

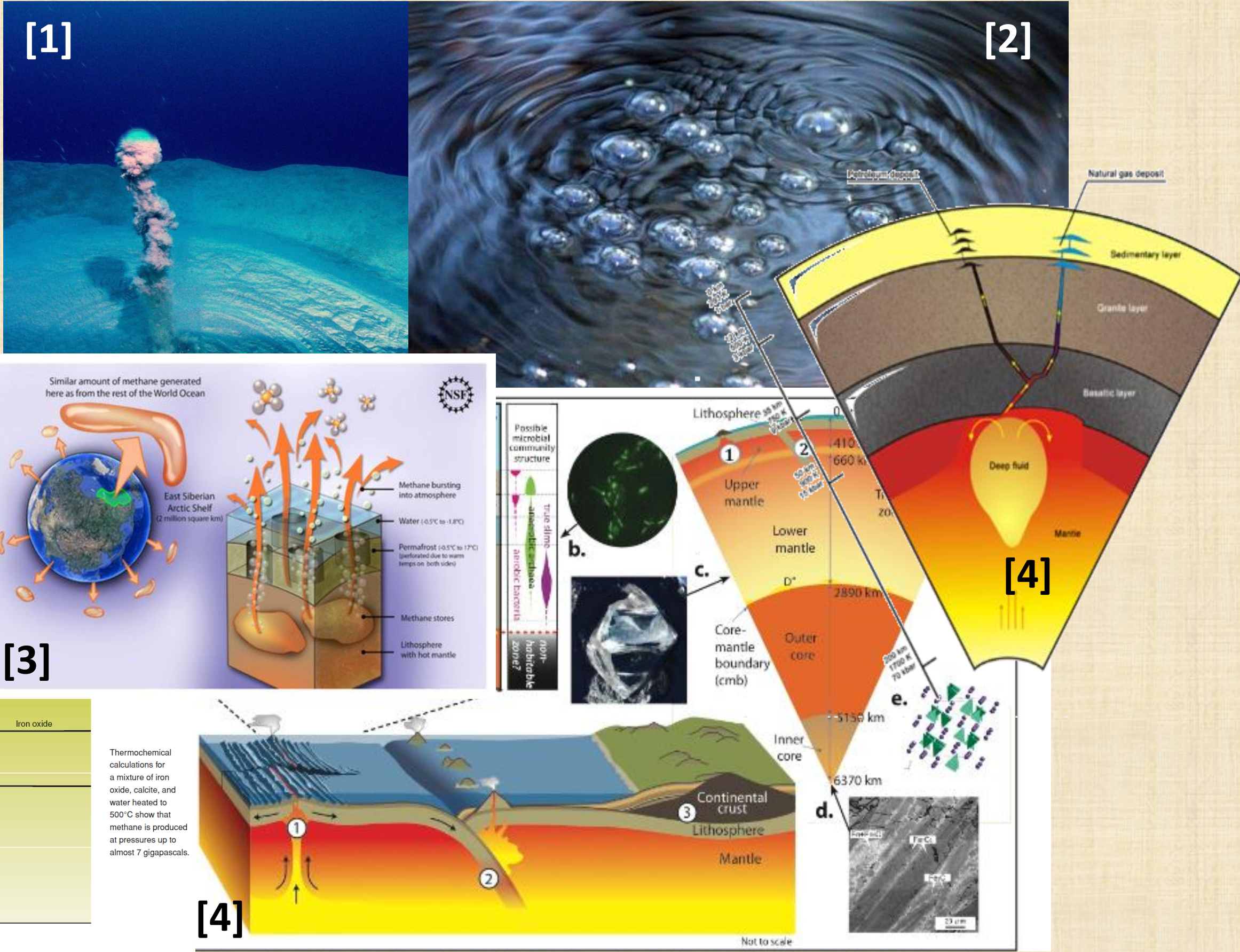
Practical Sustainability in Renewable Energy

Methane

Natural Gas Bio-gas Waste-gas

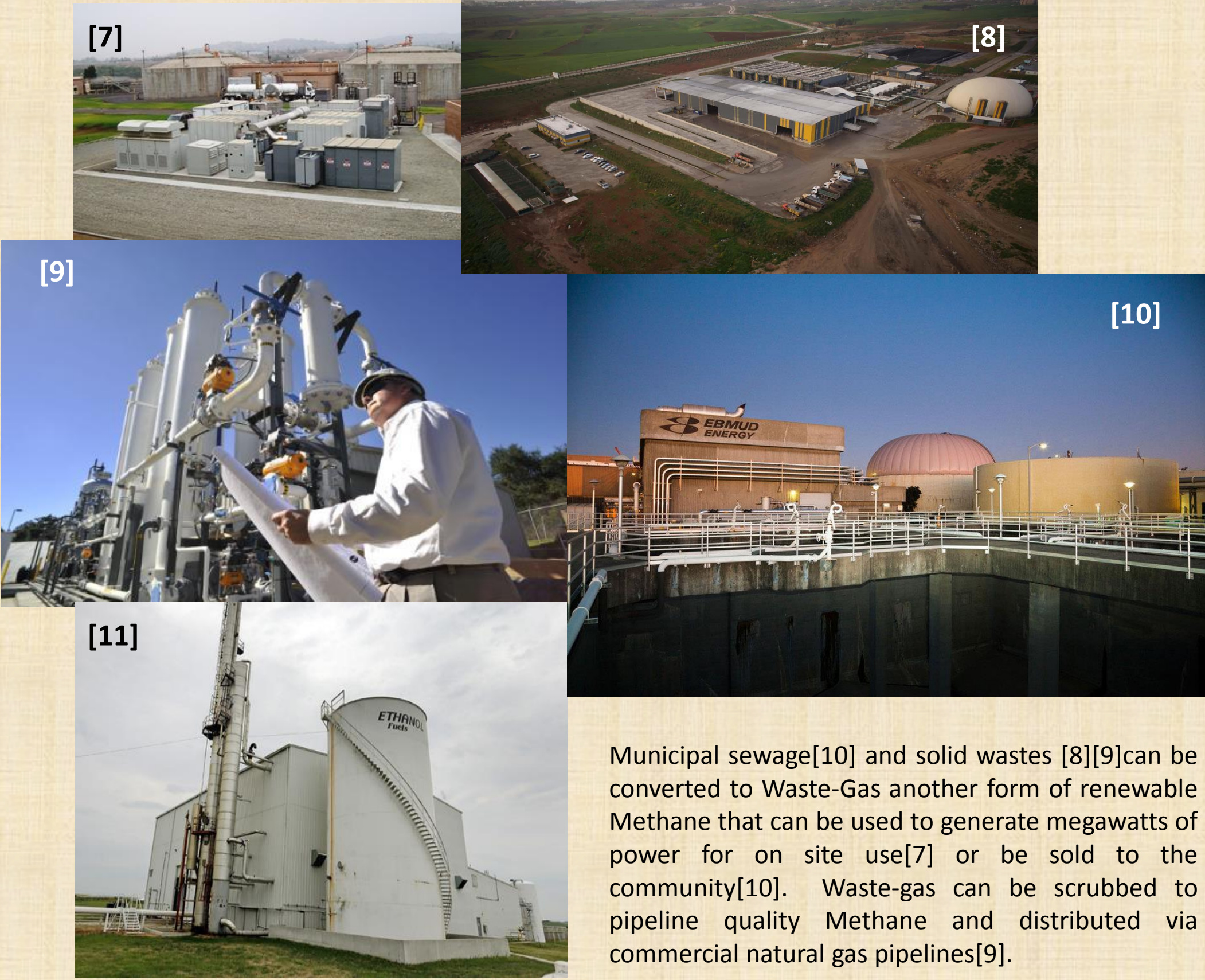
Methane the Other Renewable Energy

- **Natural Gas**
 - Earth's Mantel
 - Natural Ocean Outgassing
 - Swamps, Marshes, Fields
- **Waste-Gas Sources**
 - Municipal Solid Waste/Bio-Mass
 - Municipal Waste Water Treatment
- **Bio-Gas Agricultural Sources**
 - Farm waste and effluents
 - Bio-mass crops
 - Bio-mass waste



“The Potential for Unlimited Energy Reserves”[5], Lawrence Livermore National Laboratories. Methane is continually produced with in the earth's mantle [3][6], from the ocean floor [1], and in natural fresh water bodies such as ponds, ditches, and rice fields[2] .

Bio-Methane – Waste to Clean Energy



Municipal sewage[10] and solid wastes [8][9]can be converted to Waste-Gas another form of renewable Methane that can be used to generate megawatts of power for on site use[7] or be sold to the community[10]. Waste-gas can be scrubbed to pipeline quality Methane and distributed via commercial natural gas pipelines[9].

Methane is nature's most versatile fuel

ready to meet any energy need...

- **Transportable**
 - Pipe lined for local, regional, or national distribution
 - Compressed for storage, distribution, or use in vehicles
 - Liquefiable for high density bulk storage and transportation
- **Adaptable**
 - Can be used directly for heating/cooling, lighting, or mechanical power
 - Can be easily converted to other fuels such as gasoline or diesel fuels
 - Can be used to power central or distributed power generation grids
 - Can be used with high efficiency turbine or fuel cell CHP power plants
- **Scalable**
 - Family sized biogas digesters to large natural recovery operations
 - Can be bottled for single stove use or pipelined to large power plants
 - Distribution network can grow exponentially independent of use equipment

Renewable Methane

The Possibilities are Endless



Women collect Animal Dung for Cooking Fuel[12]. Woman and child cooking with animal dung indoors [13]. Woman and family with new bio-gas digester [14] and cooking on new biogas stove [14]. Lowering the 539 ton liquid Methane engine into the new Tote Marine Methane power cargo ship, the largest of its kind in the world [15].

Research and Development Opportunities

- **Gasification**
 - Enzymes and Biotechnologies for converting bio-mass to Methane
 - Enzymes and Biotechnologies for converting industrial waste to Methane
 - Biotechnologies for sequestering Methane from the environment
- **Conversion**
 - Enzymes and Biotechnologies for converting Methane to other fuels [16]
 - Improved chemical processes for converting Methane to other fuels [16]
 - Sequestering CO2 from burning Methane to make gasoline and diesel fuels [16]
 - Mechanical and Chemical technologies for applying Methane as power
- **Applications**
 - Development of effective Distributed Generation Grid configurations
 - Definition of Economic Models promoting cost effective use of Methane
 - Development of Social and Environmental impact models and practices

[1] National Ocean Service, NOAA, "Secrets of the Gulf Expedition Mud Volcanoes," 2007. [Online]. Available: http://flowergarden.noaa.gov/image_library/deephabitat/mudvolcano/mudvolcano2.jpg. // [2] E. Zoffagharifard, "Methane bubbles rising in streams could be a 'major source' of global warming?," 25 05 2011. [Online]. Available: <http://www.dailymail.co.uk/sciencetech/article-2641622/Are-babbling-brooks-causing-climate-change-Methane-bubbles-rising-streams-major-source-global-warming.html>. // [3] B. Oskin, "Twice as much methane escaping Arctic seafloor," 24 11 2013. [Online]. Available: <http://www.sott.net/article/269140-Twice-as-much-methane-escaping-Arctic-seafloor>. // [4] V. G. Kutchukov, "Abiogenic Deep Origin of Hydrocarbons," 2010. [Online]. Available: <http://www.intechopen.com/books/hydrocarbon/abiogenic-deep-origin-of-hydrocarbons-and-oil-and-gas-deposits-formation/exports>. // [5] Lawrence Livermore National Laboratory, "The Search for Methane in Earth, Mantle," 10 July 2005. [Online]. Available: <https://str.llnl.gov/str/julAug05/Fried.html>. // [6] H. P. Scott, R. Hemley, H. K. Mao, D. Herschbach, M. H. Fried and S. Bastea, "Methane in Earth's Mantle May Be Energy Source," 13 09 2004. [Online]. Available: https://www.prl.gov/?url=science_and_technology/chemistry-methane. // [7] Fuel Cell Energy, "Fuel cell power plants convert municipal waste challenges into ultra-clean energy solution," 2013. [Online]. Available: <http://www.fuelcellenergy.com/applications/renewable-biogas/wastewater/>. // [8] Invest Trading & Consulting AG, "Rehabilitation of the Wild Landfill and Landfill Gas Utilization," 2014. [Online]. Available: <http://www.ecoinfopower.co.uk>. // [9] Energy Systems Corporation, "East Bay Municipal Utility District in Oakland, CA," 2011. [Online]. Available: <http://techbiogasenergy.com/east-bay-mud>. // [10] PH Newswire Services, "SoCalGas, City of Escondido Create Renewable Energy From Sewage," 8 02 2011. [Online]. Available: <http://www.pnnewswire.com/news-releases/socalgas-city-of-escondido-create-renewable-energy-from-sewage-115559104.html>. // [11] Fiberight, "Eastern Iowa developer plans to turn trash into ethanol, compressed natural gas," 2013. [Online]. Available: <http://fiberight.com/eastern-iowa-developer-plans-to-turn-trash-into-ethanol-compressed-natural-gas/>. // [12] Asian Pacific Defense Forum, "Cow dung power," 01 November 2011. [Online]. Available: http://apdforum.com/en_GB/article/fmmap/articles/print/departments/culture_custom/2011/10/01/feature-pr-01. // [13] K. D. Decker, "Well-Tended Fires Outperform Modern Cooking Stoves," 24 June 2014. [Online]. Available: <http://www.resilience.org/stories/2014-06-24/well-tended-fires-outperform-modern-cooking-stoves>. // [14] takatobiogas, "Key Building Inspections gives family clean energy through biogas sponsorship," 2013. [Online]. Available: <http://takatobiogas.com/changing-lives-with-biogas/farming-family-starts-new-business-sponsored-biogas-system/>. // [15] A. Tarantola, "Here's a Natural Gas-Powered Cargo Ship Getting its 539-Ton Engine," 17 September 2014. [Online]. Available: <http://gizmodo.com/the-worlds-largest-natural-gas-powered-ships-are-almost-1619504300/1635356502/>. // [16] J. Kim, A. Maiba, L.-C. Lin, J. K. Stolaroff, B. Smit and R. D. Aines, "New materials for methane capture from diluted and medium-concentration sources," 16 April 2013. [Online]. Available: <http://www.nature.com/ncomms/journal/v4/n4/full/ncomms2697.html>.