

Evaluations of diffusion and deployment of climate mitigation technologies considering heterogeneity of technology adoption in IAM

Fuminori Sano, Keigo Akimoto, Kenichi Wada

Systems Analysis Group

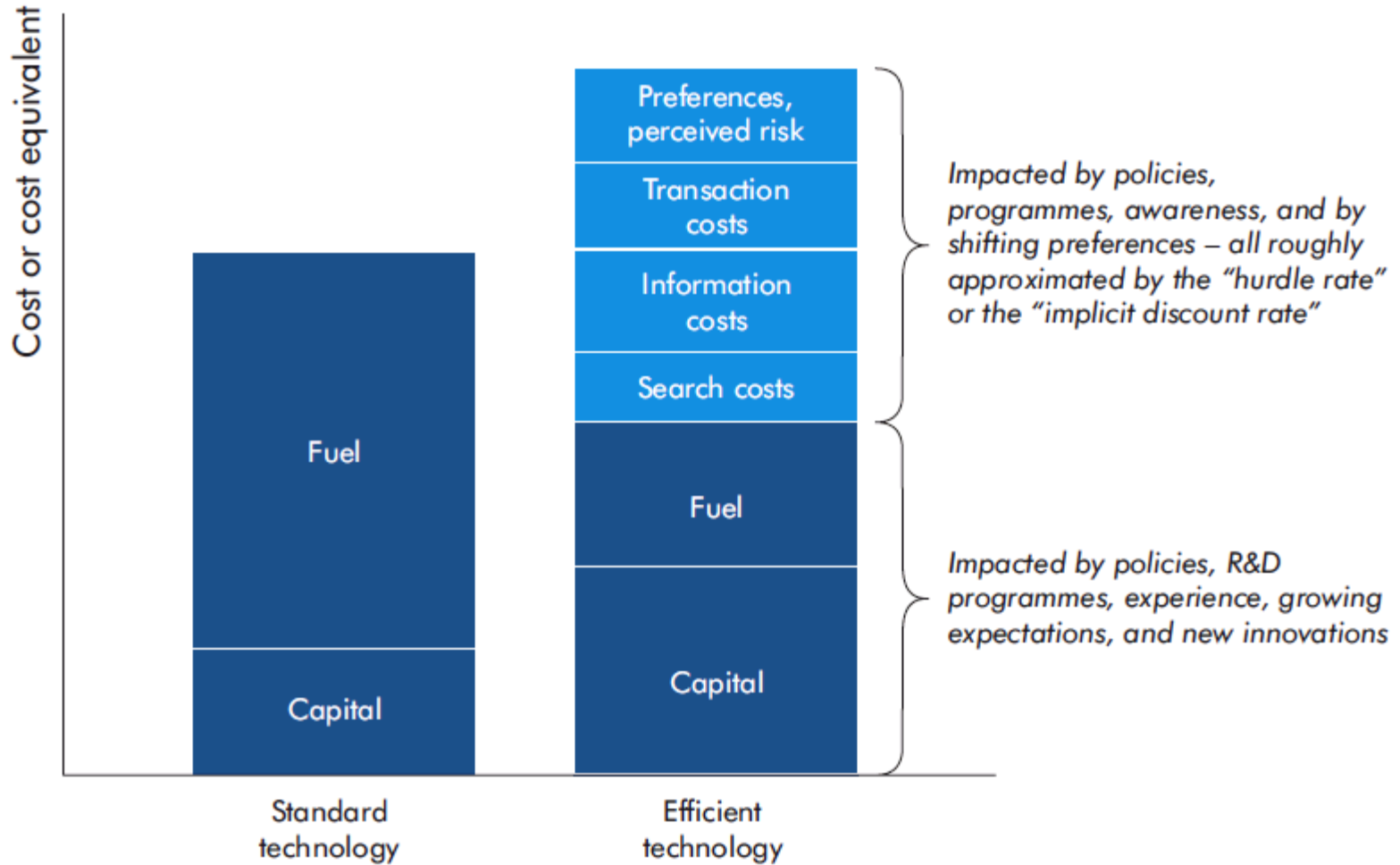
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(RITE)**



Introduction

- ◆ **Decision for technology adoption is affected by various factors; economic perspective (investment risk, access to capital for investment, imperfect information for investment, etc.), behavior perspective (credibility of information, inertia etc.) and organizational perspective (power of energy manager within an organization, corporate culture). (Sorrel, 2000)**
- ◆ **The measured implicit discount rates for investment are much higher than social discount rate and are varied by country, sector and investment body even for the same technology. For better understanding and evaluating real world dynamics of technology diffusion and deployment, it is important to consider such heterogeneous aspects in the decision for technology adoption in IAM.**
- ◆ **In this study, a setup of implicit discount rates across countries, regions, time points and technologies is applied to DNE21+ model, and then heterogeneity of technology adoption is analyzed in order to make more plausible scenarios of technology diffusion and deployment in the real world. Passenger car in road transportation sector is focused in this presentation.**

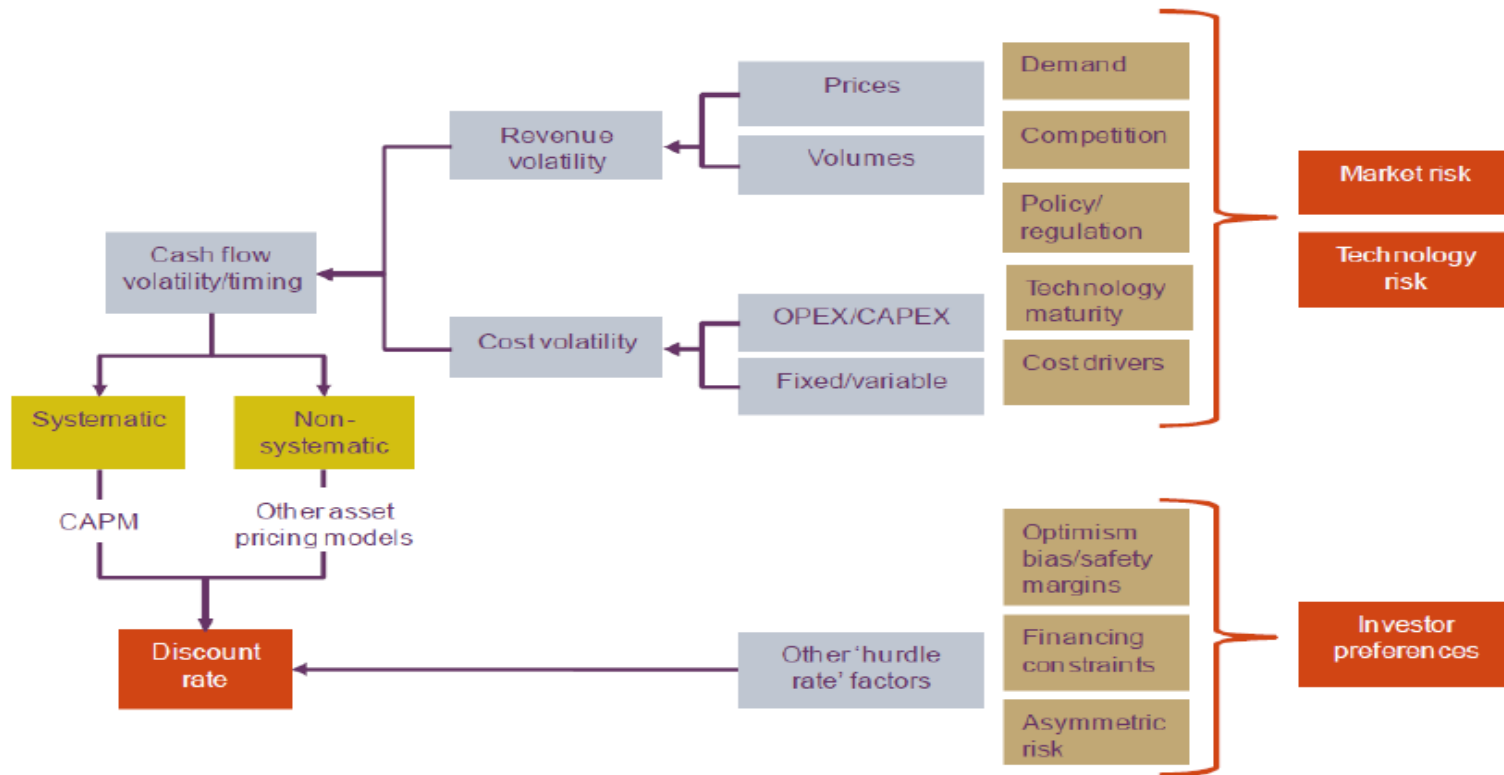
Cost structure relating to decision for technology adoption



Source: Laitner (2009).

Source: ETP 2010

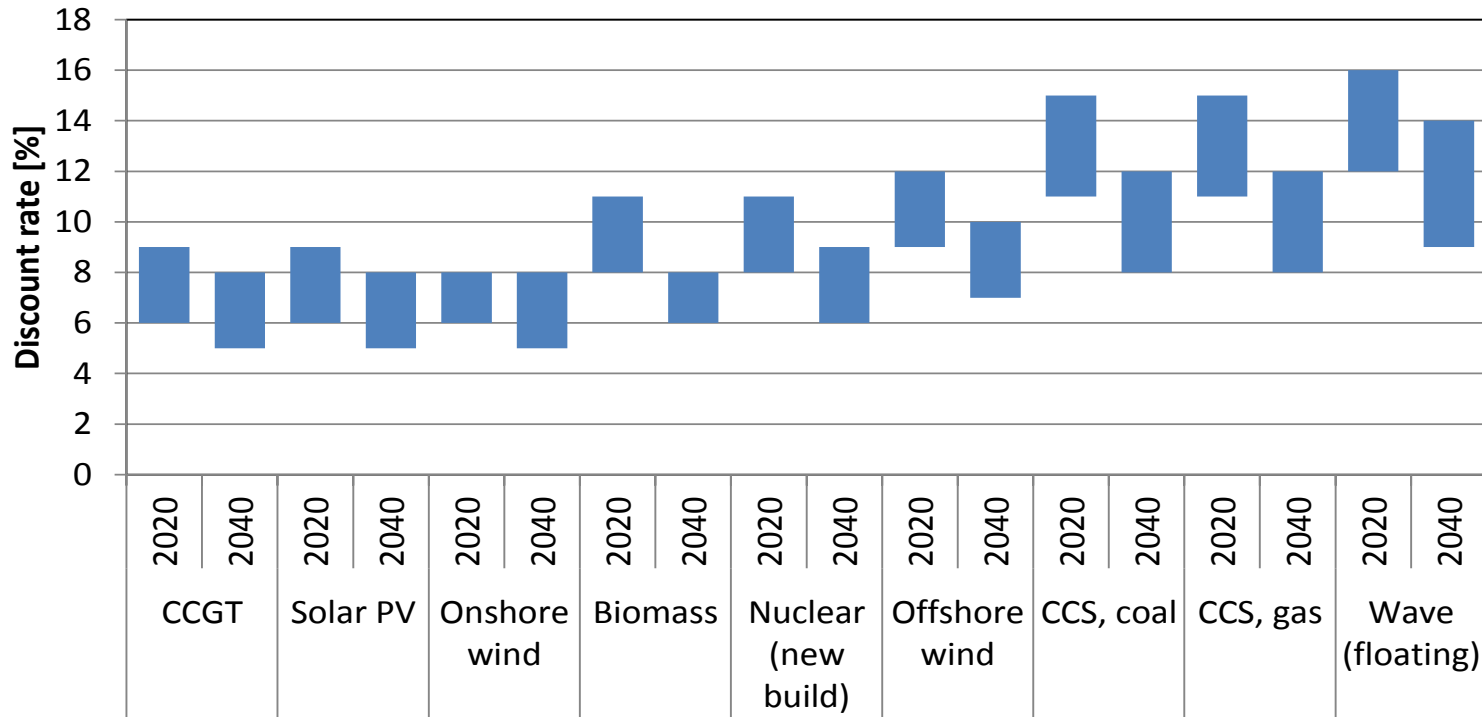
Discount Rate for Investment



Source: Oxera (2011), IIASA report (2013)

- ◆ Factors relating to implicit discount rate can be divided into 3 groups: technology risk, market risk, investor preferences.
- ◆ It is important to disentangle these multiple effects and influences on the cost of capital is important for capturing the actual condition, but very difficult.

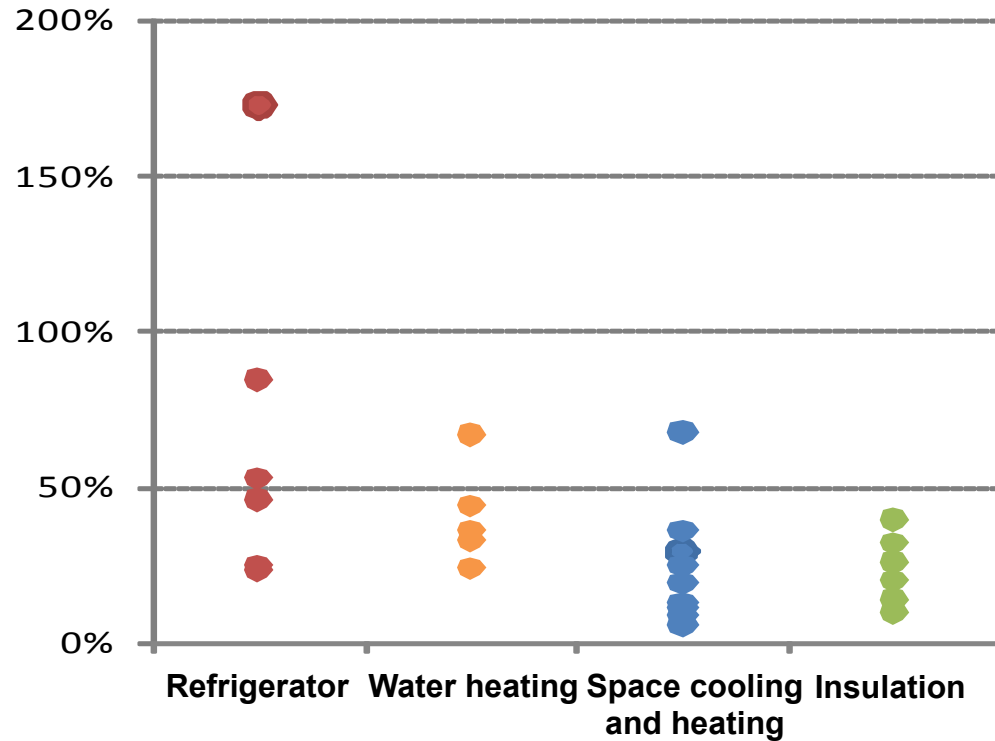
Discount Rate for Investment in Low-carbon and Renewable Generation



Source: Oxera (2011)

- ◆ **Implicit discount rates of matured technologies or small-scale technologies tends to be low. (High reliability, small investment cost, etc.)**
- ◆ **On the other hand, implicit discount rates of future technologies under uncertainty or large-scale technologies tends to be high.**

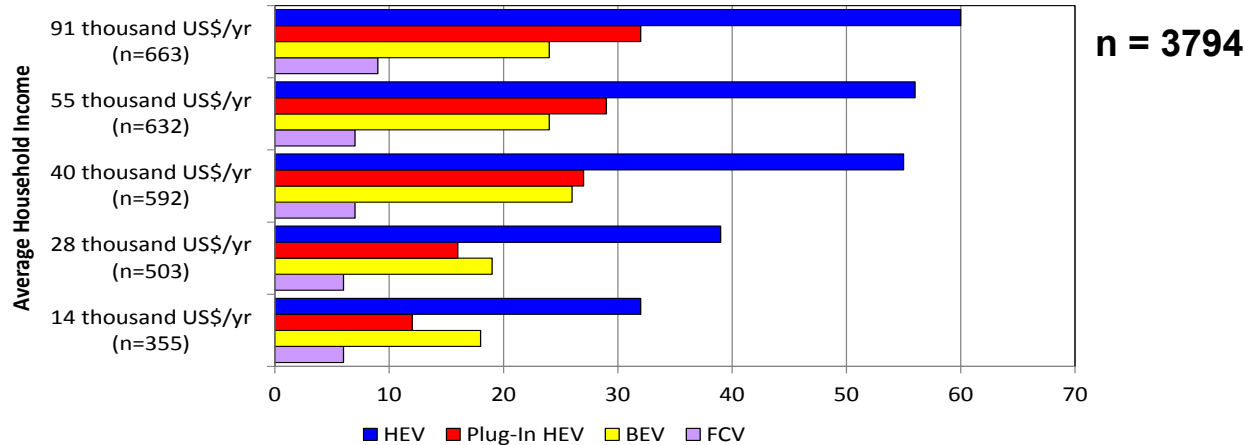
Discount Rate for Investment in residential and commercial sectors



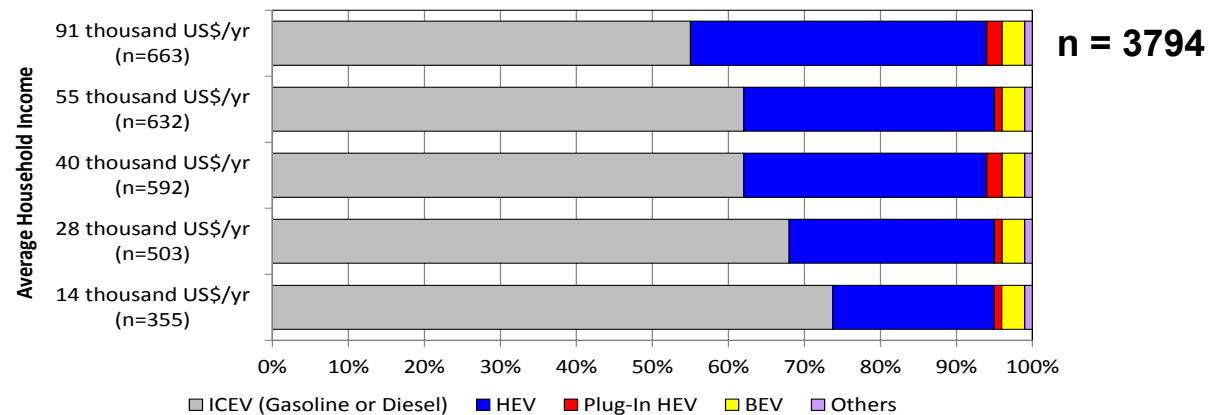
Source: summarized by Kenichi Wada (RITE) based on Soren (2002) and Dubin (1992)

- ◆ **Implicit discount rates in residential and commercial sectors are particularly high.**
- ◆ **Influences of depreciation rates (Cost reduction and efficiency improvement of technologies in residential and commercial sector is fast, so the depreciation rates will be high.), information and transaction costs (e.g., Purchasers may not have enough knowledge of products, and may not spend time searching for efficient products.), and preferences (e.g., usability, looks, etc.) on the implicit discount rate are seems to be large in end-use sectors.**

Do you want to consider technology A as your next vehicle choice?



Which technology will you purchase for your next vehicle?



Source: JAMA (Japan Automobile Manufacturers Association), 2013

◆ Rich purchasers have relatively large interest in new technologies.

Will you purchase BEV under cost condition A?

Cost condition of BEV		Number	Share [%]
No Payback	Loss: Larger than 4100 US\$	168	4
	Loss: Smaller than 4100 US\$	274	7
Payback	Longer than 5 years	960	25
	3 – 4 years	1196	32
	1 – 2 years	580	15
No preference for BEV		595	16
Total		3773	100

Source: Tsuchiya et al., 2014

- ◆ Most purchasers require 3 – 4 years payback time for purchase of BEV.
- ◆ 11% purchasers chose BEV, even if the payback is not expected at all.

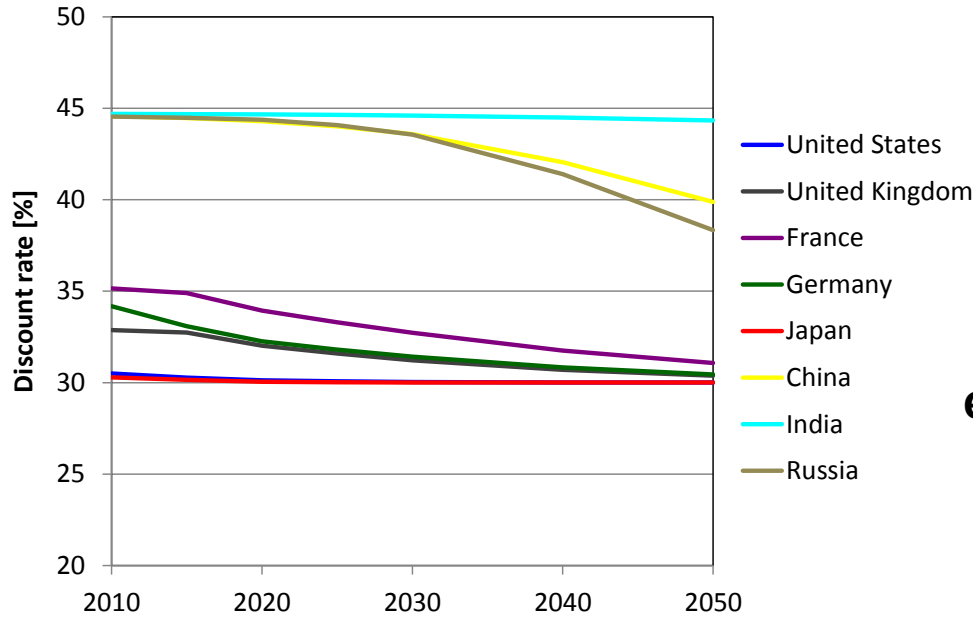
Assumed Implicit Discount Rate by Sector

Sector	Discount rate
Electricity generation	8-20%
Other energy conversion	15-25%
Industry (Energy intensive industry)	15-25%
Transport (Road)	30-45%
Purchasers preferring environment conscious products	10%
Residential and Commercial	30-55%

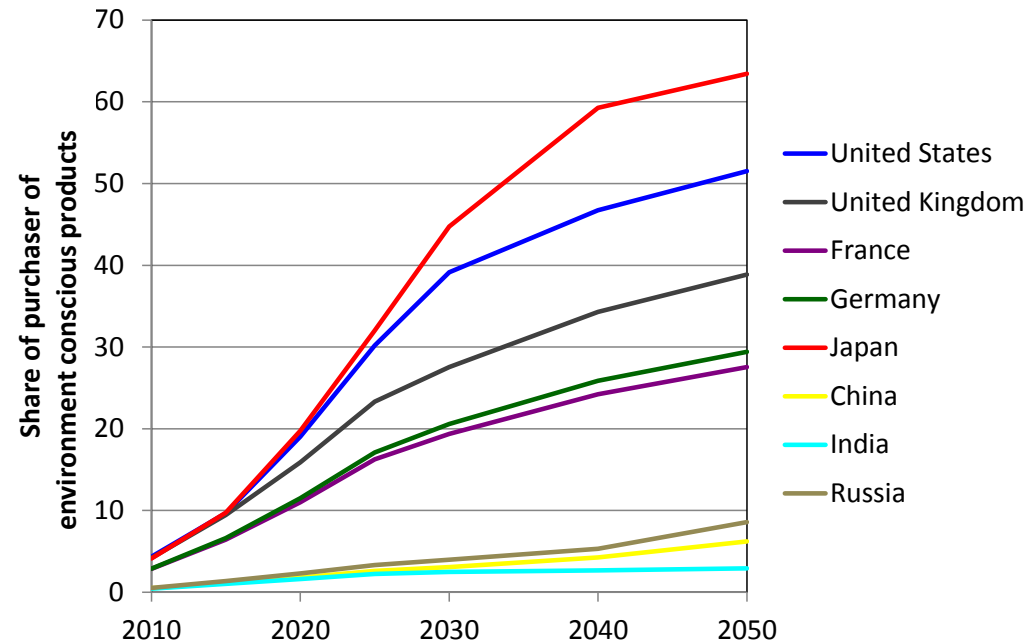
- ◆ **Discount rates for different regions and different time points are assumed to be within the ranges, depending on the region's per-capita GDP.**
- ◆ **Small passenger car (< 2,000cc) users are divided into two groups: purchasers preferring environment conscious products and purchasers preferring regular products. The purchasers preferring environment conscious products adopts 10% discount rate.**

Assumed implicit discount rate and share of environmental conscious purchasers in transport sector

Discount rate in transport sector (road)



Share of purchaser preferring to environmental conscious products in small passenger car sales



Logistic curve approach as per capita GDP is used for the assumption by region and time point.

Overview of DNE21+ model and treatment of implicit discount rate in the model

- ◆ Linear programming model (minimizing sum of discounted total world energy system cost until 2050)
- ◆ Evaluation time period: 2000-2050
- ◆ World divided into 54 regions
- ◆ Bottom-up modeling for technologies both in energy supply and demand sides (200-300 specific technologies are modeled.)
- ◆ Implicit discount rate is considered for calculating energy system cost for bottom-up individual technologies as following equations.

Annual energy system cost =

Annualized capital cost + O&M cost + Fuel cost

Annualized capital cost =

Capital cost × (discount rate / (1 – (1 + discount rate)^{Life time}))

Assumed vehicle cost and efficiency for passenger car

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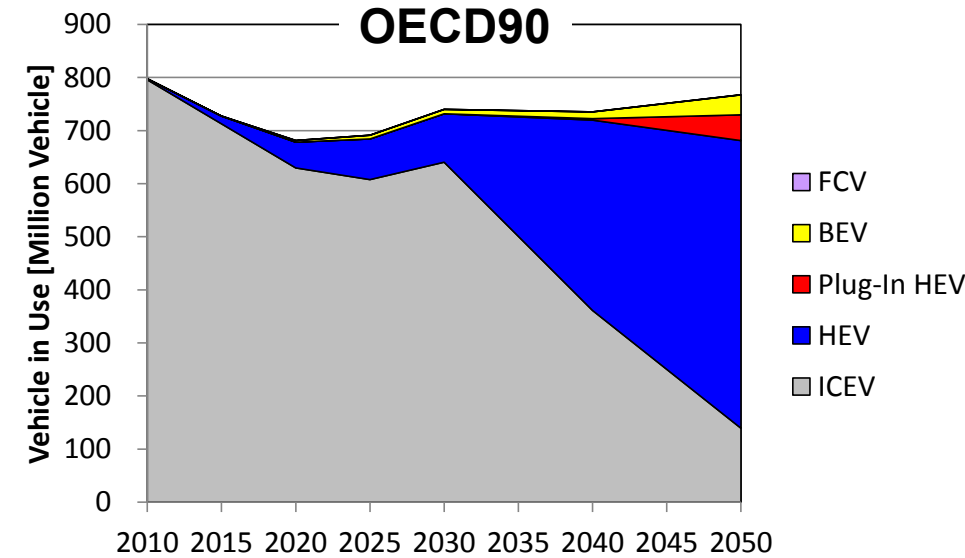
(2020 – 2030 – 2050)

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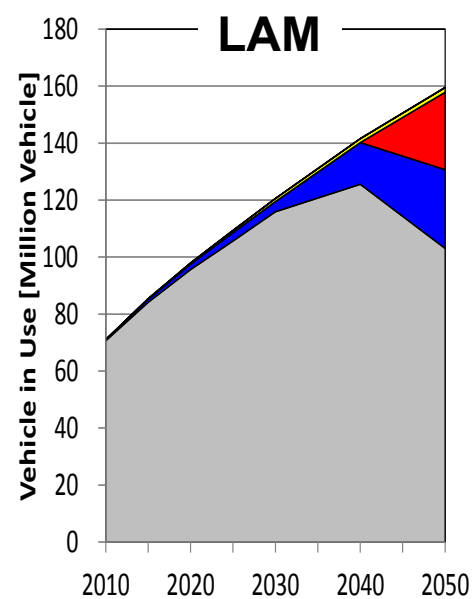
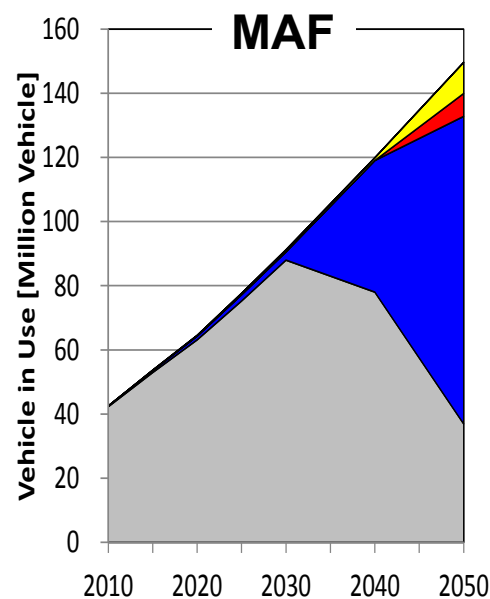
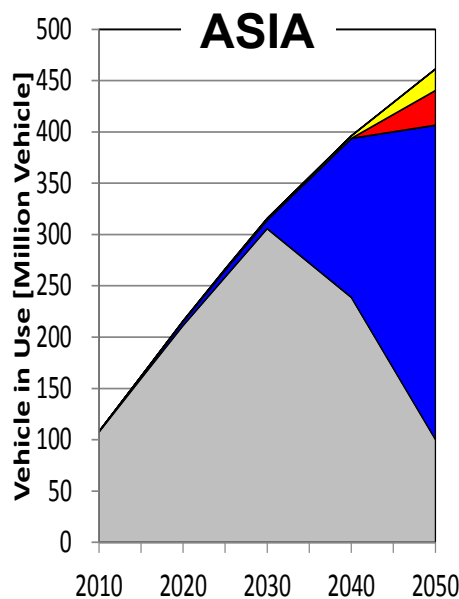
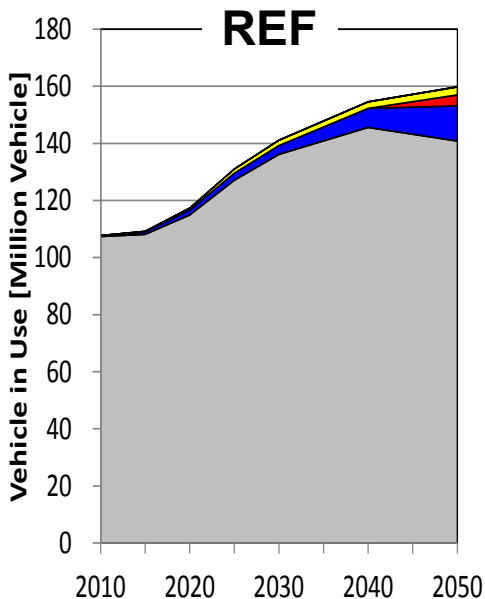
Technology	Vehicle Price [Thousand US\$/vehicle]	Vehicle Efficiency [L-gasoline eq./100km]
Small ICEV (Low Eff.)* ¹	17.0 – 17.0 – 17.0	7.7 – 7.4 – 7.1
Small ICEV (High Eff.)* ¹	20.0 – 20.0 – 20.0	4.2 – 4.0 – 3.9
Small HEV* ¹	22.7 – 22.4 – 20.3	3.0 – 2.6 – 2.4
Small Plug-In HEV* ¹	32.8 – 30.7 – 20.9	1.9 – 1.7 – 1.2
Small BEV	58.4 – 43.9 – 22.0	1.4 – 1.3 – 1.0
Small FCV	86.2 – 60.2 – 23.3	2.2 – 2.0 – 1.6
Large ICEV* ¹	37.0 – 37.0 – 37.0	11.6 – 11.1 – 10.8
Large HEV* ¹	45.5 – 44.9 – 40.6	5.8 – 5.1 – 4.6
Large Plug-In HEV* ¹	65.5 – 61.3 – 41.8	4.4 – 4.0 – 3.2
Large FCV	172.4 – 120.3 – 46.6	4.4 – 3.9 – 3.2

***1 Assumption for Gasoline Engine Vehicle.**

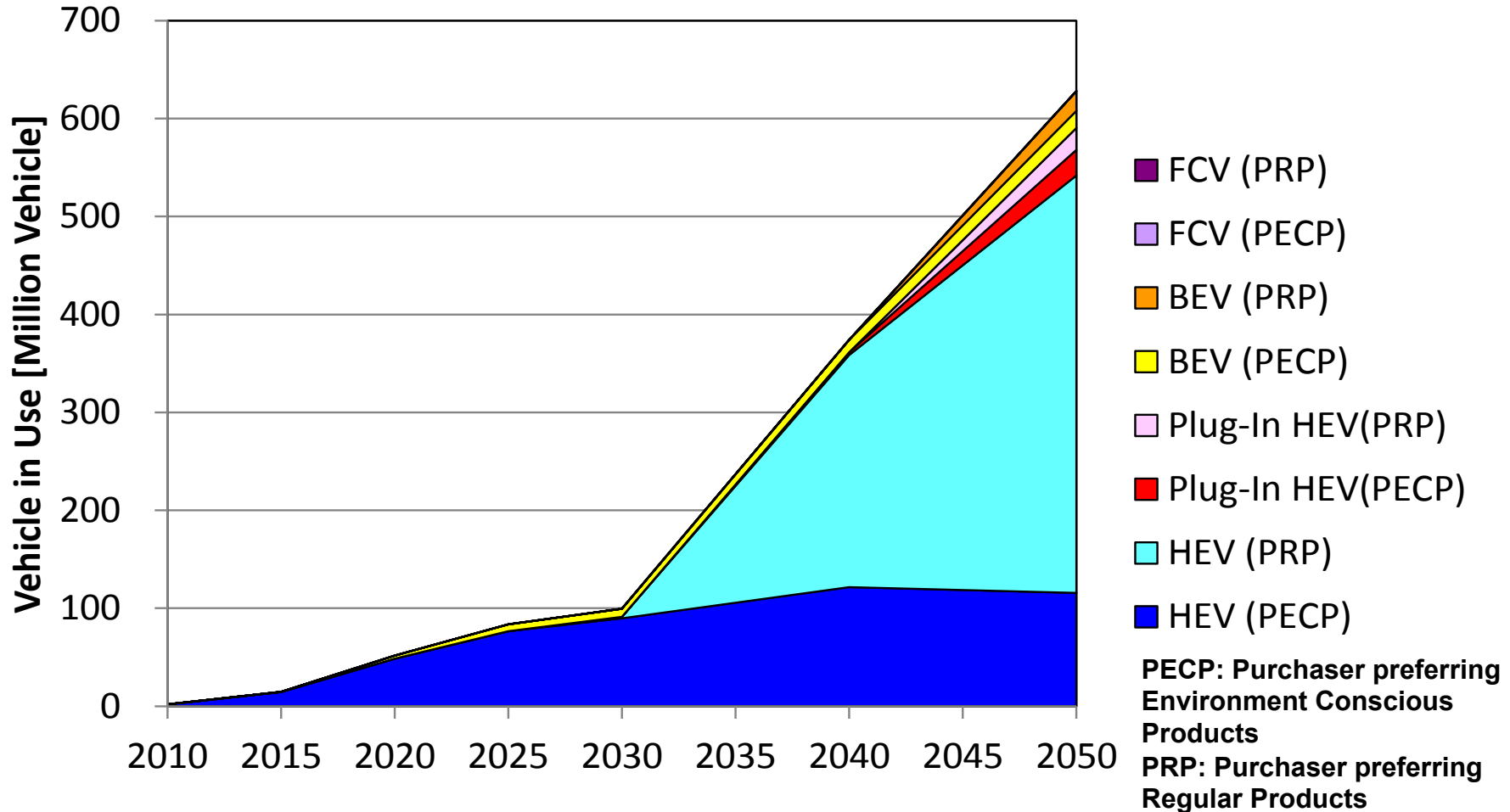
Technology deployments of passenger cars to developing countries (ALPS-3.0W/m² Case)



Diffusion of HEV is started in OECD90. According to cost reductions of HEV and discount rate improvements in other regions, HEV is adopted also in other regions such as ASIA.



Technology deployments of environment compatible passenger cars within OECD90 (ALPS-3.0W/m² Case)



- ◆ Purchasers preferring environment conscious products adopt new technologies such as HEV at early stage of their diffusion.

Conclusions and future plan

- ◆ **Model analysis considering heterogeneity of technology adoption has been carried out by setup of different implicit discount rates across countries, sectors, and time-points and also across purchaser groups.**
- ◆ **(1) Spillover of technologies from developed countries to developing countries and (2) Diffusion process from purchasers preferring environment conscious products (Early adopter) to purchasers preferring regular products (Later majority) can be practically evaluated in IAM.**
- ◆ **Appropriate and logical setup of scenario of implicit discount rates is required for this analysis. In this analysis, differences by technology (e.g., small-scale technology vs. large-scale technology, matured technology vs. future technology, etc.) are not sufficiently considered. Further improvements of this point is important.**
- ◆ **The assumed concept of purchasers preferring environmental conscious products in road transportation sector will be applied to residential and commercial sector.**