UCDAVIS

SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

An Institute of Transportation Studies Program

Extended-Range Electric Vehicles

An Enabling Platform for Sustainable Energy Pathways

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***Economy-Economy**: Can the E-REV be sold for a profit?*

The profitability of alternatively fueled vehicles is among their largest remaining hurdles. Full-performance electric vehicles (EV) were marketed and sold in California in the late '90s and early '00s, but their profitability was often called into question. Limited driving range and access to recharging outlets reduce functionality and hinder consumer acceptance. While large format batteries remain expensive and heavy, down-sizing the EV battery by hybridizing the electric-drive with a range-extending auxiliary power unit (APU) could save cost and reduce weight while still providing electric-drive capability for a significant portion of daily travel. The fuel flexibility of such an extended-range electric vehicle (E-REV) will almost certainly increase consumer acceptance for electrified vehicles. Electric motor cost is significant, but far less so than batteries.

***Economy-Equity**: Can the E-REV be sold to everyone?*

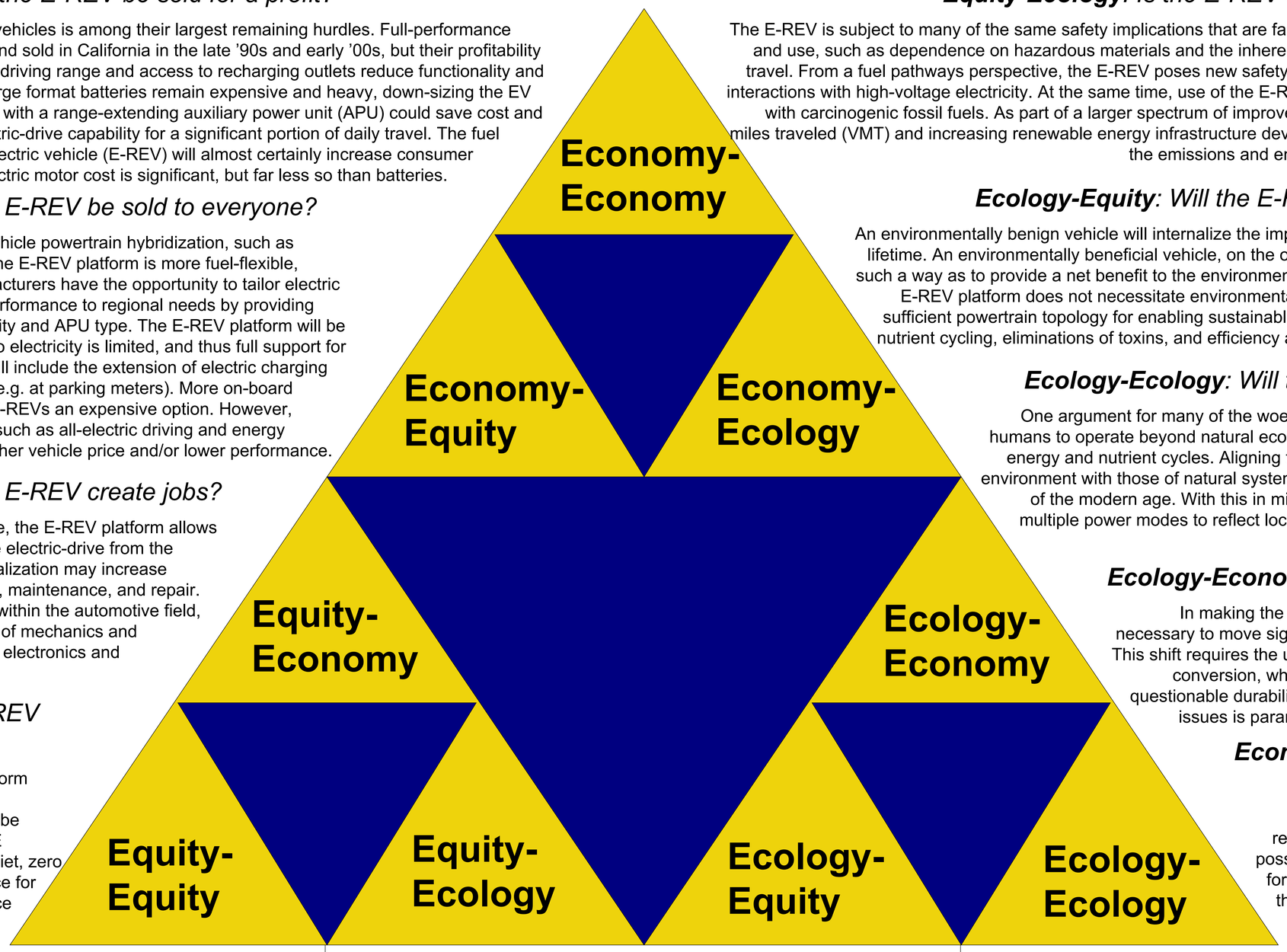
Relative to other popular options for vehicle powertrain hybridization, such as parallel or power-split configurations, the E-REV platform is more fuel-flexible, modular, and universal. E-REV manufacturers have the opportunity to tailor electric driving range, fuel type, and vehicle performance to regional needs by providing multiple options for battery pack capacity and APU type. The E-REV platform will be less attractive in areas where access to electricity is limited, and thus full support for the development of such technology will include the extension of electric charging outlets to parking lots and curb-sides (e.g. at parking meters). More on-board powerplants make high-performance E-REVs an expensive option. However, inherent benefits of E-REV operation, such as all-electric driving and energy security, may be sufficient to justify higher vehicle price and/or lower performance.

***Equity-Economy**: Can the E-REV create jobs?*

More than any other hybrid architecture, the E-REV platform allows for the distinction and separation of the electric-drive from the engine. Such powertrain compartmentalization may increase specialization in vehicle manufacturing, maintenance, and repair. This will create new and different jobs within the automotive field, adding to the existing knowledge base of mechanics and combustion an increased emphasis on electronics and electrochemistry.

***Equity-Equity**: Will the E-REV benefit lives?*

If implemented widely, the E-REV platform seems likely to enable more socially responsible vehicle use than what can be currently achieved by conventional ICE vehicles. All-electric driving enables quiet, zero tailpipe emissions operation. Preference for electric-only driving will also help reduce competition between biofuels and food resources.



***Equity-Ecology**: Is the E-REV safe to manufacture and use?*

The E-REV is subject to many of the same safety implications that are faced by conventional vehicle manufacturing and use, such as dependence on hazardous materials and the inherent safety implications posed by high-speed travel. From a fuel pathways perspective, the E-REV poses new safety concerns through the possibility of human interactions with high-voltage electricity. At the same time, use of the E-REV should also reduce human interactions with carcinogenic fossil fuels. As part of a larger spectrum of improvement measures, such as reducing vehicle miles traveled (VMT) and increasing renewable energy infrastructure development, the E-REV could greatly reduce the emissions and energy-use related impacts of vehicle use.

***Ecology-Equity**: Will the E-REV pollute the environment?*

An environmentally benign vehicle will internalize the impacts of its manufacture and use during its lifetime. An environmentally beneficial vehicle, on the other hand, should use and store energy in such a way as to provide a net benefit to the environment. Though the manufacture and use of the E-REV platform does not necessitate environmentally beneficial conditions, it does provide a sufficient powertrain topology for enabling sustainable use of renewable energy resources. Full nutrient cycling, eliminations of toxins, and efficiency are also needed for "eco-effectiveness" .

***Ecology-Ecology**: Will the E-REV work with nature?*

One argument for many of the woes of the modern world is the insistency of humans to operate beyond natural ecological limits through ignorance of natural energy and nutrient cycles. Aligning the nutrient and energy cycles of the built environment with those of natural systems may be the single most important task of the modern age. With this in mind, the E-REV may easily be operated in multiple power modes to reflect local energy cycles and resource availability where the vehicle is used.

***Ecology-Economy**: Is the E-REV affordable?*

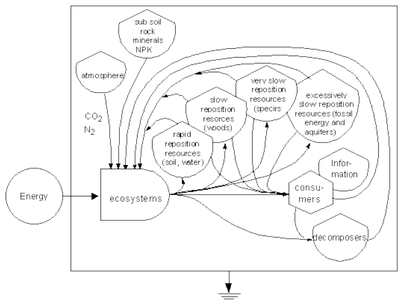
In making the E-REV more ecologically responsible, it is necessary to move significantly toward powertrain electrification. This shift requires the use of electrochemical energy storage and conversion, which currently are cost-prohibitive and have questionable durability for such applications. Addressing these issues is paramount to successful E-REV introduction.

***Economy-Ecology**: Is the E-REV eco-efficient?*

Producing a vehicle that is "eco-efficient" requires that the least energy and materials possible be used to achieve adequate vehicle form and function. Achievement is assessed through comparison to ecological analogs.

Equity

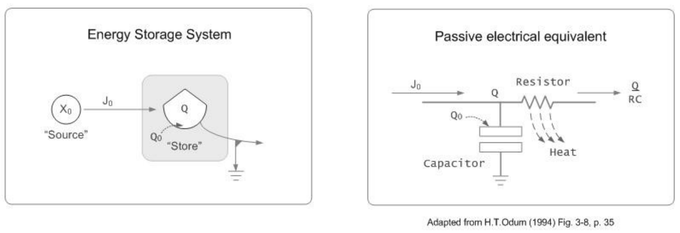
Equity requires the effective distribution of materials and energy based on system function. Like electrical current through a circuit, equity can be assessed by monitoring flows through a network. If each arc in the network carries adequate flow as required by the functions occurring at each node, then the distribution may be considered equitable, assuming all necessary functions of the system have been accurately accounted for. Flow follows function.



(Odum, 1996)

Economy

Economy is a measure of materials and energy accumulation and storage. The most functional systems are those which build economy to increase diversity of organization for cooperative, equitable system interactions. This "reciprocal altruism" has been shown consistently from Darwin to Rapaport to serve as an effective strategy for living agents and systems. Economy is less effective when "cheating" and "hording" are artificially subsidized.



Adapted from H.T.Odum (1994) Fig. 3-8, p. 35

Ecology

Ecology describes system function according to network constituents and their interactions. While individual interactions can often be simple, their aggregate effects are typically quite complex. Among the most interesting aspects of ecologically organized systems are the emergence of properties which serve new function but cannot be readily derived through the assessment of the system's interacting constituents. Form follows evolution.