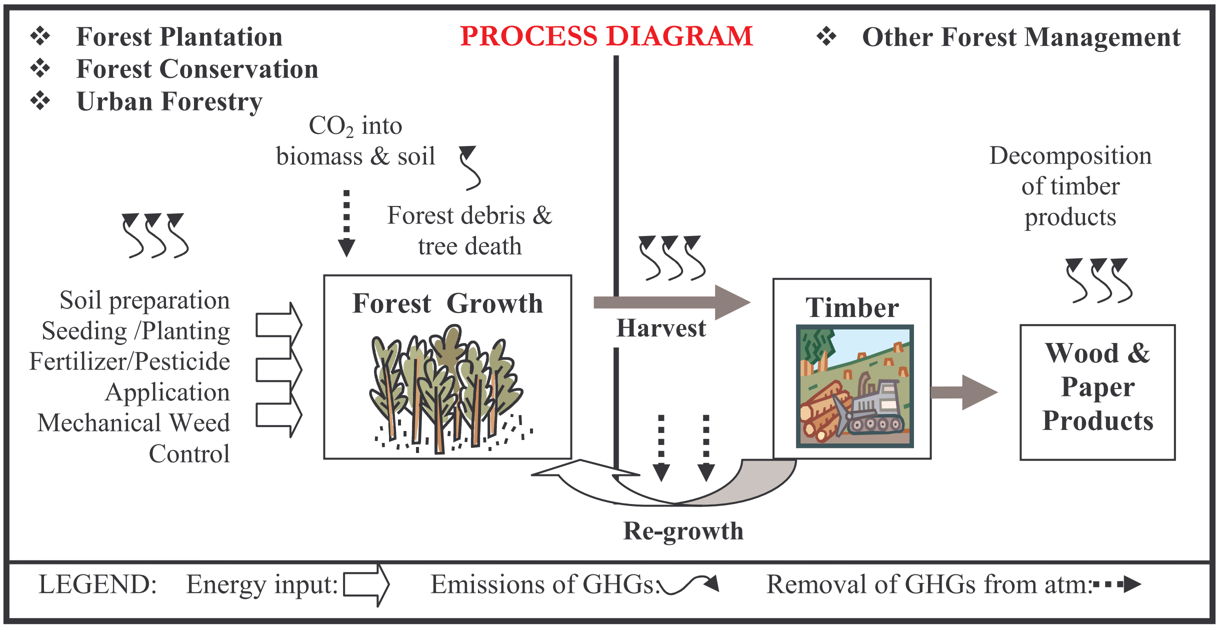
Greenhouse Gas Mitigation Planning:

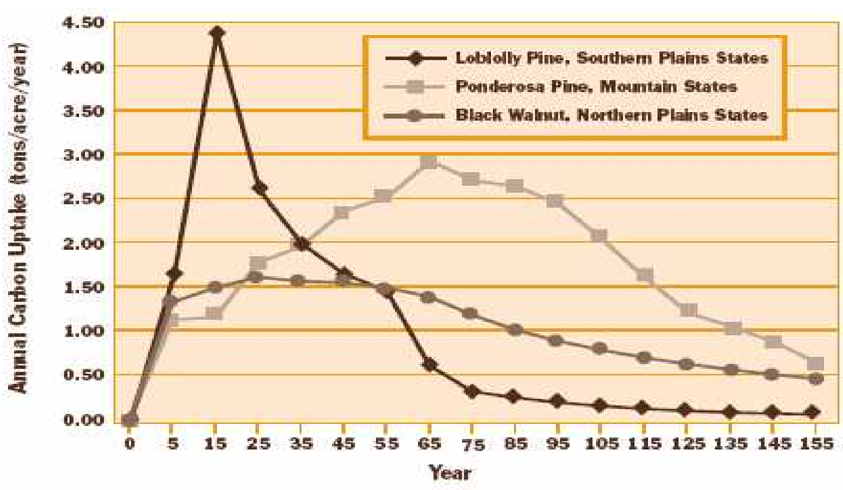
A Guide for Small Municipal Utilities

APPENDIX A

OPTION: Forest Sequestration

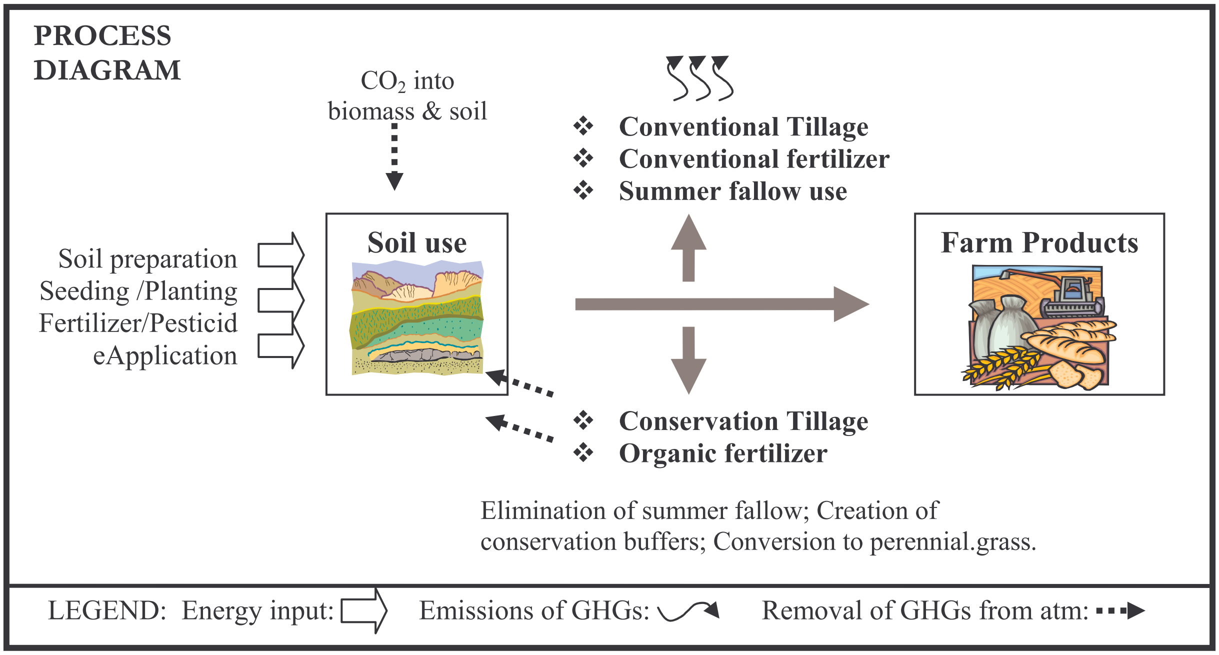


Potential Cost Centers	**Working Capital Costs** • Land purchase/lease • Site preparation • Tree Planting • Prescribed burning, cull tree removal	**O&M Costs** • Land lease • Fertilization, thinning, security, fire, and pest protection • Monitoring & verification of mitigation	**Decommissioning Costs** • None
Potential Project Revenues	• Revenue generated through harvest and sale of timber associated with modified forest management and short rotation woody biomass plantations.		
Project Baseline & Additionality	• Baseline calculations are based on current land use and determining the following: ○ The expected rate of natural biomass accumulation and storage absent active intervention ○ Activity on the land that would have occurred absent the project		
Quantification, Monitoring & Verification	• Methods are well-established for estimating aboveground biomass as well as, estimating dead wood and tracking biomass changes. Two main ways to		

(QMV)	estimate carbon content: o Using merchantable volume to a known minimum diameter of all tree species. o Using individual tree diameters and/or stand tables. • Carbon content for many North American species is well-established.
Permanence	• Sequestration is not 100% permanent. Carbon is released due to tree death through forest fires, disease, and harvest for fuel use. • A forestry project must continue carbon conservation practices for a period of 100 years to obtain credit for sequestration from CCAR
Leakage	• Activity shifting leakage is most likely to occur if land obtained for forest sequestration is already being used for other land based practices such as, agriculture or timber and fuel harvest. • Leakage will most often manifest as deforestation elsewhere.
Project Magnitude	• Projects will need to be implemented on a large land area as forest carbon storage ranges from 20 –110 tC/ha. • As a result, implementation will not occur through direct, independent implementation, but rather through collaborative projects, investment in ongoing projects or credit purchase.
Mitigation Kinetics	• CO_2 capture is dependent on tree species and will occur as soon as plants are well-established (see graph below).  Source: Based on data from Richards, Moulton and Birdsey (1993).
Ancillary Impacts	**Positive** • Increase in environmental quality for | **Negative** • Social impacts such as

	populations living near the forest sequestration project • Increased water quality. • Better erosion control. • Protection and restoration of degraded habitats • Reduced desertification in arid areas	population displacement and loss of common property use by disadvantaged sections of society. • Loss of biodiversity if forest plantations are monocultures (single species stands) • Pesticide and herbicide use to promote maximum forest growth
Regulatory Acceptance	• Forest sequestration is already an accepted GHG mitigation strategy. • Legislation and registries that allow forest sequestration mitigation include: Kyoto Protocol, DOE 1605(b), and CCAR.	
Public Perception	• No public perception issues as forest regeneration is favorably viewed by most people.	

OPTION: Agricultural Sequestration



Potential Cost Centers	**<u>Working Capital Costs</u>** • Land purchase or rental • Equipment purchase or rental • Site preparation • Labor and construction	**<u>O&M Costs</u>** • General Maintenance • Monitoring and verification	**<u>Decommissionin g Costs</u>** • Land-use change
Potential Project Revenues	• Rental payments determined by market price or government subsidy • Avoided costs of tillage equipment and fertilizer		
Project Baseline & Additionality	• The baseline needs to be calculated whether there is a project or not • The additionality will depend on if the agricultural sequestration occurs through a project: ○ Project – additionality is calculated on a case-by-case basis ○ Non-project – additionality is computed on a regional, national or sectoral level (Garcia-Oliva, 2004)		
Quantification, Monitoring & Verification (QMV)	• Quantification can incorporate leakage discounting (Garcia-Oliva, 2004)		

Permanence	• Agricultural sequestration can store carbon for:
	    ○ 20-30 years after a switch from conventional to no-tillage
	    ○ 40-60 years after crop-switching
	• Agricultural sequestration is subject to:
	    ○ Natural disturbances – fires and pests
	    ○ Human disturbances – harvesting, land management, land-use change

Leakage	• Leakage can be prevented through good control site selection, project design, and separation of test and control sites • Leakage can occur between the agricultural and forestry sectors (Lewandrowski, 2004) • Leakage can occur through the use of fertilizer, irrigation, and manuring (Schlesinger, 1999)
Project Magnitude	• Agricultural sequestration can generally store more than 1 ton of C per acre. Projects within the Climate Challenge ranged from 6 acres (for methane sequestration) to about 1000 acres (for carbon sequestration).
Mitigation Kinetics	• Agricultural SOM can increase within 6 months and continue for 10 years, until its capacity is reached.
Ancillary Impacts	**Positive** • Mainly environmental, such as improvements in soil and water quality, increases in conservation buffers and restoration of wetlands and reductions in erosion and flooding. **Negative** • Can lead to decreases in crop revenue (which can be mollified by rental payments).

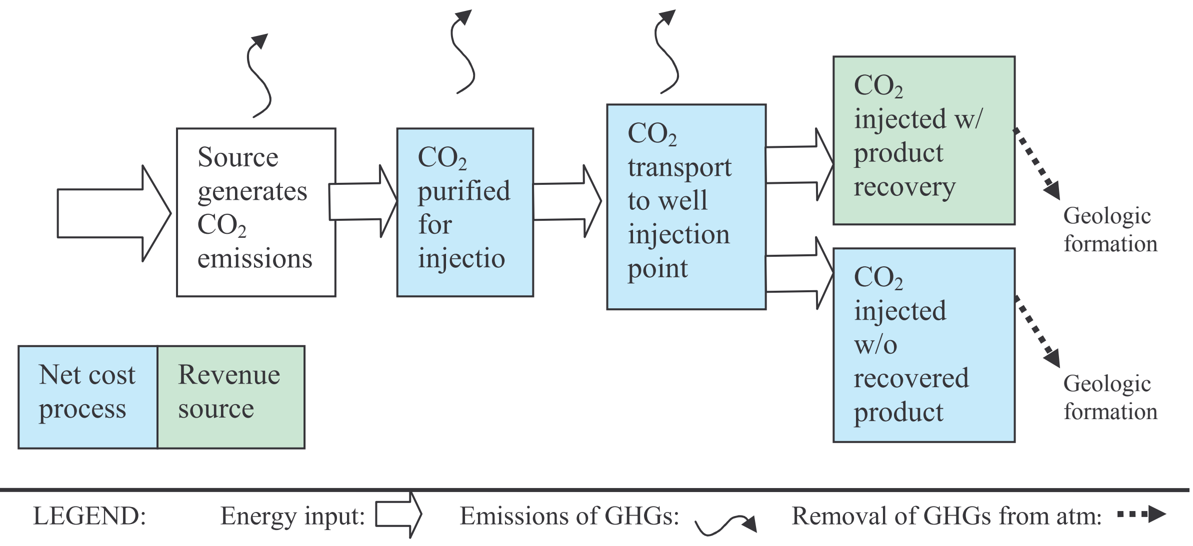
Regulatory Acceptance	• Recognized as a legitimate sequestration option by:
	    ○ IPCC – includes agricultural sequestration in LULUCF protocols and literature
	    ○ CCX – includes agricultural sequestration, and forestry and landfill methane
	    ○ McCain-Lieberman – allows trading between sectors
	• Not recognized by:
	    ○ CCAR – does not yet have protocols for agricultural sequestration

Public Perception	• Environmental Defense – providing a guidebook for landowners on GHG mitigation through agricultural and other activities

	• American Farm Bureau Federation – supports the use of no-till as a part of voluntary GHG mitigation measures

OPTION: Oil & Gas Well Storage (Enhanced Oil & Gas Recovery)

PROCESS DIAGRAM



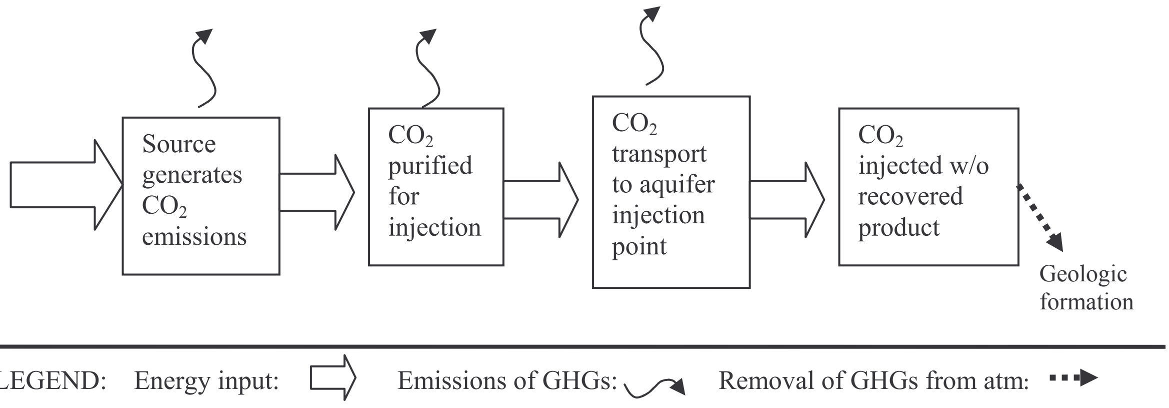
Potential Cost Centers	**Working Capital Costs** • Design & Construction • Capital purchase • Retrofitting ancillary equipment	**O&M Costs** • Increased fuel costs • Interest payments on upgrade funding • O&M of additional equipment • Regulatory costs of operation	**Decommissioning Costs** • Equipment dismantlement • Environmental remediation • Long-term monitoring • Life of project dependent on capacity and economic viability from recovered product
Potential Project Revenues	• Recovered oil and gas revenues • GHG emission reduction credits • Decrease in operational costs for purchased CO_2 (specific to existing EOR projects)		

Project Baseline & Additionality	• Baseline is an existing annual direct and indirect GHG emission inventory; • Additionality is met in that no regulatory trigger mandates project implementation and naturally occurring (mined) CO_2 would be used in project absence.
Quantification, Monitoring & Verification (QMV)	• Annual CO_2 emission removed from atmospheric sink due to capture and injection rate of the project; • CO_2 emissions offset from reduced reliance on mined CO_2 operations (if EOR project is already in place); • GHG emissions generated by industrial processes to capture, separate, transport and inject CO_2
Permanence	• GHG emissions are injected into reservoir with retention capabilities determined by geological profile; • Natural gas reservoirs are seen as especially viable as geologic timeline storage sites
Leakage	• Leakage would occur if market response is shift to cheaper sources of carbon-intensive energy supplies as a result of marginal cost increases in production process reduces competitiveness.
Project Magnitude	• Due to economies of scale, current projections estimate that depleted well storage (with or without product recovery) as a viable strategy is limited to large-scale sources (>0.5 Mt/yr) (Gielen, 2003); • Collaborative projects with large sources make this a viable option for investment by small utilities.
Ancillary Impacts	**Positive** • Decrease in GHG liability for facilities that offset need to purchase mined CO_2 for EOR and EGR operations; • The technology associated with this process is well developed and has been used commercially for 50 years. **Negative** • Operational liability to monitor and verify the integrity of the reservoir's GHG retention for an indefinite time period after injection and recovery operations has ceased; • Studies have indicated that product recovery efficiencies are reduced when CO_2 injection rates are maximized.

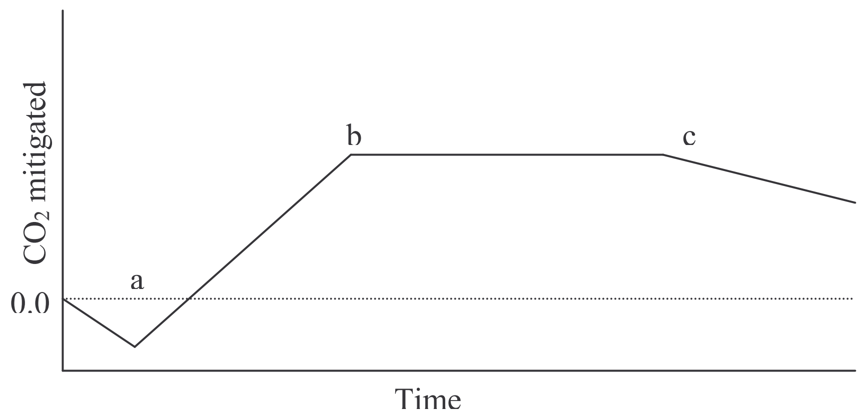
Regulatory Acceptance	• Likelihood of this strategy's acceptance is high due to the following: o 85% of government R&D is towards geologic sequestration (Rau, 2004); o Regulatory structure developed and in place due to existing EOR projects (GEO-SEQ, 2004); and o Heavily funded political lobbying by industry	
Public Perception	• CO_2 injection for enhanced product recovery is 50 years old and large-scale pilot studies designed to study these projects as carbon sequestration methods are a decade matured; no human fatality has been noted with respect to these operations (Grigg, 2002). • All sequestration methods have an undertone of the intention to continue the fossil fuel-dependent economy. This is viewed by some environmental and energy conservation groups as inappropriate allocation of R&D effort and funding that should be directed towards renewable energy and energy conservation.	

Option: Saline Aquifer Storage

PROCESS DIAGRAM

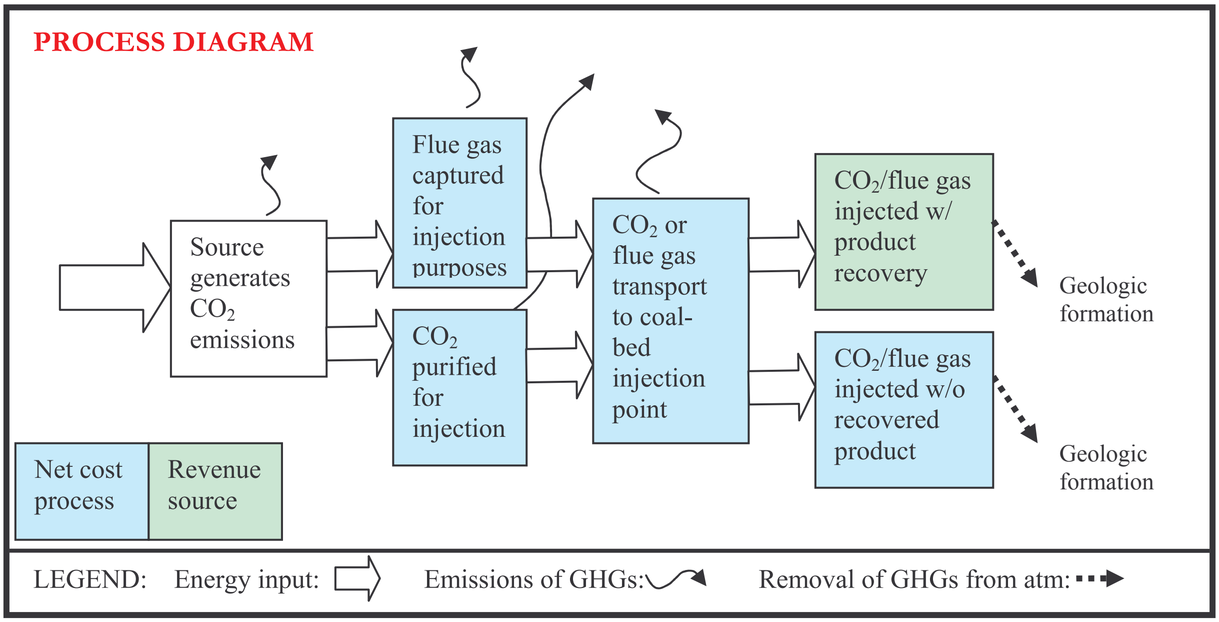


Potential Cost Centers	**Working Capital Costs** • Design & Construction • Capital purchase • Retrofitting ancillary equipment	**O&M Costs** • Increased fuel costs • Interest payments on upgrade funding • O&M of additional equipment • Regulatory costs of operation	**Decommissioning Costs** • Equipment dismantlement • Environmental remediation • Long-term monitoring • Life of project dependent on capacity
Potential Project Revenues	• GHG emission reduction credits		
Project Baseline & Additionality	• Baseline would likely be an existing annual emission inventory; • Other GHG emission sources quantified (if applicable) when upgrades expand the land use of the existing facility • Additionality is met in that no regulatory trigger mandates project implementation and naturally occurring (mined) CO_2 would be used in project absence.		

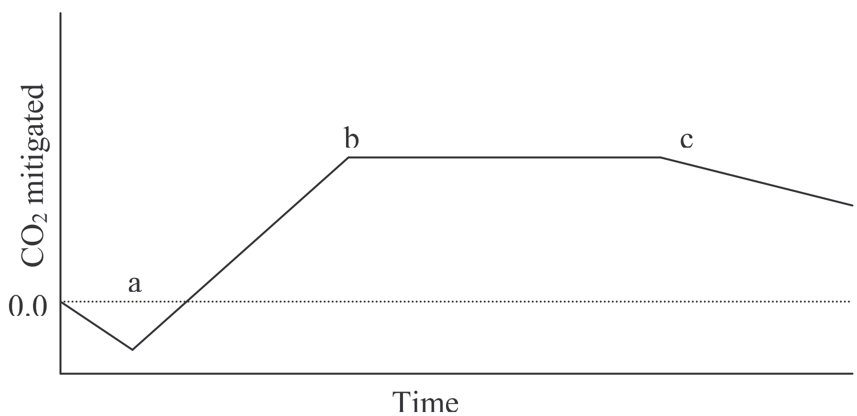
Quantification, Monitoring & Verification (QMV)	• Annual CO_2 emission removed from atmospheric sink due to capture and injection rate of the project; • GHG emissions generated by industrial processes to capture, separate, transport and inject CO_2
Permanence	• GHG emissions are injected into reservoir with retention capabilities determined by geological profile. • Saline aquifers are noted as being particularly resilient to retransmission and formation of carbonates imply longer storage periods than non-saline reservoirs (Anderson & Newell, 2003).
Leakage	• Increased costs from project implementation that are passed to consumers could drive demand to other carbon-intense supply sources.
Project Magnitude	• Due to economies of scale, current projections estimate that aquifer storage as a viable strategy is limited to large-scale sources (>0.5 Mt/yr) (Gielen, 2003); • Collaborative projects with large sources make this a viable option for investment by small utilities.
Mitigation Kinetics	• It is projected that once operation is fully online, reductions are immediate, the annual rate of which remains constant throughout life of operation (dictated by economics of maintaining operation and volumetric capacity of reservoir:  a: Construction phase of project generates GHG emissions b: Project online and reductions accumulate until volumetric capacities are reached c: Retransmission of injected CO_2 (timeline and rate of which varies with project)
Ancillary Impacts	**Positive** • Technology is well developed and has been used commercially for 50 years in **Negative** • Liability for monitoring and verifying the integrity of the

	the petroleum industry	reservoir • Undeterminable potential liability with regards to deleterious affects on human and environmental health.
Regulatory Acceptance	• Likelihood of this strategy's acceptance is high due to the following: o 85% of government R&D is towards geologic sequestration (Rau, 2004); o Regulatory structure developed and in place due to existing EOR projects (GEO-SEQ, 2004); and o Heavily funded political lobbying by industry	
Public Perception	• Similar technology used to CO_2 injection is 50 years old and large-scale pilot studies designed to study these projects as carbon sequestration methods are a decade matured; no human fatality has been noted with respect to these operations (Grigg, 2002). • All sequestration methods have an undertone of the intention to continue the fossil fuel-dependent economy. This is viewed by some environmental and energy conservation groups as inappropriate allocation of R&D effort and funding that should be directed towards renewable energy and energy conservation.	

OPTION: Coal-bed Storage for Methane Recovery



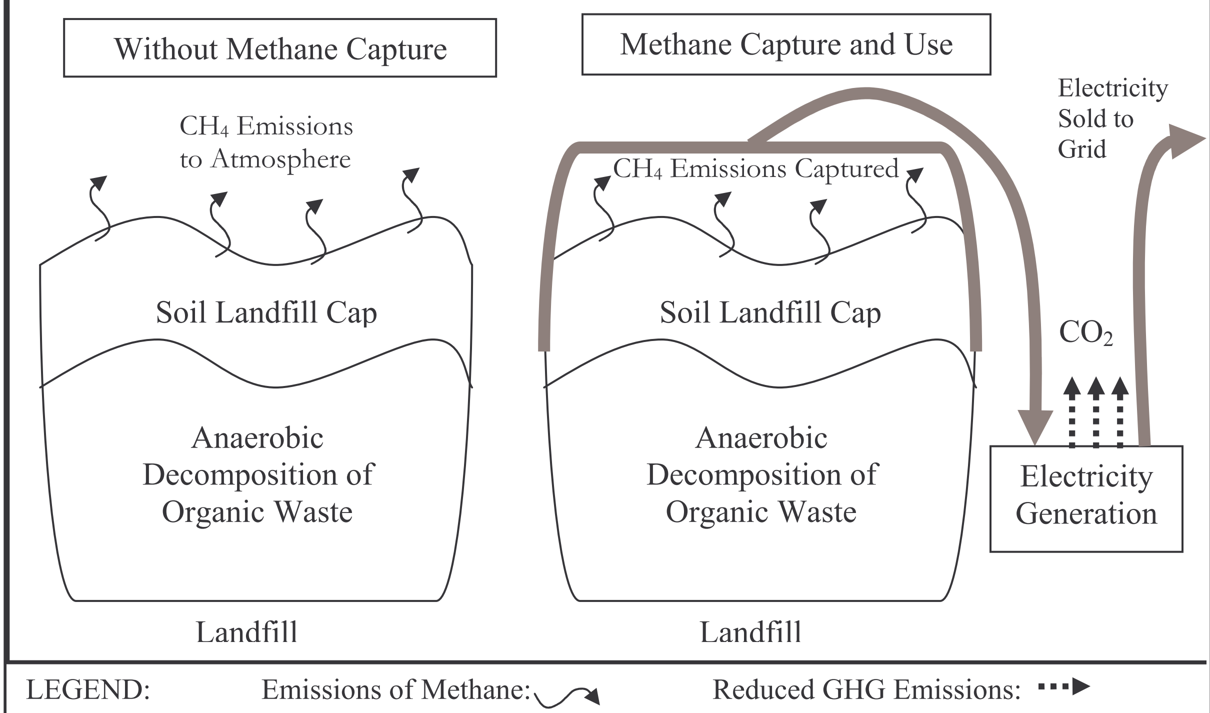
Potential Cost Centers	**Working Capital Costs** • Design & Construction • Capital purchase • Retrofitting ancillary equipment	**O&M Costs** • Increased fuel costs • Interest payments on upgrade funding • O&M of additional equipment • Regulatory costs of operation	**Decommissioning Costs** • Equipment dismantlement • Environmental remediation • Long-term monitoring
Potential Project Revenues	• Use of recovered gas product may result in decreased demand for fuel • Mitigation of other pollutants (flue gas injection) may be candidate for emission reduction credits or reduced regulatory costs. • Sale of recovered gas product to market		
Project Baseline & Additionality	• Baseline would likely be an existing annual emission inventory; • Other GHG emission sources quantified (if applicable) when project implementation expands the land use of the existing facility		

	• Additionality: The project provides real, measurable, and long-term sequestration in excess of reductions that would have occurred had the project not been implemented.
Quantification, Monitoring & Verification (QMV)	• Direct emissions before and after project implementation. Specifically: ○ Fossil fuel combustion emissions; ○ Additional emissions associated with capture and separation process; ○ Additional emissions associated with transport of CO_2/flue gas; and ○ Emissions associated with product recovery, transport, and processing.
Permanence	Modeling and pilot studies have indicated that coal-bed seams are characteristic of long retention periods due to the nature of the CO_2 stored within the pore matrix of the coal (White, 2003; Gunter, 2001).
Leakage	• Leakage could occur by project costs recovered through increased costs to consumer, thus shifting consumer demand to another source. However, with product recovery, additional operational costs may be offset substantially enough to reduce or eliminate any additional cost to customers.
Project Magnitude	• Due to economies of scale, current projections estimate that coal-bed seam storage (with or without product recovery) as a viable strategy is limited to large-scale sources (>0.5 Mt/yr) (Gielen, 2003); • Collaborative projects with large sources make this a viable option for investment by small utilities.
Mitigation Kinetics	• It is projected that once operation is fully online, reductions are immediate, the annual rate of which remains constant throughout life of operation (dictated by economics of maintaining operation and volumetric capacity of reservoir:  a: Construction phase of project generates GHG emissions b: Project online and reductions accumulate until economic or volumetric capacities are reached c: Retransmission of injected CO2 (timeline and rate of which varies with project)

Ancillary Impacts	**Positive** • The technology associated with this process is well developed and has been used commercially for decades. • Studies have suggested the feasibility of injecting "pure" exhaust gases, thus excluding the process and associated costs with CO_2 capture and separation.	**Negative** • Undetermined long-term affect of large volumes of CO_2 or flue gas stored within a coal-bed reservoir could result in health or environmental liability claims • Upgrade to facility could result in more stringent environmental regulations that incur additional costs in excess of other project revenue or benefit.
Regulatory Acceptance	• Likelihood of this strategy's acceptance is high due to the following: o 85% of government R&D is towards geologic sequestration (Rau, 2004); o Criteria pollutant reductions result if flue gas is injected (Gunter, 2001); and o Heavily funded political lobbying by industry	
Public Perception	• CO_2 injection for enhanced product recovery is 50 years old and large-scale pilot studies designed to study these projects as carbon sequestration methods are a decade matured; no human fatality has been noted with respect to these operations (Grigg, 2002). • All sequestration methods have an undertone of the intention to continue the fossil fuel-dependent economy. This is viewed by some environmental and energy conservation groups as inappropriate allocation of R&D effort and funding that should be directed towards renewable energy and energy conservation.	

OPTION: Landfill Methane Capture and Use

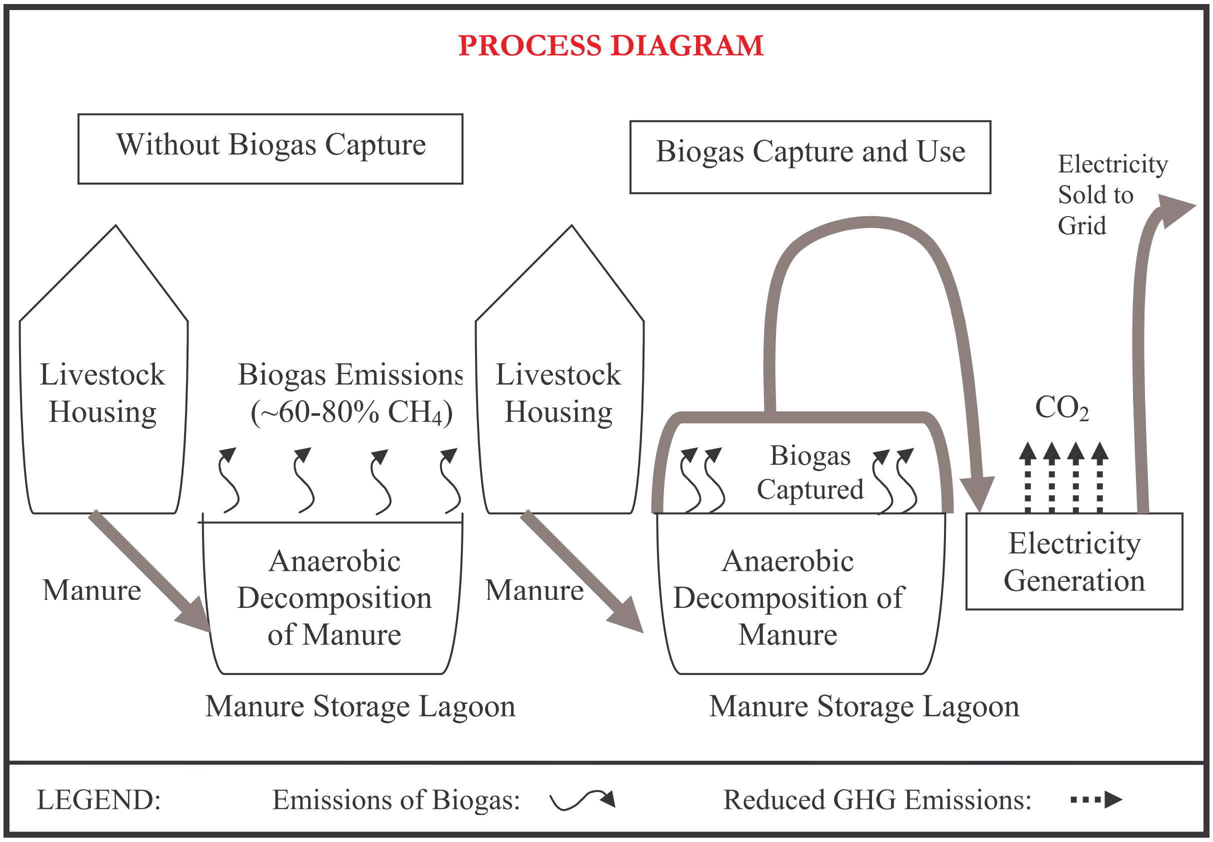
PROCESS DIAGRAM



Potential Cost Centers	**Working Capital Costs** • CH_4 Capture System • Piping • Electricity Generation Equipment • Electric Grid Connection	**O&M Costs** • General Maintenance • Leak Detection and Repair • Monitoring	**Decommissioning Costs** • 20 year project lifetime
Potential Project Revenues	• Revenue generated through sale of electricity generation.		
Project Baseline & Additionality	• Baseline would likely be existing annual methane emissions. • Additionality is met as the upgrades would provide real, measurable, and long-term reductions that would not have occurred had the upgrades not been implemented.		

Quantification, Monitoring & Verification (QMV)	• Easily quantified through gas flow and electric generation meters	
Permanence	• GHG emissions from methane are permanently reduced due to the nature of avoidance that occurs during the combustion process. • GHG offsets from renewable electricity generation are realized immediately.	
Leakage	• Leakage issues are not likely to apply.	
Project Magnitude	• For a landfill containing 3,000,000 metric tons of solid waste, a reduction of approximately 40,000 MTCE per year.	
Mitigation Kinetics	• It is projected that once operation is fully online, reductions are immediate. • The annual rate of GHG mitigation is assumed to remain constant throughout life of operation although it may begin to diminish as project nears completion.	
Ancillary Impacts	<u>**Positive**</u> • Results in reduction of other VOC emissions.	<u>**Negative**</u> • None
Regulatory Acceptance	• Likelihood of acceptance of this approach is high due to the following: o U.S. EPA Landfill Methane Outreach Program; o Capturing methane achieves compliance with the "landfill rule" regulating non-methane organic compounds o Acceptance under Kyoto Protocol and all other GHG agreements and registries as a renewable energy source. o Other environmental benefits result (e.g., criteria air pollutant reductions).	
Public Perception	• Not expected to be a problem. Electricity generation from landfill methane is already common practice and an accepted source of renewable energy.	

OPTION: Dairy Farm Manure Management

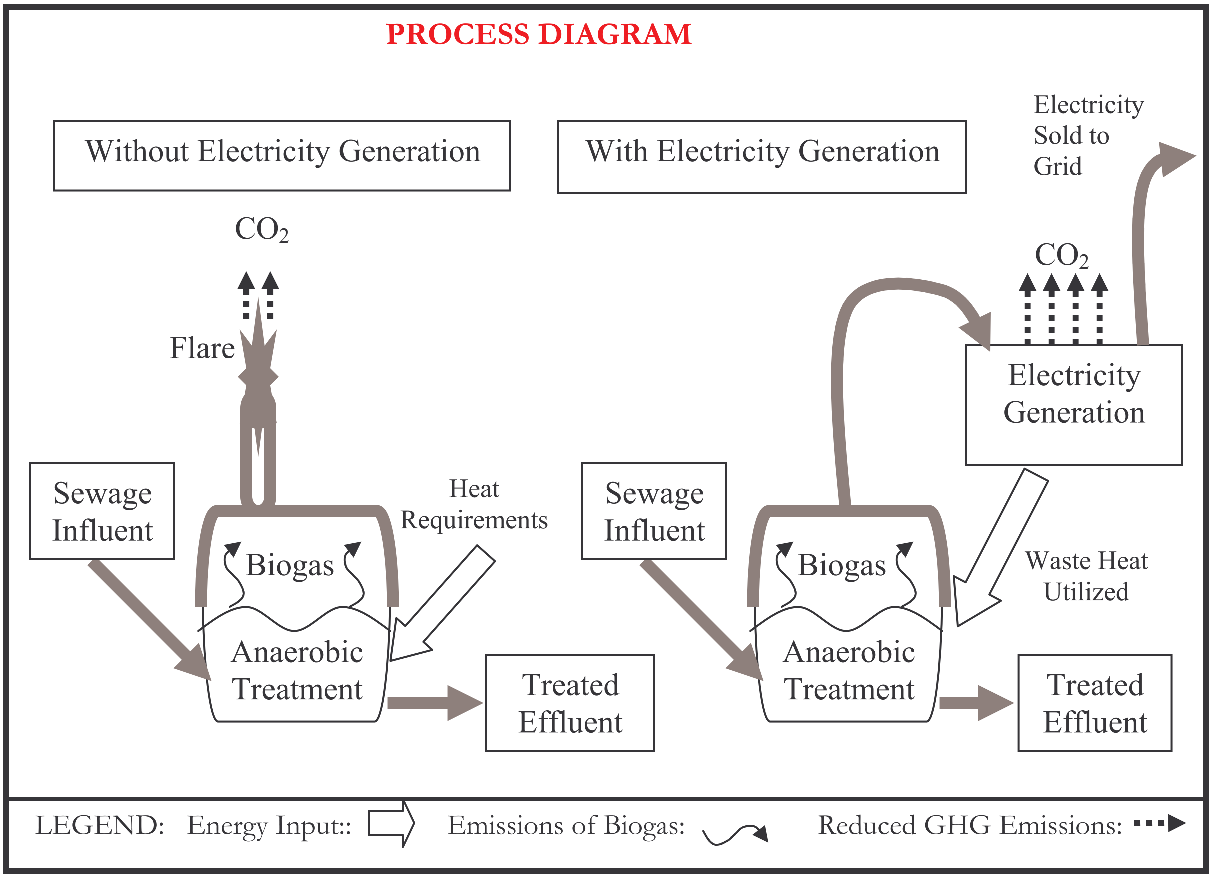


Potential Cost Centers	**Working Capital Costs** • Biogas Capture System • Piping • Electricity Generation Equipment • Electric Grid Connection	**O&M Costs** • General Maintenance • Leak Detection and Repair • Monitoring	**Decommissioning Costs** • Assumed 20 year lifetime (for consistency and comparison with other methane capture approaches)
Potential Project Revenues	• Revenue generated through sale of electricity generation. • Effluent solids are high quality fertilizer.		
Project Baseline &	• Baseline would likely be existing annual methane emissions without biogas capture technology.		

Additionality	• Additionality is met as the upgrades would provide real, measurable, and long-term reductions that would not have occurred had the upgrades not been implemented.
Quantification, Monitoring & Verification (QMV)	• Easily quantified through gas flow and electric generation meters
Permanence	• GHG emissions from methane are permanently reduced due to the nature of avoidance that occurs during the combustion process. • GHG offsets from renewable electricity generation are realized immediately.
Leakage	• Leakage likely does not apply.
Project Magnitude	• For a 500-cow dairy farm, a GHG reduction of approximately 500 MTCE per year.
Mitigation Kinetics	• It is projected that once operation is fully online, reductions are immediate. • The annual rate of GHG mitigation is assumed to remain constant throughout life of operation.
Ancillary Impacts	**Positive** • Results in substantial reduction of odor. • Prevents overflow and degradation of water quality during storm events. **Negative** • None
Regulatory Acceptance	• Likelihood of acceptance of this strategy is high due to the following: o U.S. EPA AgSTAR program; o Complies with New Source Performance Standards as Best Available Control Technology. o Acceptance under Kyoto Protocol and all other GHG agreements and registries as a renewable energy source. o Other environmental benefits result (e.g., criteria air pollutant reductions).

Public Perception	• Not likely to be an issue. Reduced odor is likely to make the public pleased.

OPTION: Wastewater Treatment Electricity Generation

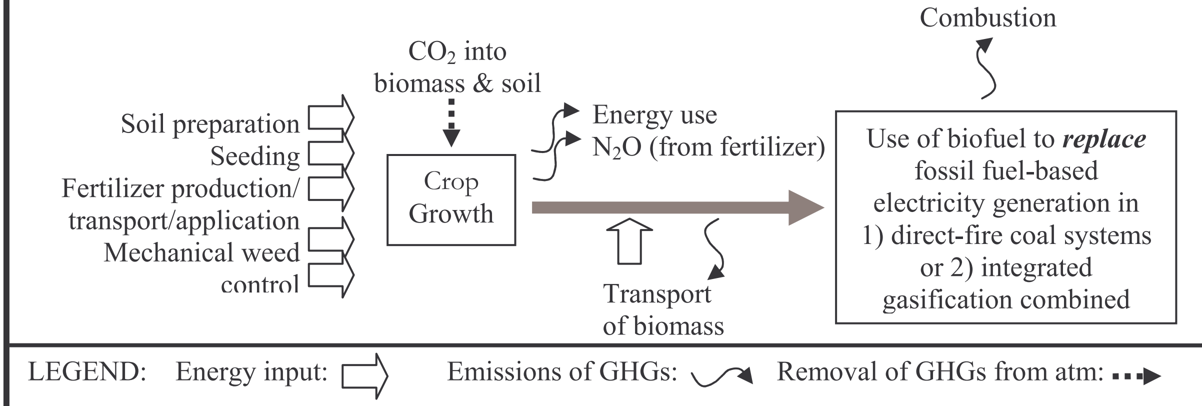


Potential Cost Centers	**Working Capital Costs** • Biogas Capture System • Piping • Electricity Generation Equipment • Electric Grid Connection	**O&M Costs** • General Maintenance • Leak Detection and Repair • Monitoring	**Decommissioning Costs** • Assumed 20 year lifetime (for consistency and comparison with other methane capture approaches)
Potential Project Revenues	• Revenue generated through sale of electricity generation or reduced electricity costs.		
Project Baseline & Additionality	• Baseline would likely be emissions associated with facility energy requirements. • Additionality is met as the upgrades would provide a real, measurable, and long-term reduction in electricity that would have been produced by fossil		

	fuel combustion.
Quantification, Monitoring & Verification (QMV)	• Easily quantified through gas flow and electric generation meters
Permanence	• GHG offsets from renewable electricity generation are realized immediately.
Leakage	• Leakage likely does not apply.
Project Magnitude	• For a generation of 500 kW, approximately 600 MTCE per year.
Mitigation Kinetics	• It is projected that once operation is fully online, reductions are immediate. • The annual rate of GHG mitigation is assumed to remain constant throughout life of operation.
Ancillary Impacts	**Positive** • None **Negative** • None
Regulatory Acceptance	• Likelihood of acceptance of this strategy is high due to the following: o Considered a renewable energy source; o Considered equivalent to flaring as Best Available Control Technology
Public Perception	• Not likely to be an issue. Flaring biogas at wastewater treatment plants is already common practice.

OPTION: Biomass-to-Energy: Electricity Generation

PROCESS DIAGRAM



Potential Cost Centers	**Working Capital Costs** • Land purchase • Power generation equipment • Project baseline estimation • Ex ante quantification of mitigation	**O&M Costs** • Land lease • Labor (farming & harvesting) • Transport of raw mat'l • Monitoring & verification of mitigation	**Decommissioning Costs** • Power generation equipment
Potential Project Revenues	• Revenue generated through sale of electricity		
Project Baseline & Additionality	• Project baseline estimation is more involved, and potentially more expensive, than for other options. It involves estimations for *two* factors: o emissions from the land used in the project o emissions expected from the energy source that is being replaced		
Quantification, Monitoring & Verification (QMV)	• QMV steps are more involved, and potentially more expensive, than for other options. o Due to the numerous energy inputs required (see Process Diagram), quantification and monitoring involve extensive data tracking (for each energy input that is attributed to the project) to determine net mitigation benefits and ongoing performance.		
Permanence	• Biomass is used to *replace* fossil fuels. As a result, it is a type of reduction		

<table>
<tr><td></td><td colspan="2">mitigation and therefore produces GHG offsets that are fully permanent.</td></tr>
<tr><td>Leakage</td><td colspan="2">• Leakage can occur when crops are cultivated explicitly for biofuel production. Land-use transitions due to the project (e.g. switching from growing crops for food to crops for biomass to energy) can lead to land-use changes (e.g. clearing of forest for more food crop production) that results in more GHG emissions.</td></tr>
<tr><td>Project Magnitude</td><td colspan="2">• Minimum sizes of biomass to energy projects are larger than the likely mitigation goals for a small municipal utility.
• As a result, implementation will not occur through direct, independent implementation, but rather through collaborative projects, investment in ongoing projects or credit purchase.</td></tr>
<tr><td>Mitigation Kinetics</td><td colspan="2">• Once the project is online, CO_2 will be captured in growing biomass after no lag period for annually harvested crops and a short lag period (i.e. >3 years) for short-rotation woody crops.
• Generation of offsets could occur at the sale of electricity.
• The annual rate of electricity production is assumed to remain constant throughout life of operation.</td></tr>
<tr><td>Ancillary Impacts</td><td><u>Positive</u>
• Potential economic benefits to farmers and farming communities.
• Reductions in criteria air pollutants due to the switch from fossil fuel usage (depending on project design)
• Natural resource benefits such as water conservation, prevention of soil erosion and habitat protection for native species (depending on project design)</td><td><u>Negative</u>
• Natural resource harms such as loss of biodiversity, increased soil erosion, reduced water quality due to increased pesticide use (depending on project design)</td></tr>
<tr><td>Regulatory Acceptance</td><td colspan="2">• Likelihood of acceptance of this approach is high due to the following:
o Biomass renewable energy is expressly supported by California legislation.
o The DOE Biomass Program is devoted the development of biomass energy technologies.</td></tr>
<tr><td>Public Perception</td><td colspan="2">• No public perception issues are problematic for biomass approaches to mitigation. If anything, biomass approaches are favorably viewed because of the potential benefits to farmers.</td></tr>
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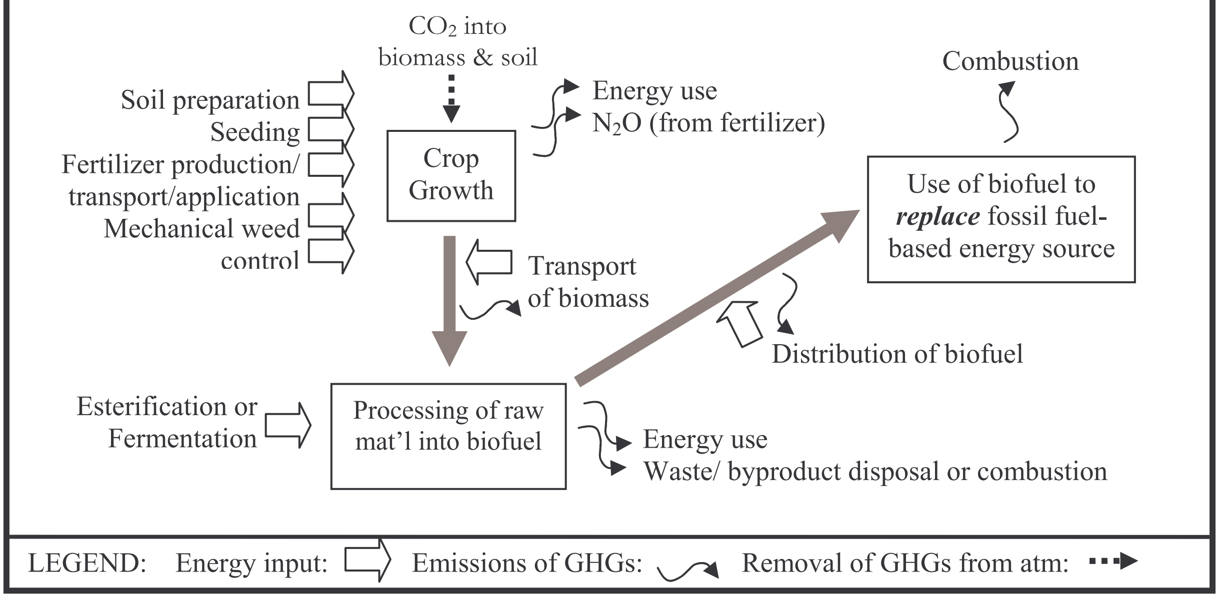
OPTION: Biomass-to-Energy: Liquid Biofuels

PROCESS DIAGRAM



Potential Cost Centers	**Working Capital Costs** • Land purchase • Processing plant equipment • Project baseline estimation • Ex ante quantification of mitigation	**O&M Costs** • Land lease • Labor (farming, harvesting & processing) • Transport of raw mat'l • Distribution of biofuel • Monitoring & verification of mitigation	**Decommissioning Costs** • Processing plant equipment
Potential Project Revenues	• Revenue generated through sale of ethanol to replace gasoline fuel, as 5-20% additive to gasoline (gasohol), or replace MTBE oxygenate additive in California • Revenue generated through sale of biodiesel to replace gasoline fuel or to replace heating fuels.		
Project	• Project baseline estimation is more involved, and potentially more expensive,		

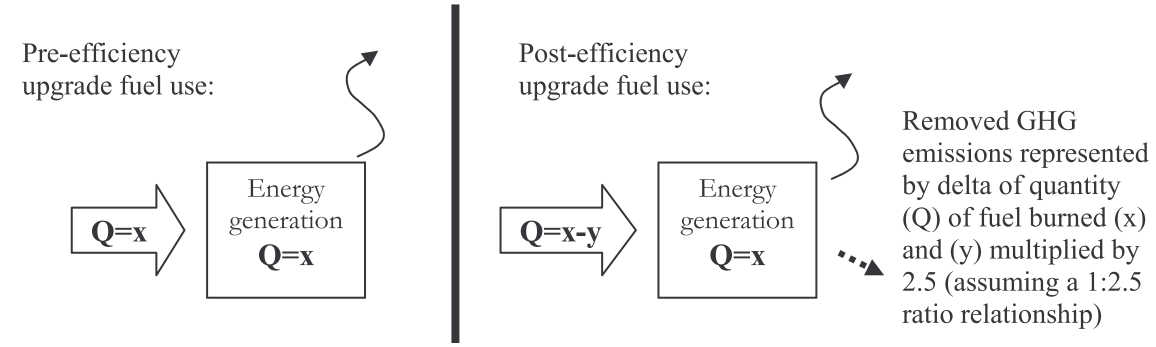
Baseline & Additionality	than for other options. It involves estimations for *two* factors: o emissions from the land used in the project o emissions expected from the energy source that is being replaced • Due to energy requirements for biofuel generation from biomass, projects that rely upon dedicated crops (as opposed to using crop wastes) for are less likely to achieve additionality.	
Quantification, Monitoring & Verification (QMV)	• QMV steps are more involved, and potentially more expensive, than for other options. o Due to the numerous energy inputs required (see Process Diagram), quantification and monitoring involve extensive data tracking (for each energy input that is attributed to the project) to determine net mitigation benefits and ongoing performance.	
Permanence	• Biofuels are used to *replace* fossil fuels. As a result, they are a type of reduction mitigation and therefore produce GHG offsets that are fully permanent.	
Leakage	• Leakage can occur when crops are cultivated explicitly for biofuel production. Land-use transitions due to the project (e.g. switching from growing crops for food to crops for biofuel) can lead to land-use changes (e.g. clearing of forest for more food crop production) that results in more emissions of GHGs.	
Project Magnitude	• Minimum sizes of biomass to energy projects are larger than the likely mitigation goals for a small municipal utility. • As a result, implementation will not occur through direct, independent implementation, but rather through collaborative projects, investment in ongoing projects or credit purchase.	
Mitigation Kinetics	• Once the project is online, CO_2 will be captured in growing biomass after no lag period for annually harvested crops and a short lag period (i.e. >3 years) for short-rotation woody crops. • Generation of offsets could occur at the sale of biofuel. • The annual rate of biofuel production is assumed to remain constant throughout life of operation.	
Ancillary Impacts	**Positive** • Potential economic benefits to farmers and farming communities. • Reductions in criteria air pollutants due to the switch from fossil fuel usage	**Negative** • Increase in criteria air pollutants due to the switch to biodiesel (depending on project design) • Natural resource harms such as

	(depending on project design) • Natural resource benefits such as water conservation, prevention of soil erosion and habitat protection for native species (depending on project design)	loss of biodiversity, increased soil erosion, reduced water quality due to increased pesticide use (depending on project design).
Regulatory Acceptance	• Biomass to energy approaches are likely to achieve regulatory acceptance because: o Biomass renewable energy is expressly supported by California legislation. o The DOE Biomass Program is devoted the development of biomass energy technologies.	
Public Perception	• No public perception issues are problematic for biomass approaches to mitigation. If anything, biomass approaches are favorably viewed because of the potential benefits to farmers.	

OPTION: Supply-Side Efficiency Improvements

PROCESS DIAGRAM

Energy efficiency upgrades are a class of project strategies that essentially reduce the amount of fuel input required to attain a given amount of energy output. Therefore, a simplistic process diagram is shown to illustrate this:



LEGEND: Energy input: Emissions of GHGs: Removal of GHGs from atm:

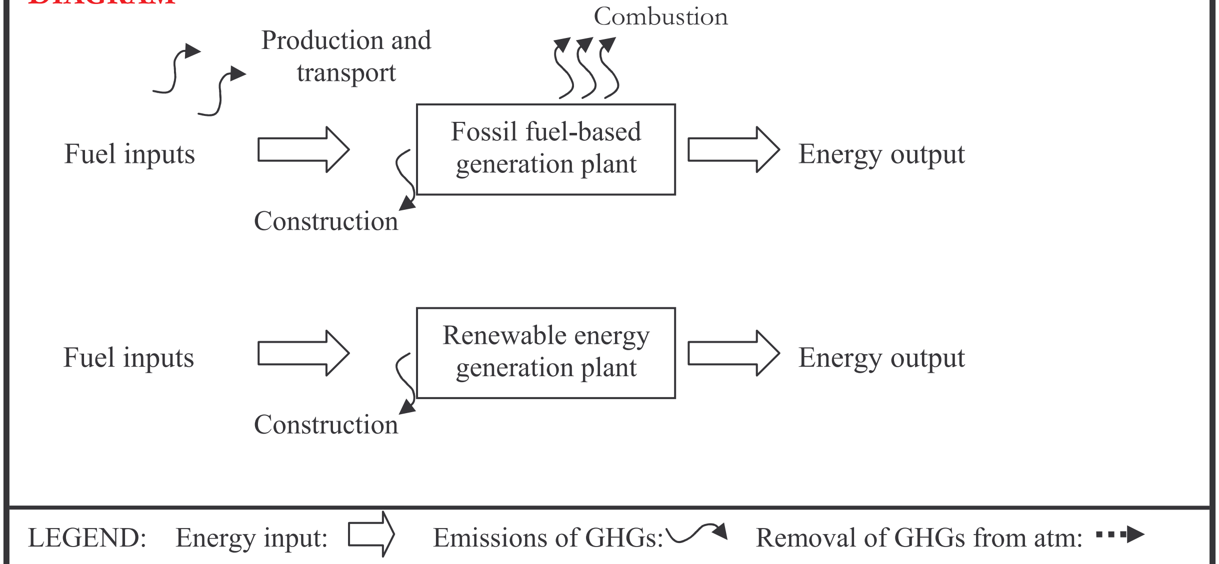
Potential Cost Centers	**Working Capital Costs** • Design & Construction • Capital purchase • Retrofitting ancillary equipment	**O&M Costs** • Interest payments on upgrade funding • Additional O&M costs for additional equipment	**Decommissioning Costs** • 40-50 year lifetime
Potential Project Revenues	• Increased efficiencies reduce fuel use rates • Decrease in other emissions may reduce regulatory costs • Sale of additional energy generation within unchanged permit / operational limits due to increased efficiency		
Project Baseline & Additionality	• Baseline would likely be an existing annual emission inventory; • Other GHG emission sources quantified (if applicable) when upgrades expand the land use of the existing facility • Additionality is met as the upgrades would provide real, measurable, and long-term reductions that are in excess of reductions that would have occurred had the upgrades not been implemented.		

Quantification, Monitoring & Verification (QMV)	• Use excepted quantification criteria such as NESCAUM's Demonstration Project, WRI's GHG Protocol, or CA Climate Action Registry's General Reporting and Certification Protocols ; • Direct and indirect emissions from existing operations and projected reductions; • Emission reduction credits must prove that efficiency upgrades produce real reductions (this is especially important for facilities that import energy supplies from offsite sources where reduced facility demand does not result in decreased production from supplier) (EPA-a, 2004); • Base-load and peak-load units should be differentiated in the emission calculations as reduction credit for energy efficiency upgrades are normally attributed to peak-load units (EPA-a, 2004)	
Permanence	• GHG emissions are permanently reduced due to avoidance of fuel consumption that occurs by increasing energy efficiency	
Leakage	• Leakage likely does not apply as any increase in efficiency will reduce overall costs thus resulting in more cost effective means to generate electricity (as opposed to driving demand to another, less efficient supplier). • If upgrades result in short-term increase in rate costs, purchasers could shift to cheaper source of energy until costs return to competitive level. This would be the case with fuel switching from a high but cheaper carbon-intense fuel (coal) to low carbon-intense but more expensive fuel (natural gas)	
Project Magnitude	• Due to economies of scale, current projections estimate that coal-bed seam storage (with or without product recovery) as a viable strategy is limited to large-scale sources (>0.5 Mt/yr) (Gielen, 2003); • Collaborative projects with large sources make this a viable option for investment by small utilities.	
Potential Project Revenues	• Increased efficiencies reduce fuel use rates • Decrease in other emissions may reduce regulatory costs • Sale of additional energy generation within unchanged permit / operational limits due to increased efficiency	
Ancillary Impacts	**Positive** • U.S. EPA recognizes energy efficiency measures as viable source of criteria pollutant emission reduction credits primarily for peak-load units;	**Negative** • Increased efficiency may reduce the marginal cost of electricity to consumers resulting in increased use of electricity thereby possibly

	• Operational outputs can be increased under existing permitted limits without the need of further offsetting or incremental costs; • Energy efficiency improvements decrease fuel costs of generation	offsetting efficiency gains. • Certain upgrades to facility could result in more stringent environmental regulations (e.g., New Source Review) that incur additional costs in excess of fuel use savings or other project revenue sources.
Regulatory Acceptance	• Clean Development Mechanism of the United Nations Framework Convention on Climate Change (UNFCCC); • U.S. EPA's Climate Protection Partnership *and* Climate Leaders Partnership Programs; • U.S. DOE's 1605(b) Registry Program; [NOTE] Likelihood acceptance of this strategy is high due to the following: ○ Current government spending is towards industrial efficiency improvements; ○ U.S. EPA guidance is provided for energy efficiency programs to qualify for State Implementation Plan credit (U.S. EPA, 2004); ○ Other environmental benefits result (e.g., criteria air pollutant reductions); ○ The meeting of other government targets (i.e., efficiency standards)	
Public Perception	• Industrial efficiency upgrades are common practice and rarely met with resistance unless, in the case of facility expansion, a perception that the project is developing over sensitive land issues (e.g., critical habitat for an endangered species)	

OPTION: Renewable Energy Transitions

PROCESS DIAGRAM

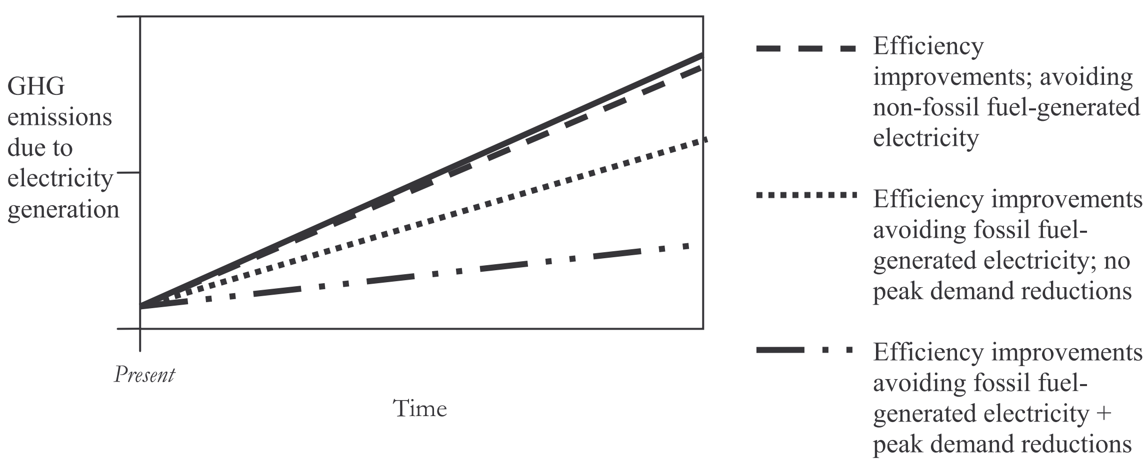


Potential Cost Centers	**Working Capital Costs** • Land purchase or rental • Equipment purchase or rental • Site preparation • Labor and construction	**O&M Costs** • Land payments or lease • Equipment maintenance and repair • Labor	**Decommissioning Costs** • Equipment disposal
Potential Project Revenues	• Sale of electricity to grid or individual consumers • Sale of renewable energy credits (RECs), for states with a Renewable Portfolio Standard (RPS) or a REC trading mechanism • Avoided costs - fuel		
Project Baseline & Additionality	• The project baseline can be calculated by multiplying the annual kWh generated by a renewable energy project by an emissions coefficient for a similarly-sized fossil fuel-based generation unit (Rio Blanco, 2004). • Additionality can include institutional, financial and technological barriers (Rio Blanco, 2004)		
Quantification, Monitoring & Verification (QMV)	• Avoided emissions can be calculated through operational records of a project		

Permanence	• Emissions reductions from the use of renewable energy are permanent as long as renewable energy generation replaces fossil fuel generation	
Leakage	• Leakage can be an issue when fossil fuel-based generation is used to produce renewable energy	
Project Magnitude	• Most renewable energy projects are between 100 kW and 100 MW • Based on an emissions coefficient for natural gas of 0.17 pounds/1 kWh, for a 1 MW project, this would reduce emissions by about 500 metric tons per year	
Mitigation Kinetics	• Reductions in GHG emissions can occur when renewable energy generation replaces fossil fuel generation in electricity supply • Reductions can also occur before generation starts, since: o Renewable fuels produce no GHG emissions o The production and transport of fossil fuels do produce GHG emissions	
Ancillary Impacts	**Positive** • Mainly environmental, such as improvements in air quality through reductions in GHG emissions and criteria pollutants	**Negative** • Noise and visual impact of wind turbines closely located to residences • Risk of mortality to birds
Regulatory Acceptance	• Recognized as a legitimate energy option by: o DOE – production tax credit of 1.8 cents per kWh o States – between 15 and 20 states have or plan to have an RPS o CA – mandates 20% renewable energy generation by IOUs by 2020, may also become a mandate for munis	
Public Perception	• Seen as long-term solution to fossil fuel use • Gained popularity through energy crises of 1970s • Similar to fossil fuel generation plants – subject to various forms of NIMBYism	

OPTION: Demand Side Efficiency Improvements

PROCESS DIAGRAM



Potential Cost Centers	**<u>Working Capital Costs</u>** • Efficient technologies (e.g. air conditioners, lighting, appliances) • Demand-response technology (e.g. real-time meters)	**<u>O&M Costs</u>** • Public education/ outreach • Monitoring & verification of mitigation	**<u>Decommissioning Costs</u>**
Potential Project Revenues	• Revenue generated through sale of ethanol to replace gasoline fuel, as 5-20% additive to gasoline (gasohol), or replace MTBE oxygenate additive in California		
Project Baseline & Additionality	• Accurately estimating baselines for projects that involve a large number of customers is potentially difficult; requires numerous projections about future consumptive patterns. • GHG mitigation benefits of efficiency projects depend entirely upon the type of energy demand that is being reduced. Projects that minimize demand for a *non*-fossil fuel-based energy supply abate little or no GHG emissions and therefore are unlikely to achieve additionality. • Efficiency improvements that reduce peak electricity demands are most likely to achieve additionality because this energy is most often supplied		

	by less-efficient, fossil fuel-powered generators.	
Quantification, Monitoring & Verification (QMV)	• QMV is difficult with the dispersed nature of the mitigation; it is inherently more difficult to track numerous, individual activities. • QMV costs and uncertainties can be avoided by planning/selecting efficiency projects that involve one type, or a few, customers or technologies with large reductions potentials.	
Permanence	• Efficiency improvements lead to lowered GHG emissions. They are a type of reduction mitigation and therefore produce GHG offsets that are fully permanent.	
Leakage	• Major leakage issues associated with demand side efficiency improvements were not found.	
Project Magnitude	• Project magnitudes of efficiency improvements can vary widely. • As a result small municipal utilities can implement these projects independently and/or through collaborative projects and investments in ongoing projects.	
Mitigation Kinetics	• Once operational, efficiency improvement projects produce immediate GHG emissions offsets. • If the project relies on a large number of participants, the annual rate of GHG mitigation will fluctuate and the utility should use a conservative estimate when quantifying expected offsets during the project planning.	
Ancillary Impacts	**Positive** • Positive public perception • Conserving natural resources • Preventing pollution (e.g. reduced emissions of criteria air pollutants)	**Negative**
Regulatory Acceptance	• Efficiency improvements are explicitly identified as a central GHG mitigation strategy in existing climate change policies at multiple jurisdictional levels (e.g. Kyoto Protocol, West Coast Governors'	

	Climate Change Initiative) • Likelihood acceptance of this approach is also high due to the following: ○ U.S. EPA guidance is provided for energy efficiency programs to qualify for State Implementation Plan credit ○ Other environmental benefits result (e.g., criteria air pollutant reductions)
Public Perception	• No public perception issues for efficiency improvement approaches.

WORKSHEET: Example Using BWP

Three of the GHG mitigation project recommendations for BWP are used in this example worksheet to illustrate the complete mitigation comparison process for Step 6. A blank worksheet is provided on the last page of Appendix A (Table A-1).

Option X = Olive 1 & Olive 2 shutdown (efficiency improvement)
Option Y = Collaboration with IPP on geological sequestration project.
Option Z = Dairy farm methane capture project

[a] = 2.5% reduction in GHGs for every 1% efficiency improvements
[b] = criteria pollutant reduction
[c] = possible seismic activity
d = odor reduction

	Four core attributes mitigation options should have				Other attributes that influence the choice of mitigation option(s) to embark upon							
	Able to establish project baseline and additionality	Availability of quantification, monitoring & verification methods	Permanence (should be maximized)	Able to avoid leakage	Project magnitude (size needed to offset certain amount of GHGs)	Mitigation Kinetics (understanding of timeframe for GHG abatement)	Ancillary impacts (aware of positive and/or negative impacts)	Cost per ton (approximate range)	Regulatory Acceptance	Preferred by stakeholders	Existing relationships able to participate in collaborative project	Positive public perception
Option X	Yes	Yes	100%	Yes	2.5% [a]	Instant	Pos [b]	$-115 to -588	Yes	Uncer-tain	No	Yes
Option Y	Yes	Uncer-tain	< 100%	Yes	large	instant	Neg [c]	$10 to 60	Uncer-tain	Uncer-tain	Yes	Uncer-tain
Option Z	Yes	Yes	100%	Yes	~1 MTCE/ cow	Instant	Pos [d]	$-30 to 30	Yes	Uncer-tain	Uncer-tain	Yes

* MT = metric tons of carbon *MTCE = metric tons of carbon equivalents

Table A-1. Blank worksheet for mitigation comparison process.

	Four core attributes mitigation options should have				Other attributes that influence the choice of mitigation option(s) to embark upon							
	Able to establish project baseline and additionality	Availability of quantification, monitoring & verification methods	Permanence (should be maximized)	Able to avoid leakage	Project magnitude (size needed to offset certain amount of GHGs)	Mitigation Kinetics (understanding of timeframe for GHG abatement)	Ancillary impacts (aware of positive and/or negative impacts)	Cost per ton (approximate range)	Regulatory Acceptance	Preferred by stakeholders	Existing relationships able to participate in collaborative project	Positive public perception