In the cluster approach, a group of technologies share a common component—"key technology"—which is subject to learning.

- Only the investment costs undergo the learning process.
- Therefore, we only attribute capital cost to key component technologies.

Learning Implementation

In linear optimization models, the cost reduction of technology based on experience requires the use of technology as a trigger that contradicts with the original paradigm of TIMES (selecting least-cost technology).

- Methods have been developed to implement endogenous learning in linear models using MLJP, which is computationally burdensome.
- In the proposed methodology—the same as in the real world—technology-forcing policies play a very crucial role in imposing the learning process and consequently cost reduction of emerging technologies.

Learning Results

- With learning adoption of hybrid vehicles as well as fuel cell vehicles increases significantly.
- In 2050 alternative fuel vehicles become competitive with the conventional vehicles.

Demand Response Implementation

- Electricity sector in CA-TIMES has 48 timeslces (6 representative months and 8 representative hours in each day).
- Load profile of commercial and residential service demands are defined.
- We can implement Load shifting and Peak shaving in CA-TIMES.

Mitigation Cost Curves

- MAC curves can have a variety of reasons (introduction of a CO2 tax price-based) and the introduction of a carbon cap system (quantity-based).
- Transportation sector is the most cost-effective sector for emissions reduction.
- Many of transport end-uses rely in (part) on the same fuels to decarbonize (i.e. biofuels).

Future Work

- In the future work, we increase the spatial and temporal resolution of the CA-TIMES model electricity sector in order to include a representation of the Western US electricity grid into the long-term energy system model of California.
- The spatial modeling addition (inclusion of the entire WECC) will enable the CA-TIMES model to accurately represent electricity imports/exports, reduction in the variability of renewable energy due to geographic aggregation, and track spatial locations of power plants and related emissions.
- We can model benefits of the electric grid with high penetration of renewables to optimally charge electric vehicles. On the top of these transportation sector related results, we also study how the implementation of smart grid and flexible demand in the building sector can benefit the grid and utility companies.
- We investigate how cost reduction in fuel production (hydrogen and electricity) and storage technologies can facilitate the adoption of alternative fuel vehicles and pave the road for low-carbon energy future.