**CPE = chemical potential energy

Fuel Life Cycle Analyses

Fuel: *Electricity from coal*　　　　　　Name: *Answer key*

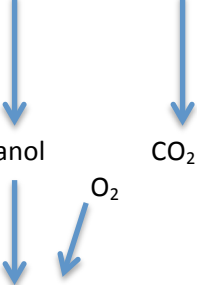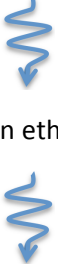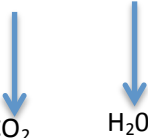| Matter	Energy	Additional Energy Inputs	Environmental Effects
Millions of years ago: CO_2　　　H_2O ↓　　　　↓	Sunlight 〰️	Energy for mining & transportation	Landscape destruction Mining tailings
Process: photosynthesis, heat & pressure, extraction Location: underground coal fields			
↓　　↓ Coal　　O_2 ↓	〰️ CPE in coal 〰️		CO_2 & greenhouse effect Air pollution -Acid rain -Particulates -Mercury
Process: combustion, electricity production Location: power plant			
↓　　　↓ CO_2　　H_2O	〰️ Heat, motion, electricity 〰️		
Process: charge & drive car Location: car			
	〰️ CPE in battery 〰️ Electricity 〰️ Kinetic E, heat		Battery materials
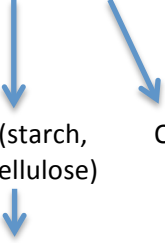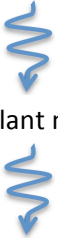
Summary of sustainability analysis:

**CPE = chemical potential energy

Fuel Life Cycle Analyses

Fuel: *Ethanol (cellulosic or grain)*   Name: *Answer key*

Matter	Energy
CO_2　　　H_2O	Sunlight
Process: photosynthesis, biosynthesis (grow crop) Location: field of plants	
Plants (starch, cellulose)　　O_2	CPE in plant material
Process: preparation, fermentation, distillation (purification) Location: refinery	
Ethanol　　CO_2 　　O_2	CPE in ethanol
Process: combustion Location: car	
CO_2　　H_2O	Kinetic E, heat

Additional Energy Inputs	Environmental Effects
Energy for planting, harvesting, transport Fertilizer production	Decreased biodiversity Nitrogen and phosphorous runoff GHG emissions Carbon sequestration
Energy for processing biomass into ethanol Energy for transportation	CO_2 came from atmosphere and is not a new burden

Summary of sustainability analysis:

Fuel Life Cycle Analyses

Fuel: *Gasoline*   ## Name: *Answer key*

Matter	Energy	Additional Energy Inputs	Environmental Effects
Millions of years ago: CO_2 H_2O ↓ ↓ Process: photosynthesis, heat & pressure, extraction Location: underground	Sunlight ↓	Energy for extraction & transportation	Oil spills
↓ ↓ Crude oil O_2 ↓ Process: refining (separating components of mixture) Location: refinery	CPE in crude oil ↓	Energy for refining and transportation	Regulated air pollution
↓ Gasoline O_2 ↓ ↓ Process: combustion Location: car engine	CPE in components including gasoline ↓		CO_2 & greenhouse effect Air pollution
↓ ↓ CO_2 H_2O	Kinetic energy (car movement), heat		

Summary of sustainability analysis:

**CPE = chemical potential energy

Fuel Life Cycle Analyses

Fuel: *Electricity from natural gas*

Name: *Answer key*

Matter	Energy	Additional Energy Inputs	Environmental Effects
Millions of years ago: CO_2 H_2O	Sunlight	Energy for extraction	Fracking -Water pollution -Earthquakes
Process: photosynthesis, heat & pressure, extraction Location: gas & oil fields			
CH_4 O_2	CPE in natural gas	Energy for transportation (less than for coal)	Air pollution (less than coal) Less CO_2 per BTU than coal (more hydrogen, less carbon)
Process: combustion, electricity production Location: power plant			
CO_2 H_2O	Motion Electricity		Battery materials
Process: charge & drive car Location: car			
	CPE in battery Electricity Kinetic E, heat		

Summary of sustainability analysis:

**CPE = chemical potential energy

Fuel Life Cycle Analyses

Fuel: *Electricity from biomass*   Name: *Answer key*

Matter	Energy
CO_2 H_2O ↓ ↓	Sunlight 〰↓
Process: photosynthesis, biosynthesis (grow crop) **Location: field of plants**	
Plants (cellulose) O_2	CPE in plant material 〰↓ 〰↓
Process: combustion, electricity production **Location: power plant**	
CO_2 H_2O	Heat, light, motion 〰↓ Electricity 〰↓
Process: charge and drive car **Location: car**	
	CPE in battery 〰↓ Electricity 〰↓ Kinetic E, heat

Additional Energy Inputs	Environmental Effects
Energy for planting, harvesting, & transport Fertilizer production	Decreased biodiversity Nitrogen and phosphorous runoff GHG emissions Carbon sequestration
	Air pollution -VOCs -Particulates CO_2 came from atmosphere and is not a new burden
	Battery materials

Summary of sustainability analysis:

**CPE = chemical potential energy

Fuel Life Cycle Analyses

Fuel: *Electricity from hydro*   **Name:** *Answer key*

Matter	Energy		Additional Energy Inputs	Environmental Effects
	Water with gravitational PE			Obstruction of waterway affects ecosystem
Process: electricity production Location: power plant at dam				
	Motion Electricity			Battery materials
Process: charge and drive car Location: car				
	CPE in battery Electricity Kinetic E, heat			
Process: charge & drive car Location: car				

Summary of sustainability analysis: