Track 2: Sustainable Energy

I. **Renewable Energy: Wind and Wave**
II. **Renewable Energy: Solar**
III. **Biomass: Waste to Fuel**
IV. **Biomass Energy Recovery Optimization**

1. Renewable Energy Wind & Wave:

Speakers discussed renewable energy conversion equipment now in various stages of development, e.g., concept, prototype, demonstration, or initial commercial application. The session covered technology suppliers ranging from sole concepters to multibillion-dollar international energy companies. The session focused on the technology itself, but the technology must also demonstrate financial viability.

Cost-Effective Tidal-Stream Power Demonstrated

Robert Keith Smith, Pulse Tidal

For more than a year, Pulse Tidal has been operating a grid-connected tidal-stream power demonstration device that delivers cost-effective energy. Pulse uses an oscillating hydrofoil for energy capture: horizontal wing-shaped blades move up and down in the water column, much like a whale's tail. This oscillating motion is converted to electricity through a hydraulic and mechanical linkage. The self-contained device, which is located in the United Kingdom, operates in shallow water, has no visual impact, and does not threaten wildlife.

Wave Energy Proving Itself Cost-Effective

Dennis J. Gray, Poseidon Energy Inc.

Look across the open sea at the large, rolling waves. Does the abundance of energy become glaringly obvious? Scientists have concluded that wave energy is at least an order of magnitude greater than wind or solar. Now, Poseidon's wave energy can beat the cost of wind energy (less than $0.05/kWH), making the cost of clean renewable energy competitive with that of fossil-fuel energy. The company has tested a scale model, and independent suppliers and fabricators have estimated the cost of full-sized versions. Independent observers also have verified the power output of Poseidon's device.

Cal-ePower Vertical-Axis Wind Turbine (VAWT) Produces High Power Densities

Summer A. Scobell, California Energy & Power

Small wind turbines can provide power for individual home owners, and MW-scale turbines can generate large amounts of power for utilities. But few, if any, solutions exist for institutions needing 100 kW to 10 MW of wind energy. The Cal-ePower VAWT was designed to work in distributed generation systems of that size, and users can install it wherever they need power. The device is equipped

with a wind-concentrating airfoil on its leading edge. The design is final, patented, and ready for commercialization. The machine was designed to solve the major problem with VAWTs: the oncoming air that drives the turbine also impedes the returning blades.

Vertical-Axis Wind Turbine Arrays Enhance Power Density

John O. Dabiri, California Institute of Technology

The Caltech Field Laboratory for Optimized Wind Energy has achieved a field demonstration of order-of-magnitude increases in the power density of wind energy technology, significantly exceeding commercially available capabilities. Whereas modern wind farms produce 2 to 3 watts of power per square meter of land area, and modern solar technologies achieve power densities of 20 watts/ sq. meter, the Caltech initial field tests indicate that power densities approaching 100 watts/ sq. meter are feasible using commercially available vertical-axis wind turbines in layouts that enhance constructive aerodynamic interference between neighboring turbines.

Ocean Thermal Energy Technology Comes to Dry Land

Jeremy Feakins, Ocean Engineering and Energy Systems

Ocean Engineering and Energy Systems is scaling up ocean thermal energy conversion technology (OTEC) to provide commercial power and is developing the first commercial land-based application of the technology. OTEC is a base-load system producing power 24/7—not like intermittent technologies that need the sun to shine or the wind to blow. It extracts solar energy collected in tropical oceans and converts it into electricity. The method has a low thermal efficiency, but it involves no cost of fuel. OTEC uses the temperature difference between warm surface water (heat source) and cold water from deep in the ocean (heat sink) to drive a heat engine and produce electric power.

Small Plants To Augment Big California Renewable Projects

Hal LaFlash, Pacific Gas and Electric Co.

Renewable resources—including hydroelectric, biomass, geothermal, wind and solar generation—have helped satisfy California's electrical energy needs for years. Now, the state wants to increase the "eligible renewables" in the generating portfolio from 11% in 2008 to 20% this year and 33% by 2020. Obstacles have arisen, but utilities have addressed some of the problems by using power from smaller plants to augment the power from larger renewable energy plants.

2. Renewable Energy Solar:

Speakers plan to discuss renewable energy conversion equipment now in various stages of development, e.g., concept, prototype, demonstration, or initial commercial application. The session will cover technology suppliers ranging from sole concepters to multibillion-dollar international energy companies. The session will focus on the technology itself, but the technology must also demonstrate financial viability.

CLFR Technology Improves Solar Thermal Solutions

Jayesh Goyal, Areva Inc.

Compact linear fresnel reflector (CLFR) technology vastly improves solar thermal solutions. The invention maximizes steam output for power generation, using a land-efficient and reliable solution to generate superheated steam. The invention has been developed and constructed at Bakersfield, California, for demonstration in October.

The Powerdish: Changing How the World Gets Solar Electricity

David L. Townley, Infinia Corp.

The Powerdish, a concentrator-dish, free-piston Stirling solar electric generating system produced by Infinia Corp., has been developed and delivered in multiple sizes to customers over the past 25 years. During that time, Infinia has received 31 patents on the system. In the last 4 years, Infinia integrated its free-piston Stirling engine technology with a solar concentrator dish; developed a high-performance, cost-effective solar electric system that can be mass produced using automotive-style production processes; and deployed the system at nine sites in the United States, Spain, and India for field testing and demonstration.

Molten Salt Storage Extends Solar Day at CSP Plant

Ernesto Alvarez, TSK Energy & Industrial Plants

TSK is using molten salt storage to extend the solar day at its latest 50-MW CSP plant. The addition of salt storage, which is a custom design, allows for peak demand response and extends the generation time after sundown. The plant uses a parabolic mirror and synthetic oil technology to generate the heat for conversion to electricity.

3. Biomass: Waste to fuel:

This session focused on technologies and sustainable solutions to generate storable power, liquid fuels, and value-added products from biomass, algae, and a variety of waste products.

Transforming Sunlight into Food and Fuel for the World

Chris J. Walker, PetroAlgae

Light and environmental management systems from PetroAlgae help grow aquatic microorganisms at a rate that consistently exceeds four times their natural growth rates. That increase aids commercial-scale production of two end-products: a fuel feedstock and a protein, referred to as biocrude and protein products. The fuel feedstock is intended for use in existing refineries, producing renewable fuels identical to the petroleum-based fuels they replace. The high productivity achieved with the product produces low-cost fuel feedstock, which should increase refinery profitability without government subsidies.

30-Year-old Fluidized Bed Technology Coming of Age

James A. Starkey, EPI (Energy Products of Idaho)

In the search for renewable and sustainable energy supplies and carbon-neutral technologies for producing power and heat energy, the power-generation industries are turning their attention to a technology more than three decades old. That is how long fluidized bed technology has been used successfully to turn biomass and other alternative and waste-derived fuels into energy. This presentation described how the technology has converted more than 250 renewable fuels—ranging from agricultural and animal waste to garbage and sewage sludge—into low-emission, carbon-neutral energy. Recent developments have positioned fluidized bed gasification as a viable method of retrofitting fossil-fuel-fired boilers to biomass cofiring.

Storable Renewable Fuels Help Meet Continual Power Requirements

Ronald L. Kent, Southern California Gas Company, a Sempra Energy Utility

Solar and wind-based power resources do not always meet continuous, dynamic, utility-scale electric power requirements; therefore, plants of the future should have access to storable renewable fuels. To that end, Sempra Energy utilities (Southern California Gas Company and San Diego Gas and Electric) are working to develop storable renewable fuels. The efforts include (1) recovering and upgrading biomethane from anaerobic digesters; (2) adapting oxy-fuel power system to combust synthesis gas from biomass gasification, glycerol (a biodiesel production byproduct), algae slurries, and hydrogen; and, (3) gasifying biomass feedstock and then converting the syngas to methane and/or electric power.

Converting Energy-Rich Polymer Waste to Fuel

Jay Schabel, Polyflow

At $70 per barrel, the United States uses more than $39 billion of oil and gas each year to manufacture polymers. Less than 7% of those polymers are recycled at the end of their useful life, which means approximately $37 billion in polymers ends up in the city dump. In fact, it is the most concentrated form of energy entering landfills. Polyflow uses mixed and dirty polymer waste in place of crude oil to produce the same products produced from crude oil.

Diesel, Jet, and Gasoline Fuels from Waste

Joseph A. Kocal, UOP LLC

Fuels from renewable feedstocks are going to make up an increasing share of the energy pool. Fungible biofuels will be the lower-cost and reduced-risk option due to use of existing infrastructure. Sustainability criteria must be considered in every step of the process from cultivation through fuel combustion in transportation. Feedstock availability is an important enabler. First generation biofuels will be produced from natural oils and greases that do not compete with food. Second generation feedstocks such as lignocellulosic wastes and algal oils are on the horizon. A diversity of feedstocks will be required to achieve a significant substitution of petroleum-based fuels. UOP has developed catalytic processes for conversion of oils and greases to green diesel and green jet fuels that can be used directly in existing infrastructure. These fuels meet all specifications. Technology for the conversion of lignocellulosic feedstocks to fungible gasoline, diesel, and jet fuels is currently under development.

Monetizing CO2 Emissions for Energy and Climate Security

Mark P. Allen, A2BE Carbon Capture LLC

Energy security and climate security are often seen as competing goals that cannot be pursued in a unified industrial strategy. This presentation will address monetizing CO2 emissions into fuel, energy production efficiency gains, and carbon capture and sequestration offsets—all through photosynthesis. Three examples will be given that illustrate the use of algae for oxyfuel enhanced electric power generation, integrated coal/biomass liquid fuel production, and TerraDermTM nitrogen fixation and carbon sequestration in soil.

4. Biomass Energy Recovery Optimization

This session focused on needs, challenges, technology, and collaboration in recovering power and energy from biomass that can include sewage sludge, municipal solid waste, algae, and agricultural waste.

Panel Discussion

Panelists:
Chair: Surendra Thakral, Parsons
Mamadou Diallo, Caltech Materials and Process Simulation Center
Art Chianello, City of Bakersfield Water Division
Steve Fan, City of Los Angeles Wastewater Engineering Services
Jeff Noelte, Inland Empire Utilities Agency

Biogas-to-Energy: Review of Current State-of-the Art, Business Climate, Technical and Economic Challenges

Mark McDannel, Los Angeles County Sanitation Districts
Biogas (i.e., digester gas and landfill gas) has been used for energy production for decades. Biogas is collected and used in engines, large turbines, microturbines, or fuel cells to generate electricity. Recent increases in power prices and interest in renewable power have led to development of projects that were not previously economically viable. Electricity providers in California must meet a 20% Renewable Portfolio Standard (RPS) in 2010 and a 33% standard by 2020. Biogas has the potential to provide hundreds of megawatts in California and thousands of MW nationwide. Compared to existing capabilities, the benefits include reduction of fossil fuel usage and greenhouse gas emissions and increased electricity supply requiring minimal transmission upgrades. New technologies with lower criteria pollutant emissions are needed as stricter emission regulations threaten long-term usage of established technologies such as engines. This presentation provided a review of established, recently commercialized, and development-stage biogas-to-energy technologies. Detailed discussions were presented on use of internal combustion engines and combustion turbines. Engines have been the workhorses of the industry for the last 20 years, but stricter emission limits have stopped new installations in southern California. With the stricter emission limits on engines, combustion turbines are capturing more market share. Specific details were presented on the Sanitation District's new Calabasas Landfill Gas-to-Energy Facility, a 12-MW plant using the new low-emission–high-efficiency Solar Mercury 50 turbine that started up in July 2010.

Cost Savings with MicroSludge for Increased Anaerobic Digester Capacity

Robert J. Stephenson, Paradigm Environmental Technologies Inc.
Without sludge pretreatment, anaerobic digestion of sludge from wastewater treatment plants (WWTPs) proceeds slowly and converts only a small portion of waste activated sludge (WAS) to biogas. By improving digester performance, a

WWTP's capital and operating costs to manage sludge can be significantly reduced. MicroSludge is a sludge pretreatment process that ruptures the microbial cell membranes in sludge to improve the performance of anaerobic digestion. MicroSludge uses a cell disrupter (a modified high pressure homogenizer) to rupture the bacteria cells of thickened WAS. By speeding up the rate of digestion and by reducing the viscosity of sludge to enable thicker sludge to be fed to digesters, MicroSludge enables greatly increased digester throughput. WWTPs needing additional digester capacity can avoid building more digesters, saving costs to build and operate digesters. By increasing the conversion of sludge to biogas and by reducing the amount of sludge for disposal, MicroSludge enables more biogas to be produced for energy generation and lowers sludge disposal costs. For lower cost anaerobic digestion of municipal sludge, municipalities should address two needs: (1) they should increase digester throughput must because digesters are very costly, using up to half of a municipal WWTP's capital and operating budgets; and (2) they should make digesters more efficient at converting WAS to biogas and at reducing the quantities of residual sludge for disposal. MicroSludge performance has been validated through full-scale technology trials at Des Moines, Iowa; Los Angeles County, California; and Chilliwack (near Vancouver), Canada. MicroSludge has been demonstrated at full scale, but a longer track record is a must for WWTPs to have confidence in the technology.

Sustainable Management of Biosolids — Renewable Energy for the 21st Century

Ashok K. Rao, Parsons

Over the past 30 years, supercritical water oxidation (SCWO) technology has had some academic and industrial interest for destruction of hazardous materials. More recently, this technology has been focused on efficient recovery of sustainable energy from municipal and industrial sludge. Under conditions above 221 bars and 374°C (critical point of water), very rapid oxidation of organics takes place and more than 99.99% destruction efficiencies can be achieved in a fraction of a minute reaction time—regardless of the nature of the organic species. The products of the reaction include clean, permit-free, CO2 rich gas; nonhazardous, fully oxidized, inorganic, phosphate-rich, fine mineral residue; and treated water with traces of COD (< 5 ppm). The process is inherently more efficient (~ 90% thermal energy recovery) than traditional incineration or gasification of wet waste because SCWO avoids loss of the latent heat that is needed to evaporate water from wet wastes prior to incineration or gasification. The process is being licensed under the trade name of AquaCritox® by SCFI Group in Ireland. The power generated by this process is classified as renewable energy. Extensive pilot runs in the context of energy recovery from industrial/municipal sludge have been successfully completed in Europe. Commercial operations are scheduled to begin in 2011 in Cork, Ireland.

Producing Ultra-Green Biogas

Lowell E. Howard, ESC Corp.

Several needs relate to biogas purification equipment: (1) lower capital cost, (2) lower operating cost, (3) need for the systems to have a smaller footprint to facilitate installations where space is at a premium, and (4) need for the treatment equipment to be more "green." The CompHeet® process fulfills all of these needs. The CompHeet process removes and retains siloxanes and other harmful contaminants from biogas on a special regenerable media. When the accumulation of contaminants reaches a preset level, the PLC isolates the vessel to be regenerated and switches the flow to a fresh vessel for uninterrupted operation. Hot, inert gas is used to strip the accumulated contaminants from the media. These contaminants are conveyed to a hot inert gas generator where they are destroyed. At a preset time, the regeneration process is stopped, the vessel is cooled and remains in standby until the other vessel requires regeneration. Waste heat from compression is harvested and used to drive the CompHeet process, reducing its operating cost. Heat from combustion can also be recovered as the process exhaust is clean. This replaces the need for additional energy that would be wasted by other technologies. In 2006, the CompHeet process was developed to ultrapurify anaerobic digester and landfill gas. Two field pilot studies were conducted that demonstrate the unit's ability to remove harmful contaminants from biogas and to regenerate the media for continuous operation. After several years of engineering and refinement, the first commercial installation and startup of this unit will occur in late 2010.

Algae to Biofuel

Vikram M. Pattarkine, OriginOil Inc.

Algae have been receiving increased attention as the most promising biomass for capturing CO2, producing renewable energy, and promoting energy security by reducing our dependence on foreign oil. The major technical obstacles for algae to become the preferred green energy feedstock are energy-efficient, scalable, and cost-effective systems to (1) rapidly grow large quantities of algae and (2) extract oil from algae biomass. OriginOil Inc. has addressed these challenges by developing a proprietary photobioreactor for rapidly growing large quantities of algae biomass through optimum light and nutrient delivery and an energy-efficient single-step extraction (SSE) process to separate oil, water, and biomass without using chemicals or expensive energy-intensive equipment. In the OriginOil SSE process, algae cells in suspension are passed through a device that subjects the cells to a combination of Quantum Fracturing™, pH modification, and electromagnetic pulsing. The treated suspension flows into an oil-water separation unit, where the lysed cells settle by gravity and lipid floats to the top. Lipid is captured using a lipid skimmer. Water is recovered, treated, and returned to the algal growth container. The conventional process of oil extraction comprises dewatering and steam drying of algae biomass before oil can be extracted. These processes require a large amount of energy, whereas the

OriginOil SSE process does not. The SSE process, while separating lipids, also causes algae biomass to flocculate and settle by gravity in a clarifier, which makes biomass harvest and water recovery energy-efficient as well. At full scale, the lipid extracted from algae would be degummed and further processed to manufacture value-added products. OriginOil's first partner is MBD Energy in Australia using algae for CO2 capture.

Application of AFC Technology for Making Renewable Energy
Alan F. Rozich, PMC BioTec Co.
Biological systems are capable of achieving total conversion of organics to either CO2 and water (aerobic) or CO2 and methane (anaerobic) with major increases in methane output of anaerobic digesters. AFC technology has a 40-year basis with twelve full-scale total conversion (zero sludge) aerobic systems operating since 1995 and the anaerobic version in deployment. AFC uses three steps: (1) organics are fed to an aerobic or anaerobic reactor (2) a solids separation step separating organic particulates, and (3) a chemical treatment step making organic particulates biodegradable for return to the reactor. AFC now uses mechanical chemical grinding approach (MCG) which reduces particulate particle sizes and lowers costs to $20/dry ton. AFC radically improves anaerobic digester (AD) performance reducing sludge disposal costs while increasing methane production using a retrofit approach. Typical AD systems operate at 45-50% conversion efficiency while AFC systems operate over 90% efficiency. AFC technology makes ADs an economic reality for renewable energy, particularly in the backend of bioethanol and algae biofuels systems where methane becomes an energy co-product. AFC aerobic process is proven technology while demonstration anaerobic plants with MCGs are planned for showcase applications in key locations. Pilots are now operating at Samsung and a large municipal plant in Korea with US pilot testing for algae and bioethanol under way with partner companies. Showcase installations will demonstrate enhanced energy production and minimal disposal costs. Korea and Europe are key global targets to deploy AFC. Longer term, demonstration AFC facilities using various feedstocks will accelerate technology adoption as a contributor to economic sustainable energy production.