TRANSIT MANAGERS AND ELECTRIC CHOICES

VEHICLES, FACILITIES, AND INFRASTRUCTURE

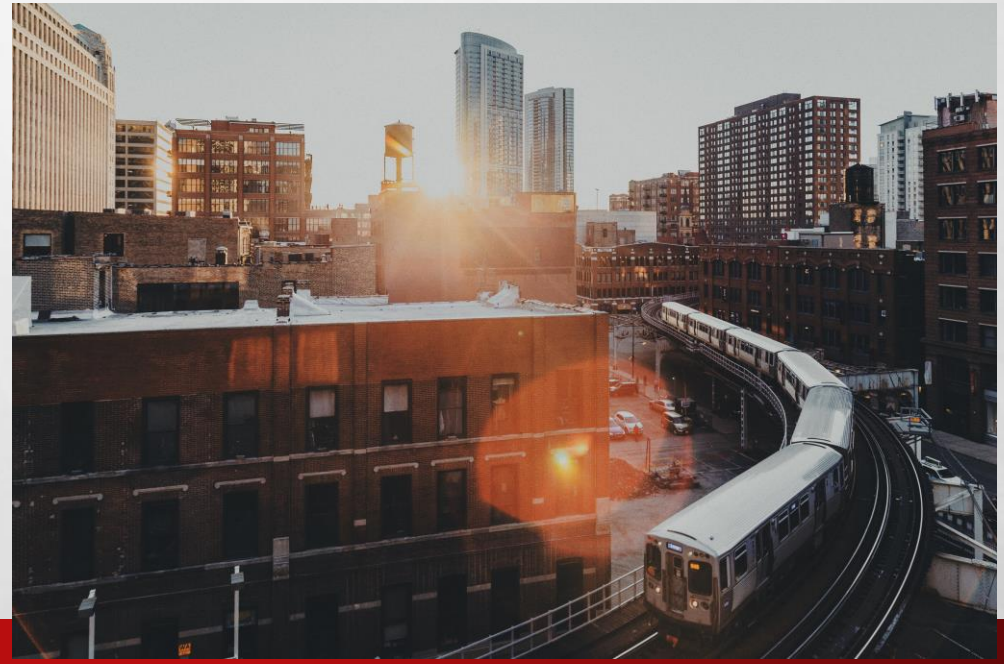
CURRENT TECHNOLOGY - RIVIAN

• RIVIAN	$73,000 BASE	• FORD RANGER	$26,000 BASE
• 835HP	908LB-FT	• 270HP	310LB-FT
• WEIGHT	7,173LB	• WEIGHT	4,145LB
• RANGE	314MI (70MPGE)	• RANGE	468MI (23MPG)
• TOW	11,000LB	• TOW	3,500LB

WHY ARE WE HEADED TO ELECTRIC FLEETS?

- CARBON IN OUR ATMOSPHERE IS BEING TAKEN SERIOUSLY

- NATIONS, COMPANIES, INDIVIDUALS ARE PLANNING FOR MOBILITY AND POWER GENERATION WITHOUT COAL, AND WITHOUT MOST COMBUSTION FUELS



HOW PRACTICAL ARE ZERO EMISSION BUSES

BATTERY ELECTRIC 13C/KWH

- PROTERRA (ZX5 225-675 KWH)
- BYD (K9MD, 446KWH)
- NEW FLYER CHARGE NG 525 KWH
- GILLIG (490 TO 686 KWH)

HYDROGEN FUEL CELL $16/GAL

- NEW FLYER
- TOYOTA/CAETANOBUS
- VAN HOOL
- SAFRA/SYMBIO

BATTERY SOURCE MEASURES

- KW
- THINK HORSEPOWER
- BATTERY PACK RATED AT 230KW
- REPLACES ENGINE RATED AT 308HP

- KWH
- THINK GALLONS OF FUEL
- BUS HOLDS 300 KWH
- REPLACES FUEL TANK OF 7.9 GALLON CAPACITY

LESSONS FROM EARLY ADOPTERS

FOOTHILL - TRANSITION

- BEGAN ZERO EMISSION FLEET 2010
- CHALLENGES WITH 13 OF 32 BUSES LED TO ORDER - 20 HYD FUEL CELL
- SJRTD, RENO, TARC, ALBQ, INDY

- ANTELOPE VALLEY - ADAPT
- BEGAN ZERO EMISSION FLEET 2014
- ADDED RANGE EXTENDER WAVE
- COMPLETED 7 MILLION MILES ELECTRIC
- FIRST ALL ELECTRIC LOCAL TRANSIT FLEET

CALIFORNIA LAW CREATES A MARKET

CARB ESTIMATES ENTIRE TRANSIT FLEET WILL BE BEB IN 2044

- 2019 CALIFORNIA TRANSIT SYSTEMS – NOW 12,500 BUSES
  - 551 BEB; 38 FCEB
  - NEXT FIVE YEARS
  - 531 BEB; 8 FCEB

HYDROGEN FUEL CELL - SARTA

- SARTA - CANTON, OHIO
- 25% OF BUS FLEET (20)
- ONLY WATER VAPOR AT BUS
- 85KW CELL, 50KW BATTERY

WHY CHOOSE BATTERY OR FUEL CELL

- BATTERY

- MANY IN THE FIELD (+/-2,000)
- RANGE ISSUES ARE IMPROVING
- COMBINATION OF RECHARGE METHODS

- FUEL CELL

- HOT OR COLD EXTREMES
- HILL EXTREMES
- SPEED OF REFUEL CYCLE
- ONLY GREEN HYDROGEN WILL SPUR

PREPARE YOUR TRANSIT SYSTEM

- ELECTRIFICATION MASTER PLAN
- UTILITY AGREEMENT FOR “UP TO THE FENCE”
- UTILITY AGREEMENT FOR COMMERCIAL VEHICLE
- PROCURE, INSTALL ELECTRICAL CHARGERS
- BUILD NEW OR DESIGN BUILD IN PHASES
- MAKE FACILITY ACCOMMODATIONS

- STUDY THE SWOT FOR EACH MANUFACTURER
- PREPARE RFP, ANALYZE RESPONSES
- MAINTENANCE AND OPERATIONS PLAN
- QUALITY CONTROL DURING PLANT INSPECTION
- TEST SIMILAR VEHICLE WHILE WAIT FOR DELIVERY

ONCE GRANT APPROVED - PREPARE FOR IMPLEMENTATION

- CUSTOMERS
- COUNCIL, BOARD
- UNION
- SCHOOLS
- MAINTENANCE TECHNICIANS
- OPERATIONS SUPERVISORS
- OPERATORS
- EMERGENCY FIRE, POLICE, EMT

CUSTOMER INFRASTRUCTURE

- WHERE TO PLACE BUS INITIALLY
- COMMUNICATIONS PRESS
- COMMUNICATIONS WEB/MEDIA
- ANTICIPATE QUESTIONS

- COUNCIL DISTRICTS
- TITLE VI
- PLANS FOR AVOIDING DISRUPTIONS
- PLANS FOR EXPANSION
- PLANS FOR REDUNDANCY

WILL MAINTENANCE REALLY SIMPLIFY?

NOT AT FIRST

INITIAL OEM PRODUCTS HAVE NOT MET ALTOONA RANGE

INITIAL FLEET ISSUES HAVE HAD SOME SERIOUS RELIABILITY ISSUES

YES, GRADUALLY

- TYPICAL GASOLINE AUTO – DRIVETRAIN INCLUDES 2,000 PARTS
- TYPICAL EV HAS 20 PARTS

BE READY FOR ARGUMENTS

NOT THAT CLEAN

- COAL, NATURAL GAS ELEC GENERATION
- COAL - BROWN/BLACK HYDROGEN
- NATURAL GAS - GREY HYDROGEN
- RENEWABLES, NGSR – GREEN, BLUE CCS

CLEAN, GETTING CLEANER

- PROPORTION OF RENEWABLES GROWING; POWER GRID; HYDROGEN
- POWER PLANT CAN GENERATE POWER MORE EFFICIENTLY THAN THOUSANDS OF ICE ENGINES

HOW MUCH WILL POWER COST?

CONSUMPTION

- TOU - TIME OF USE, DRIVER HABIT
- TIERED RATE E.G. 11C/KWH, THEN 13C/KWH AFTER 25,000 KWH
- DEPOT CHARGERS V. FAST CHARGERS
- ASSUME 15 MWH FOR 30 BUS FLEET PER DAY

RATE STRUCTURE

- ELECTRICITY DEMAND CHARGES
- RATCHET CLAUSES (LOW DEMAND MONTHS)
- COMMERCIAL ELECTRIC VEHICLE RATES (PGE)
- UTILITY MANAGED CHARGING
- TARIFFED ON-BILL FINANCING (INFRASTRUCTURE)

TWIN POWER-OVERHEAD, BATTERY

OKC, DAL, MILW, DETROIT

FOOTHILL, KING COUNTY

CHARGING CHOICES

DEPOT CHARGE

- CONDUCTIVE
- TYPICAL 4-7 HOURS; 150-200 MILE
- POSSIBLE VANHOOL/PROTERRA USED PUBLIC CHARGERS FOR 1,700 MILE TRIP; AVG 280 MILES OF TOTAL PROJECTED RANGE BETWEEN CHARGES

ON ROUTE CHARGE

CONDUCTIVE

STATIC - EG. OVERHEAD EARLY PROTERRA

DYNAMIC - EG. TROLLEY STYLE

INDUCTIVE

STATIC – WAVE (AVTA, UTA)

ARE THERE 400 MILE SYSTEMS ?

- ANTELOPE VALLEY
- 2014 SET OUT TO BE FIRST ALL ELECTRIC FLEET
- FIRST BUSES 150 -220 MILE RANGE
- NEEDED AT LEAST 290 EFFECTIVE RANGE
- CLAIM TO HAVE REACHED 400
- NOW OVER 7 MILLION MILES ELECTRIC

HOW DID AVTA GET THERE?

- STATIC INDUCTIVE RECHARGE
- THINK “TOP OFF THE (BATTERY) TANK”
- EACH 10 MINUTES GAINS 20 MILE RANGE
- DOZEN 250kW CHARGERS ON ROUTES
- CONTRAST WITH PANTOGRAPH

HOW DOES INDUCTIVE CHARGING WORK

PAD - AC PASSES THROUGH INDUCTION COIL

MOVING CHARGE – FLUCTUATING MAGNETIC FIELD

CHANGING MAGN. FIELD – AC IN BUS INDUCTION COIL

PASSES THROUGH RECTIFIER – CONVERTS TO DC

THINK INDUCTION STOVETOP