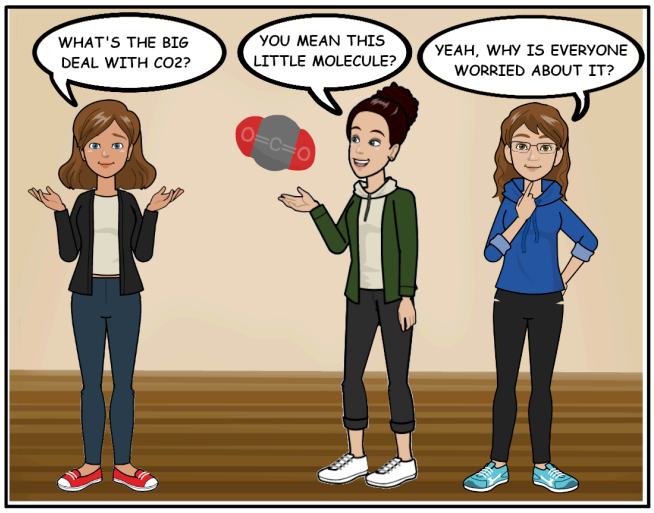
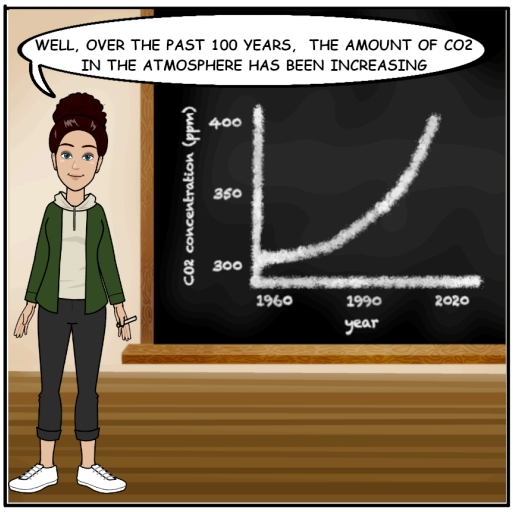
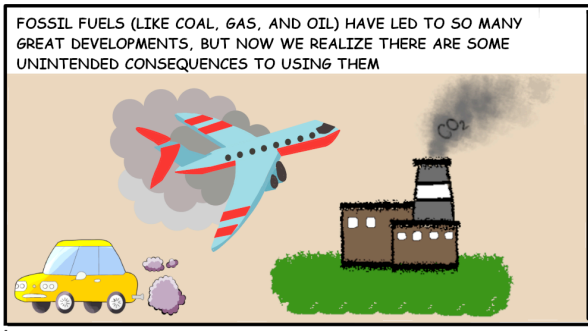
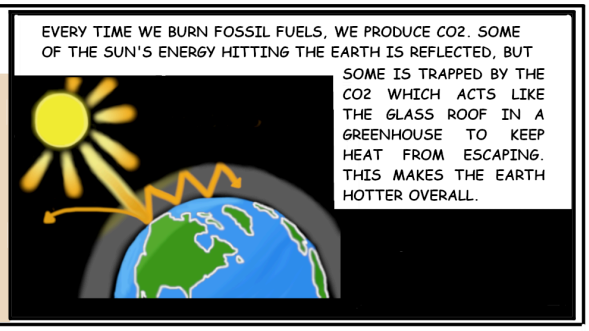
ELECTROCHEMICAL CO2 REDUCTION

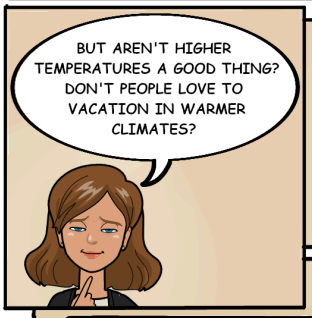
WRITTEN AND DRAWN BY
RILEIGH DIDOMENICO, KELSEY LEVINE, AND LAILA REIMANIS

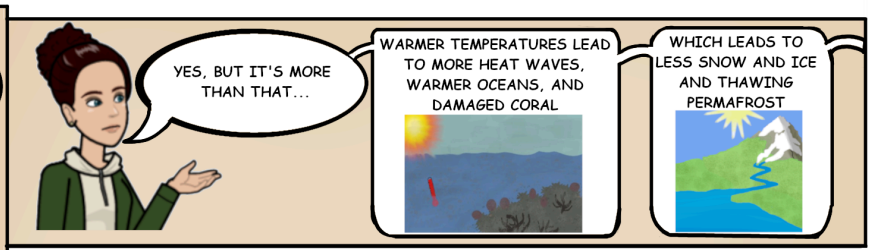


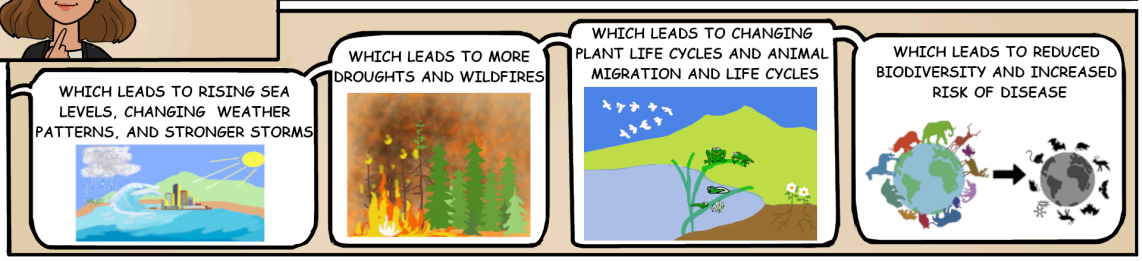


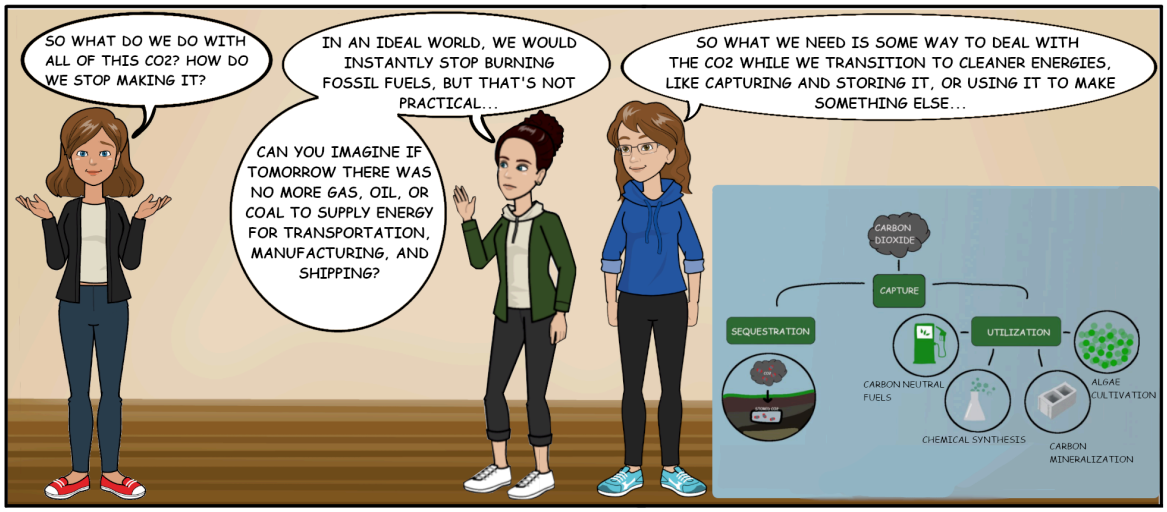


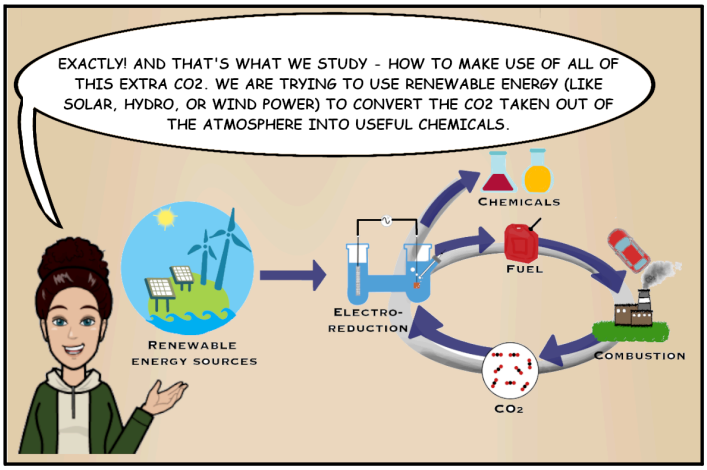


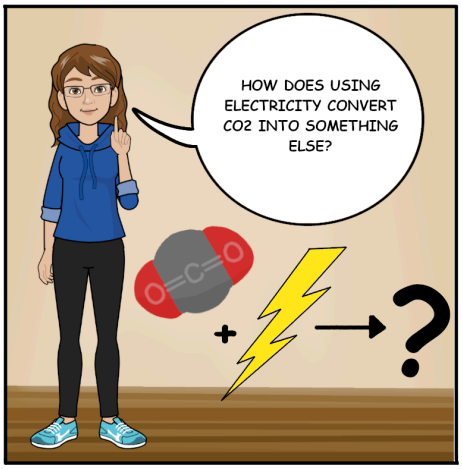







SO WHAT DO WE DO WITH ALL OF THIS CO2? HOW DO WE STOP MAKING IT?
IN AN IDEAL WORLD, WE WOULD INSTANTLY STOP BURNING FOSSIL FUELS, BUT THAT'S NOT PRACTICAL...
CAN YOU IMAGINE IF TOMORROW THERE WAS NO MORE GAS, OIL, OR COAL TO SUPPLY ENERGY FOR TRANSPORTATION, MANUFACTURING, AND SHIPPING?
SO WHAT WE NEED IS SOME WAY TO DEAL WITH THE CO2 WHILE WE TRANSITION TO CLEANER ENERGIES, LIKE CAPTURING AND STORING IT, OR USING IT TO MAKE SOMETHING ELSE...
CARBON DIOXIDE
CAPTURE
SEQUESTRATION
UTILIZATION
CARBON NEUTRAL FUELS
ALGAE CULTIVATION
CHEMICAL SYNTHESIS
CARBON MINERALIZATION


EXACTLY! AND THAT'S WHAT WE STUDY - HOW TO MAKE USE OF ALL OF THIS EXTRA CO2. WE ARE TRYING TO USE RENEWABLE ENERGY (LIKE SOLAR, HYDRO, OR WIND POWER) TO CONVERT THE CO2 TAKEN OUT OF THE ATMOSPHERE INTO USEFUL CHEMICALS.
RENEWABLE ENERGY SOURCES
ELECTRO-REDUCTION
CHEMICALS
FUEL
COMBUSTION
CO2


HOW DOES USING ELECTRICITY CONVERT CO2 INTO SOMETHING ELSE?
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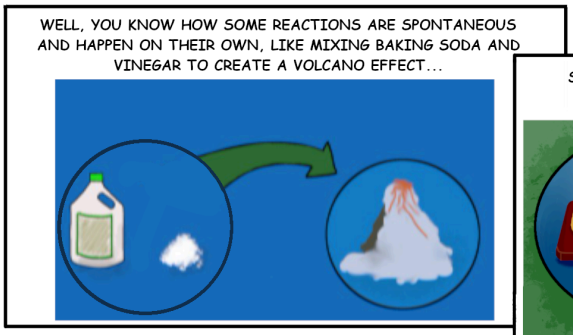
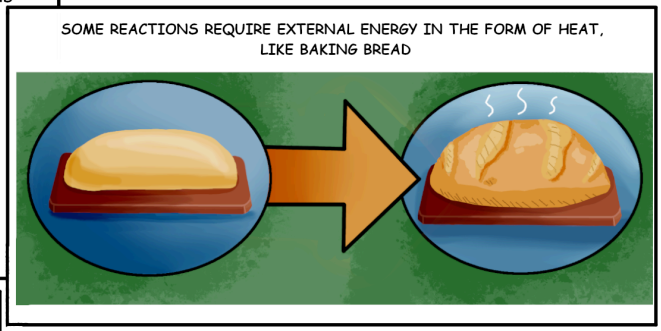
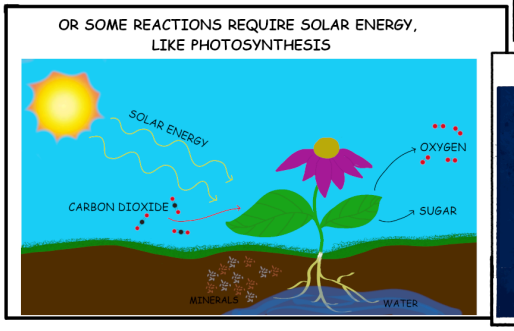
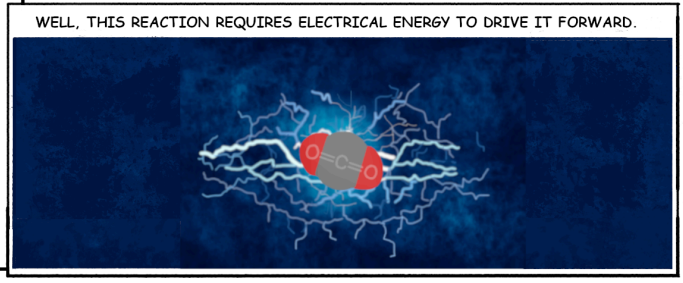
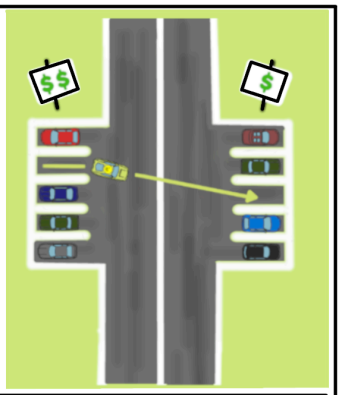

WELL, YOU KNOW HOW SOME REACTIONS ARE SPONTANEOUS AND HAPPEN ON THEIR OWN, LIKE MIXING BAKING SODA AND VINEGAR TO CREATE A VOLCANO EFFECT...


SOME REACTIONS REQUIRE EXTERNAL ENERGY IN THE FORM OF HEAT, LIKE BAKING BREAD


OR SOME REACTIONS REQUIRE SOLAR ENERGY, LIKE PHOTOSYNTHESIS
SOLAR ENERGY
CARBON DIOXIDE
OXYGEN
SUGAR
MINERALS
WATER

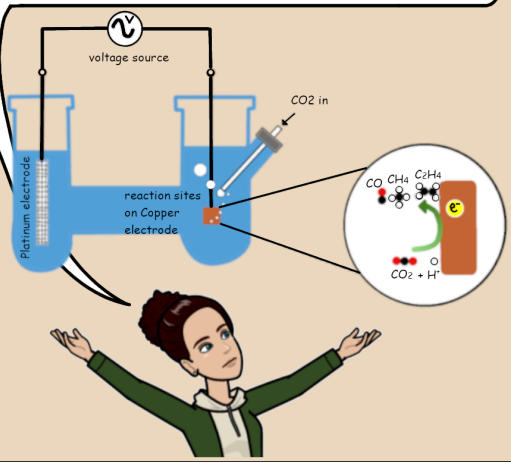

WELL, THIS REACTION REQUIRES ELECTRICAL ENERGY TO DRIVE IT FORWARD.

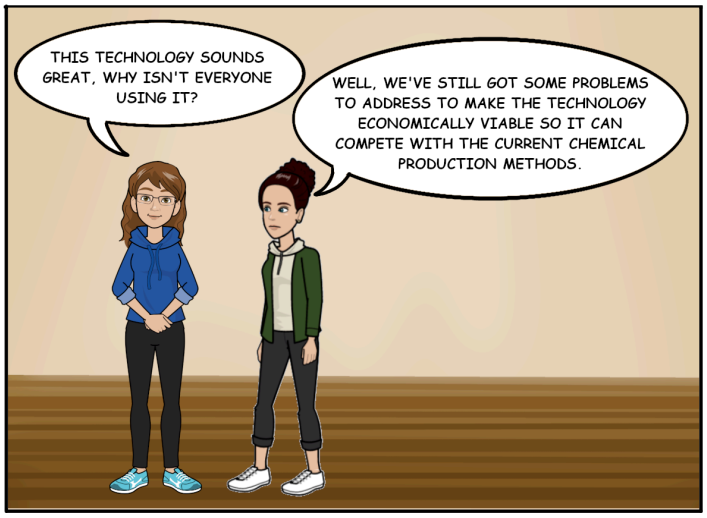
IMAGINE YOU ALWAYS PARK YOUR CAR IN THE LOT ON THE LEFT SIDE OF THE STREET BECAUSE IT IS CHEAPER THAN PARKING ON THE RIGHT. EVERY MONTH, THE PRICE TO PARK ON THE LEFT INCREASES UNTIL IT IS ACTUALLY MORE EXPENSIVE! TO SAVE MONEY, YOU DECIDE TO SWITCH LOTS AND PARK ON THE RIGHT SIDE.



WE DO THE SAME THING IN OUR SYSTEM, EXCEPT THE PRICE IS ENERGY, THE CARS ARE ELECTRONS, THE LEFT PARKING LOT IS THE METAL ELECTRODE, AND THE RIGHT PARKING LOT IS THE CO_2. BY INCREASING THE VOLTAGE (ENERGY), WE CAN RAISE THE ENERGY OF THE ELECTRONS. IF WE RAISE THE ENERGY HIGH ENOUGH, THE ELECTRONS WILL FIND AN EMPTY SPACE WITH A LOWER ENERGY IN THE CO_2 AND TRANSFER THERE. ADDING ELECTRONS TO THE CO_2 FORMS NEW PRODUCTS LIKE METHANE OR ETHANOL (FUEL), ETHYLENE (USED TO MAKE PLASTICS), AND MORE.

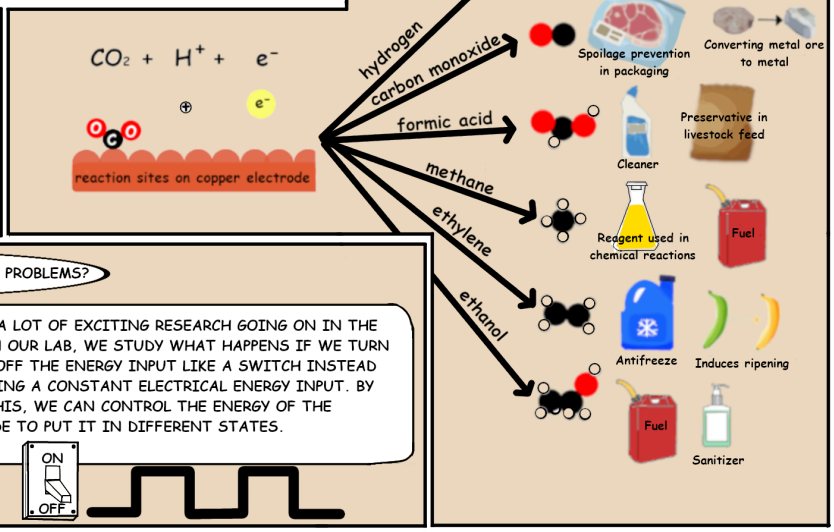
THIS IS WHAT OUR EXPERIMENTAL SYSTEM LOOKS LIKE. WE HAVE OUR COPPER ELECTRODE IN A SALT SOLUTION WHERE THE CO_2 ATTACHES TO REACTION SITES ON THE ELECTRODE AND IS THEN CONVERTED INTO SOMETHING ELSE WHEN WE APPLY A VOLTAGE AND FORCE THE ELECTRONS TO MOVE.



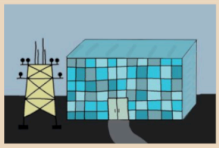


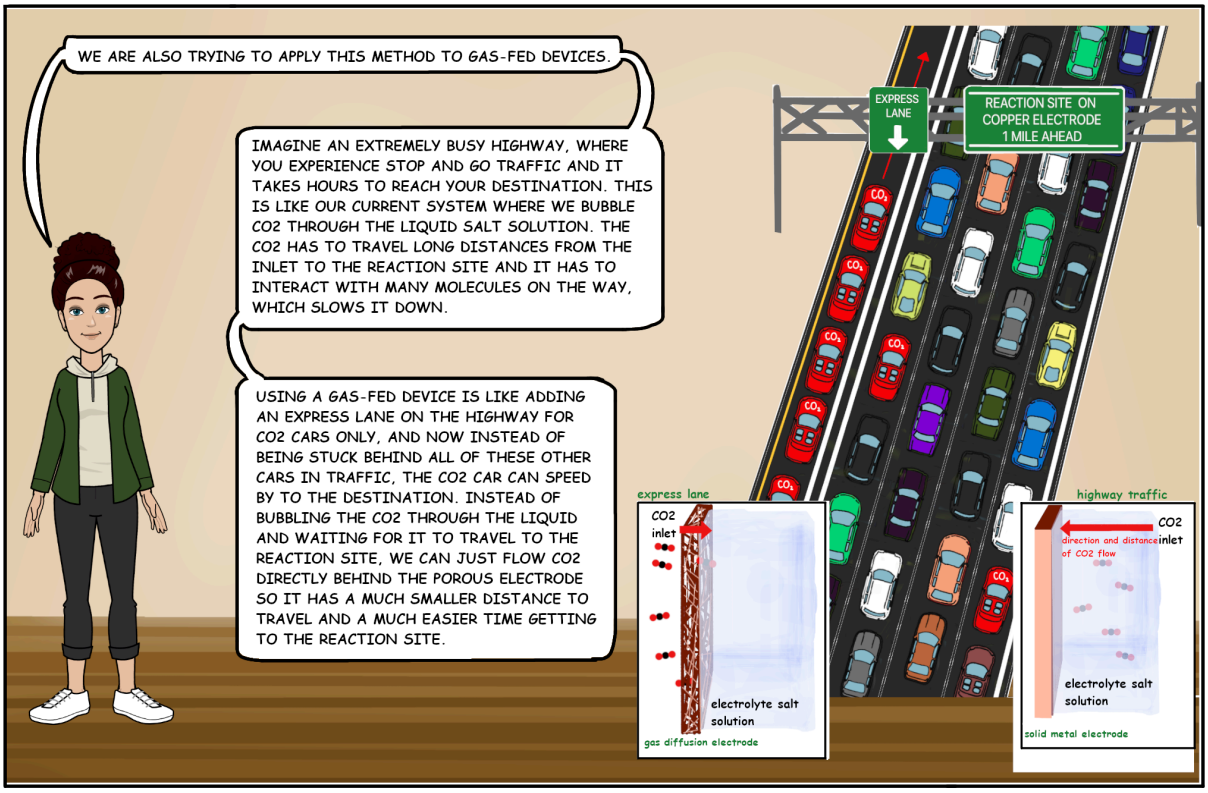
FIRST, WE NEED TO MAKE SURE THAT THE SYSTEM CAN RUN STABLY OVER THOUSANDS OF HOURS SO IT NEEDS LESS FREQUENT MAINTENANCE AND REPAIRS WHICH BRINGS DOWN THE COST.

SECOND, WE NEED TO IMPROVE PRODUCT SELECTIVITY BECAUSE IT IS CHEAPER TO MAKE A LOT OF ONE CHEMICAL INSTEAD OF A LITTLE OF LOTS OF DIFFERENT CHEMICALS. THAT WAY WE DON'T SPEND LOTS OF MONEY ON SEPARATING EVERYTHING LATER.

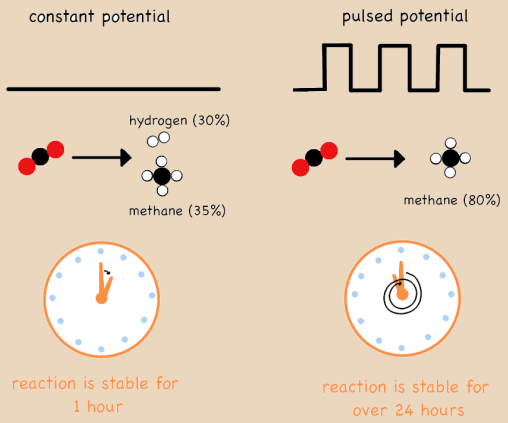


AND THIRD, WE NEED TO BE ABLE TO CONVERT LOTS OF CO_2 AT ONCE TO KEEP UP WITH COMMERCIAL SUPPLY AND DEMAND.

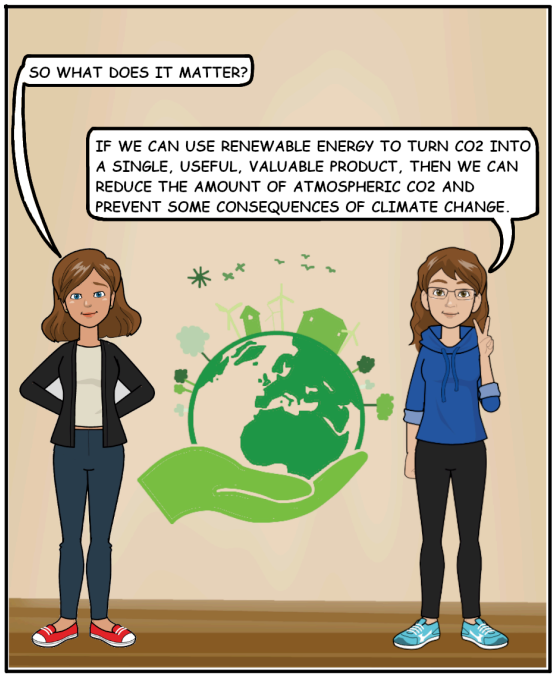




SO FAR, WE HAVE FOUND THAT PULSING THE ELECTRODE POTENTIAL REDUCES THE AMOUNT OF HYDROGEN WE MAKE AND CAN INCREASE THE AMOUNT OF CARBON PRODUCTS WE MAKE. HYDROGEN IS AN UNWANTED PRODUCT FROM A SIDE REACTION, SO STOPPING THAT REACTION MEANS WE CAN ENHANCE THE OTHER REACTIONS WE DO WANT TO HAPPEN - LIKE CONVERTING CO2 INTO METHANE OR ETHYLENE.



WE HAVE ALSO FOUND THAT PULSING THE ELECTRODE ALLOWS US TO CONVERT CO2 TO OTHER CARBON PRODUCTS FOR OVER 24 HOURS. WHEN WE DON'T PULSE THE ELECTRODE, THE CO2 CONVERSION REACTION ONLY RUNS STABLY FOR ABOUT AN HOUR BEFORE THE REACTION RATES START DECREASING.



THE INSPIRATION FOR THIS WORK CAME FROM THE COMICS BY DR. LUCAS LANDHERR. AVATARS WERE MADE WITH PIXTON AND ALL OTHER IMAGES WERE CREATED IN GIMP.


HELIOS
HI! OUR NAMES ARE KELSEY, RILEIGH, AND LAILA. WE ARE RESEARCHERS IN THE HANRATH ENERGY LAB IN THE SMITH SCHOOL OF CHEMICAL AND BIOMOLECULAR ENGINEERING AT CORNELL UNIVERSITY. THIS COMIC EXPLAINS OUR RESEARCH ON PULSED ELECTROCHEMICAL CO2 REDUCTION. FOR MORE INFORMATION ON OUR WORK OR ON OUR LAB, CHECK OUT https://hanrath-group.cbe.cornell.edu/research/electrocatalysis/