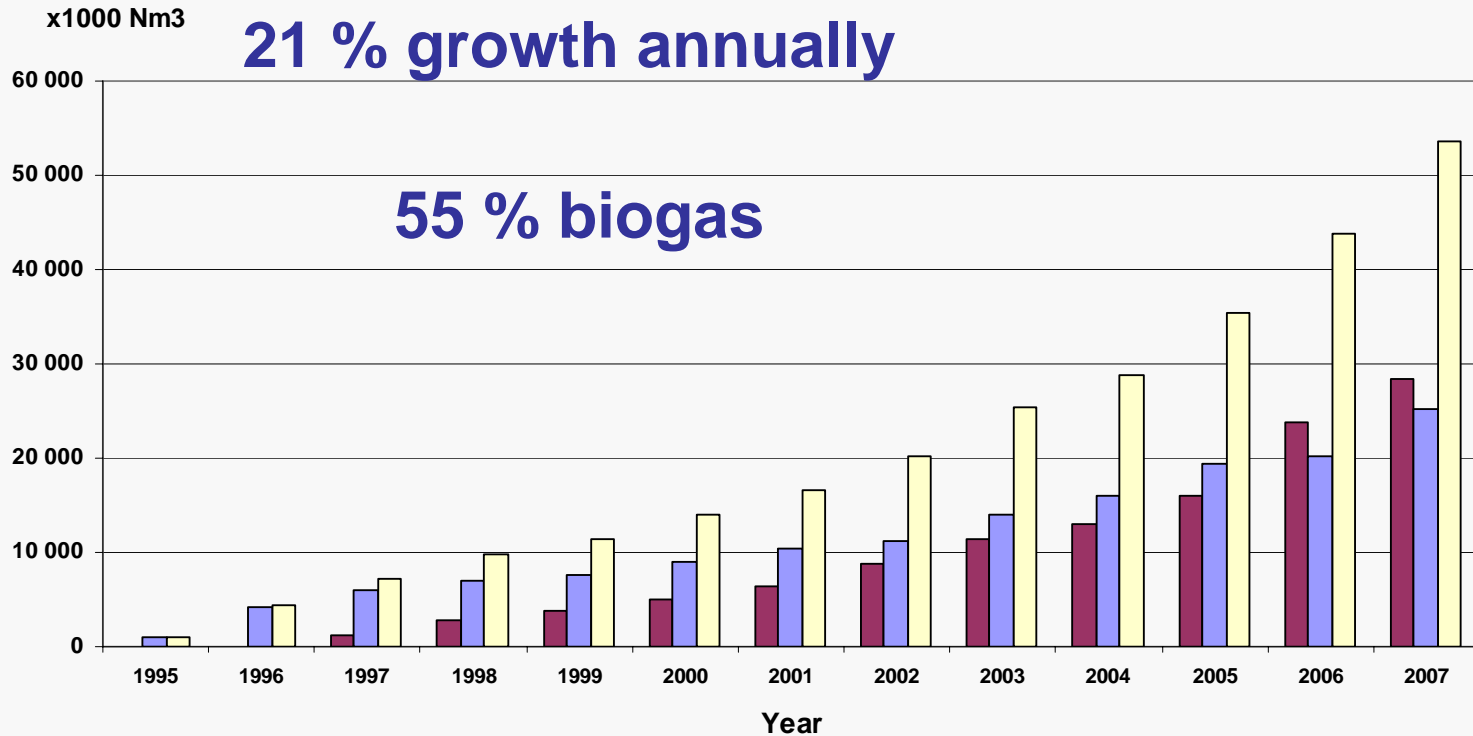
Methane Fueling Stations in Sweden



Sales of Methane Gas for Vehicles in Sweden



- Biogas
- Natural gas
- Total





By 2030 Biomethane Could Replace 25-35 % of Fossil Fuels Used for Road Transport in Europe



1,400,000 km natural gas grid in 32 countries
Biomethane can be distributed in the gas grid to the consumers

A wide range of biomass feedstock & high efficient production both from digestion and gasification

600,000 CNG vehicles already in traffic
2,000 existing fueling stations for CNG and CBG

Liquefied biomethane will play a important role



BUSINESS REGION
GÖTEBORG



Renewable Methane: Building Upon the Success in Sweden



- In 2006 the State of California signed a joint agreement with Sweden to collaborate on the development of bioenergy and biomethane in particular
- Sweden has the largest biomethane program in the world

Undersecretary Desmond, Minister Sommestad, Commissioner Boyd Sign MOU between CA and Sweden



Biomethane is the Lowest Carbon Fuel – According to LCFS

Fuel Pathway

Impact (gCO₂e/MJ)

• Landfill gas to CNG	11.26
• Biogas to CNG	13.45
• Landfill gas to LNG	26.05
• Biogas to LNG	28.27
Electricity (best case renewable mix)	34.90
H2 (best case SB1505 scenario)	33.09
Gasoline (CA reformulated)	96.09
Diesel (ULSD)	94.71
Biodiesel (from soybeans, with land use impact)	68.93
Conventional Natural Gas	68.00



Biomethane Buses Would 1/5 of the Emissions of Fuel Cell Buses

Draft CALSTART Report for Sempra Energy

<i>Propulsion Technologies & Fuels</i>				<i>Estimated Emissions</i>		
Vehicle Type	Engine	Type	Fuel	CO ₂ g/mile	NOx g/mile	Other Criteria Emissions
CNG	> 2007	Stoichiometric	NA - CNG Pipeline	2,763	1.18	√
CNG	> 2007	Stoichiometric	CNG Bio Source	458	1.18	√
Hythane	> 2007	Lean Burn	20% H ₂ SMR	3,031	TBD	√
Hythane	> 2007	Lean Burn	20% H ₂ Bio Source	2,804	TBD	√
Fuel Cell	> 2007	FC Hybrid	H ₂ SMR	2,500	0	√

Data Sources: Low Carbon Fuel Standard Documents, TIAX Documents, Professor M Miller



Biomethane Hybrid Buses and FC Buses (Biomethane) Clean Winners

Draft CALSTART Report for Sempra Energy

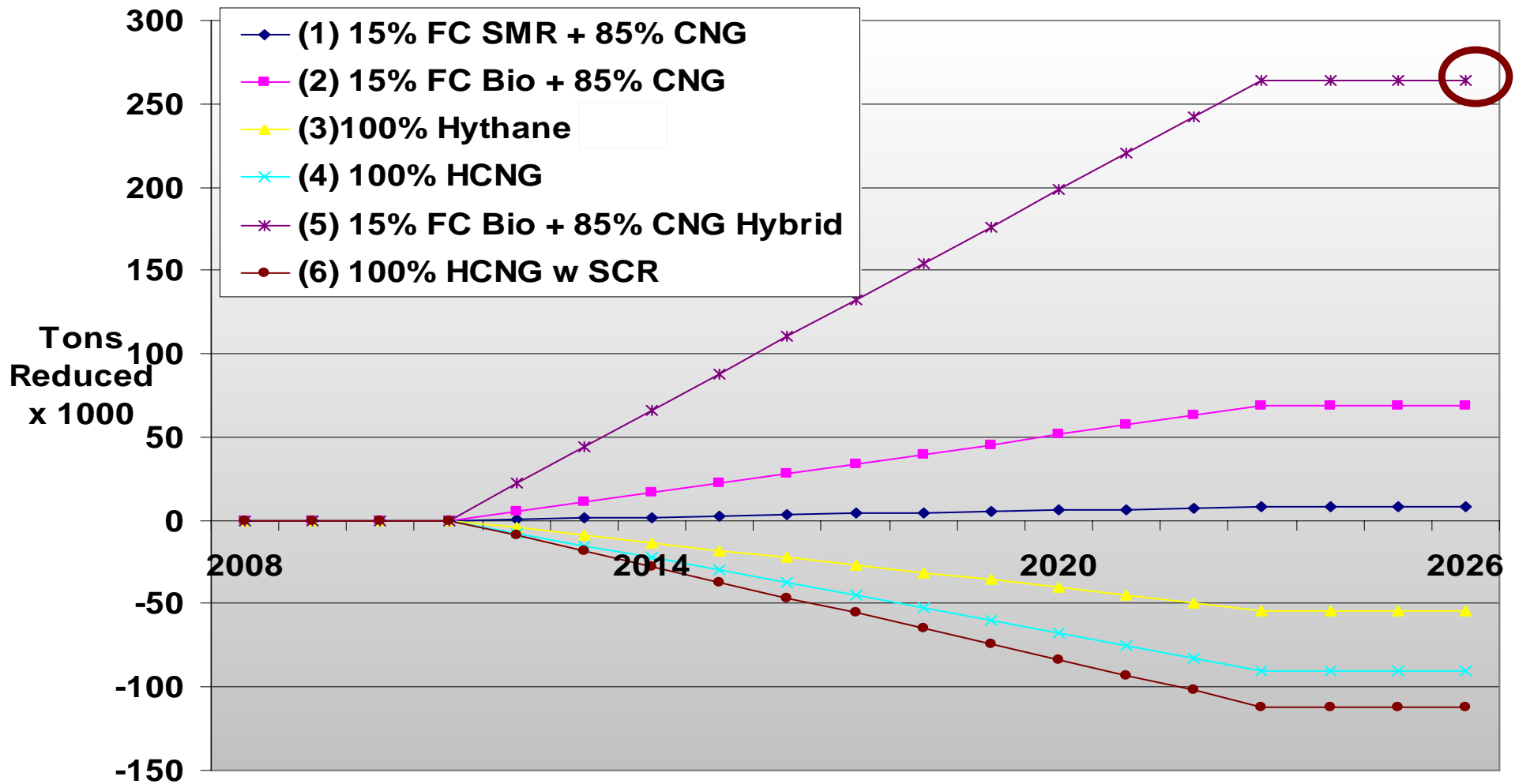
<i>Propulsion Technologies & Fuels</i>				<i>Estimated Emissions</i>		
Vehicle Type	Engine	Type	Fuel	CO ₂ g/mile	NOx g/mile	Other Criteria Emissions
Fuel Cell	> 2007	FC Hybrid	H ₂ Bio Source	500	0	√
HCNG	> 2007	Lean Burn, Low Swirl	30% H ₂ SMR	3,213	.47	√
HCNG	> 2007	Lean Burn, Low Swirl	30% H ₂ Bio Source	2,832	.47	√
HCNG w/SCR	> 2007	Lean Burn, Low Swirl	NA - CNG Pipeline	3,319	0.079	√
CNG Hybrid	> 2007	Stoichiometric	CNG Bio Source	338	0.944	√

Data Sources: Low Carbon Fuel Standard Documents, TIAX Documents, Professor M Miller



Scenario Review for CO₂

CO₂ Reduction (Metric Tons) vs Baseline





Summary NOx & CO₂ Emissions

(Current Z-Bus Regulation in Yellow)

Propulsion/Fuel	Scenarios (%)						
	Base	1	2	3	4	5	6
CNG	100	85	85				
CNG-Bio							
Hythane				100			
Hythane Bio							
FC SMR		15					
FC – Bio H ₂			15			15	
HCNG					100		
HCNG – Bio H ₂							
HCNG w/SCR							100
Bio CNG Hybrid						85	
NOx Tons Reduced*	0	36.0	36.0	TBD	142.0	172.0	220.0
CO ₂ Tons Reduced x 1,000	0	7.95	68.4	-54.1	-90.5	263.8	-112



“Score” for non-FC Scenarios - Matches FC Scenario “Score”

Propulsion/Fuel	Scenarios (%)									
	Base	1	2	3	4	5	6	11	12	
CNG	100	85	85					60	68	
CNG-Bio								15	7	
Hythane				100						
Hythane Bio										
FC SMR		15								
FC – Bio H ₂			15			15				
HCNG					100					
HCNG – Bio H ₂								25	25	
HCNG w/SCR							100			
Bio CNG Hybrid						85				
NOx Tons Reduced*	0	36.0	36.0	TBD	142.0	172.0	220.0	35.0	35.0	
CO ₂ Tons Reduced x 1,000	0	7.95	68.4	-54.1	-90.5	263.8	-112	68.4	9.6	



Cost of Biomethane Production in Sweden (2008)



Process	~ €/ kWh	~ €/ l petrol eq.
Sewage sludge	0.03 – 0.04	0.23 – 0.36
Organic waste	0.03 – 0.05	0.23 – 0.42
Energy crop gas (38 MW)	0.07 – 0.08	0.53 – 0.67
Synt. natural gas (100 MW)	0.04	0.36

Sources: Swedish Gas Centre, BioMil





Pricing Carbon in Transportation – Critical Element of Growth of Biomethane Industry

- **Federal cap and trade legislation – unlikely to be a factor in transportation market**
 - Waxman-Markey as it passed out of House was designed to create a low price for carbon with assurances it would not rise quickly
- **California’s Low Carbon Fuel Standard (LCFS)**
 - Approved by CARB in 2009
 - 10% reduction in carbon intensity of fuel sold in CA by 2020
 - Does not place a cap on total carbon emissions from transportation sector
 - “back-loaded” – reductions not likely to occur until 2017-2020 time frame



To Pipe or Not

- Using gas pipeline could improve economics, but may not favor use of fuel in transportation sector
- Protocols currently in place for utilities to get Renewable Portfolio Standard (RPS) credits by inserting biomethane
- Similar system don't yet exist to give credit for transportation projects
- In some cases feedstock not in location close to pipeline, yet truck traffic significant





What's Needed to Make Use of the Lowest Carbon Fuel?

- **Need to build production plants and run vehicles**
- **Give other fleets and operators a chance to see first hand and “kick the tires”**
 - SunLine and AC Transit have played similar role relative to use of hydrogen in transportation
- **Need to better understand the CA economics of biomethane and other issues**
 - Sweden economics are different (can biomethane work in a state with relatively low cost fuel?)



Leading Biogas Producer Has Received Permits for 3 CA Biogas Plants

Microgy, Inc.



- Microgy has received permits to build three biogas plants in California
- At each site Microgy is cleaning up the biogas and generating “pipeline” quality biomethane
- Credit crisis has stalled projects
- Technology can produce gas for pipeline and transportation needs

Largest US biogas plant (Huckabay Ridge, TX) -- 635,000 mmbtu/yr gas production targeted

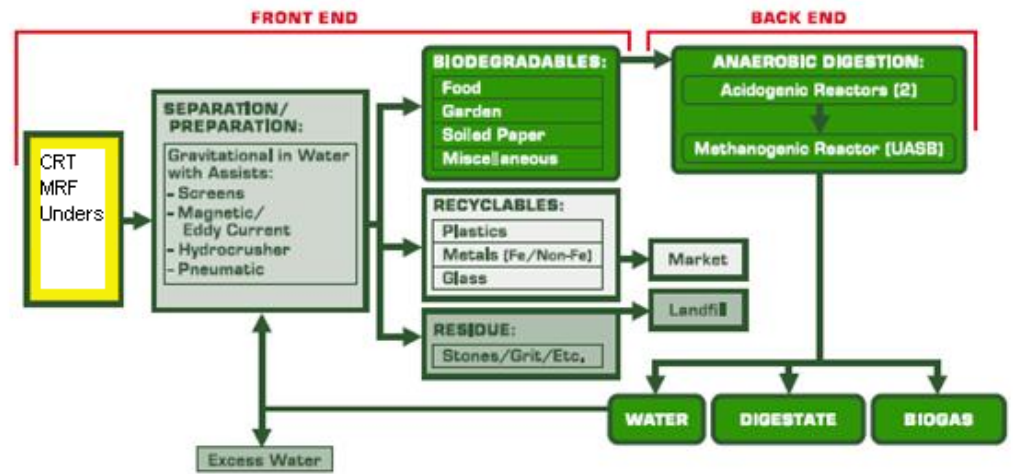


CR&R Perris Project

- First in the nation use of Arrow Bio system for municipal waste stream sorting and AD processing to biogas – process would reduce flow to landfill while cutting emissions
- Fuel to be used in growing CNG-powered refuse truck fleet



ArrowBio System Logic





Waste Management – Linde Project

- Follow-on to Altamont project
- Implementing commercialization of new landfill gas clean-up technology
- Southern CA (SCAQMD Basin) location
- LNG to be used in Waste Management fleet



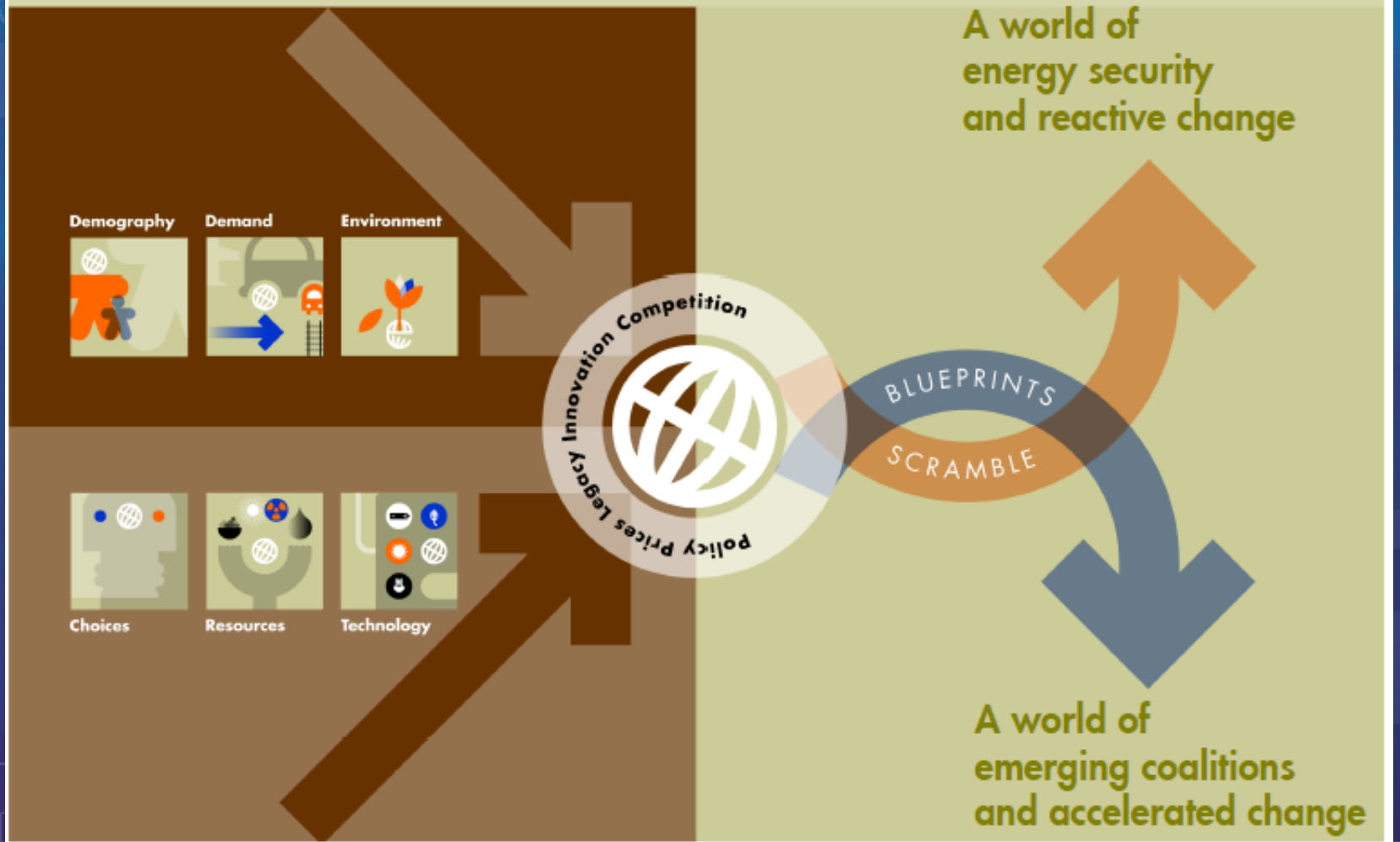


CALSTART Biomethane Transportation JumpStart Program

- Dairy Waste
- Municipal Trash
- Agricultural Waste
- Landfill Gas
- Trial of differing feedstocks
- Differing biogas creation techniques
- Differing biogas cleanup technologies
- Pipeline, Liquifaction, Compression
- Displacement/Conversion of gasoline and diesel



Shell energy scenarios help us to imagine alternative futures





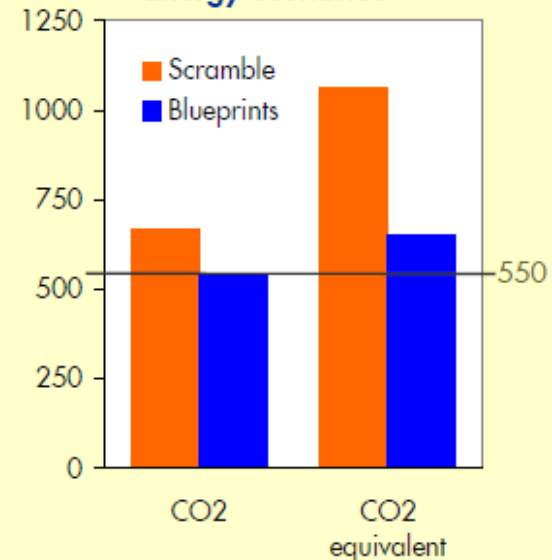
Neither Scenario Works

The Blueprints scenario highlights that much more has to be done

Using the outputs of the Shell energy scenarios in conjunction with the MIT models indicates the following and illustrates how critical non-energy GHGs are

- Shell Blueprints resulted in the lowest 'possible achievable' GHG emissions
- Blueprints *stabilises* at a pathway of 650 ppm CO₂e (540 ppm CO₂)
- Scramble is over 1000 ppm CO₂e (670 ppm CO₂), *and rising*, at end of the century
- Scramble's CO₂e ppm is 60% higher than its CO₂-only ppm. In Blueprints it is only 20%

PPM pathways of Shell Energy Scenarios



Pathways include emissions from energy and non-energy sources; CO₂ equivalent (CO₂e) includes all GHGs not only CO₂

Source Shell energy scenarios and MIT



Summary

- CA needs to reduce carbon emissions to 80% below 1990 levels by 2050 – from 15 BGGE to 2.5
- Biomethane is the lowest carbon transportation fuel with virtually zero technical risk
- Following the Sweden model, California needs to establish some production plants that can serve as learning centers for others
- Sweden has figured out how to create an economic value proposition – Will the United States?



Hilarides Dairy Truck -- 1 of 2 trucks running on biomethane in California today

Clean Transportation Solutions SM
Advanced Transportation Technologies SM



www.calstart.org