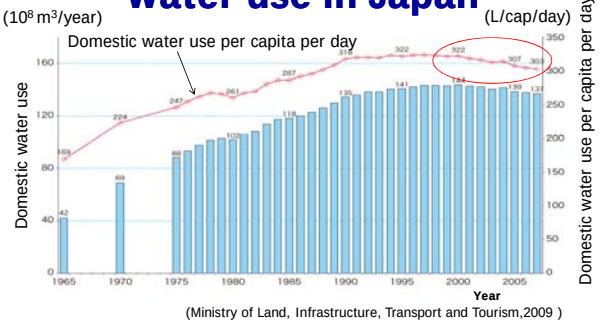
Prediction of the Domestic Water Use in Tokyo Considering the Effect of Water-Related Appliances

Tokyo Metropolitan University

Naoko NAKAGAWA
Akira KAWAMURA
Hideo AMAGUCHI

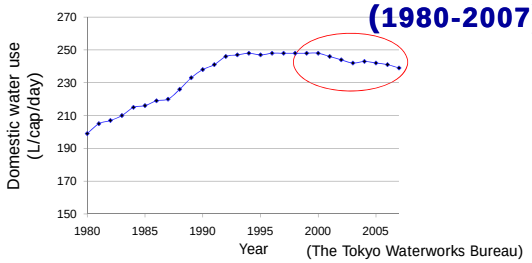
Change of the domestic water use in Japan



(Ministry of Land, Infrastructure, Transport and Tourism,2009)

The amount of the domestic water use decreases in these 6-7 years.

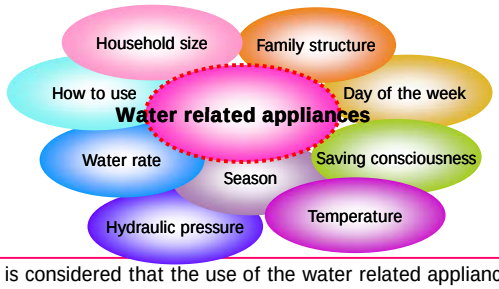
Change of the domestic water use per capita per day in Tokyo (1980-2007)



(The Tokyo Waterworks Bureau)

The amount of the domestic water use in Tokyo is also decreasing in these 6-7 years

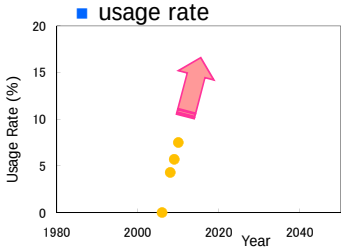
Factors influencing domestic water demand



It is considered that the use of the water related appliances greatly influences the trend to decrease domestic water use per capita per day in recent years.

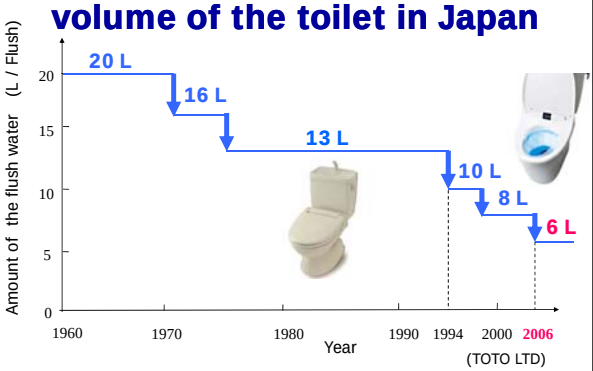
Usage rate of the 6 L-type water saving toilet

- saving rate : 53 %
- usage rate



The usage rate of the 6L-type toilet was increasing rapidly after being introduced into the market.

Change of the lowest flush water volume of the toilet in Japan



(TOTO LTD)

Objective

Dishwasher

Full automatic washing machine

Water-saving-type toilet

Water- saving tap plug

24 hours bath

The aim of this study was to analyze the influence of the water related appliances and make a quantitative prediction of domestic water use under the spread of new water related appliances for household water use in Tokyo.

Model for domestic water use

Amount of domestic water use (L/cap/day)

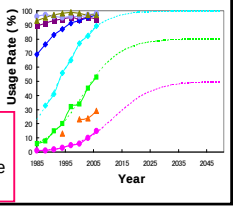
$$= \sum_{i=1}^{n} [\{b_i \times (1-a_i) + (1-b_i)\} \times Q_i]$$

i : purpose of water use (kitchen (cooking and washing), laundry, toilet, bath, face wash and others) .

a_i : saving rate by each water saving appliances.

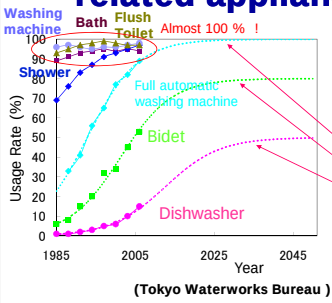
b_i : usage rate of each water saving appliances.

Q_i : maximum demand for water by each water use purpose, before introducing new water related appliances.



The domestic water use was assumed to change due to usage rate and saving rate of new water related appliances and estimated by summing the amount of water consumed for each purpose.

Change of the usage rate of water related appliances in Tokyo



(Tokyo Waterworks Bureau)

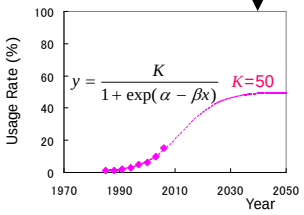
predicted usage rate

$$y = \frac{K}{1 + \exp(\alpha - \beta x)}$$

The future trends of new water related appliances were predicted by a logistic function with the least-square methods

Dishwasher

- a (saving rate)= 80 %
- b (usage rate)

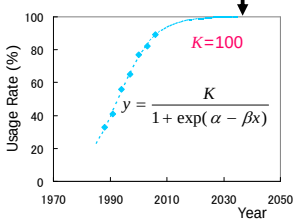


Amount of domestic water use (L/cap/day)

$$= \sum_{i=1}^{n} [\{b_i \times (1-a_i) + (1-b_i)\} \times Q_i]$$

Full automatic washing machines

- a (saving rate)= 14 %
- b (usage rate)



Amount of domestic water use (L/cap/day)

$$= \sum_{i=1}^{n} [\{b_i \times (1-a_i) + (1-b_i)\} \times Q_i]$$

24 hours bath

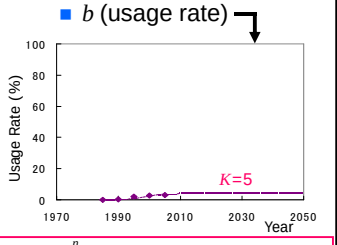
Heat insulation

Circulation

Disinfection

Purification

- a (saving rate)= 50 %
- b (usage rate)

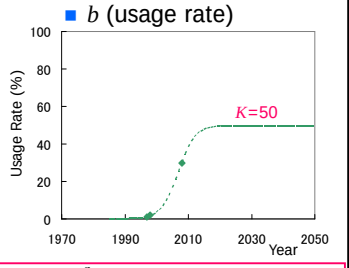


Amount of domestic water use (L/cap/day)

$$= \sum_{i=1}^{n} [\{b_i \times (1-a_i) + (1-b_i)\} \times Q_i]$$

Water- saving tap plug

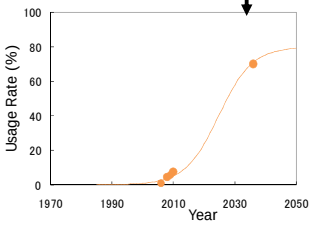
- a (saving rate)= 50 %
- b (usage rate)



Amount of domestic water use (L/cap/day) $= \sum_{i=1}^{n} [\{b_i \times (1-a_i) + (1-b_i)\} \times Q_i]$

6 L-type water saving toilet

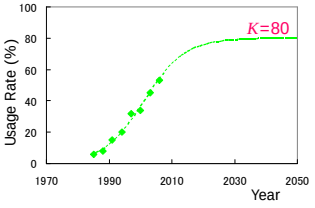
- a (saving rate)= 53 %
- b (usage rate)



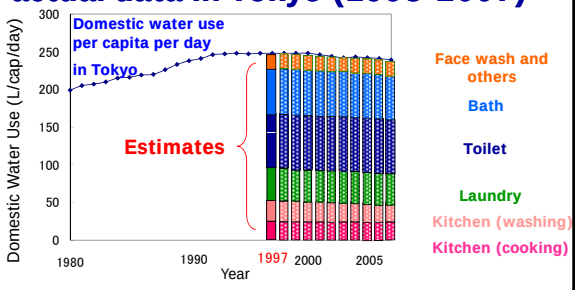
Amount of domestic water use (L/cap/day) $= \sum_{i=1}^{n} [\{b_i \times (1-a_i) + (1-b_i)\} \times Q_i]$

Bidet (for washing with a fountain of warm water)

- assumed 1 L increase
- b (usage rate)

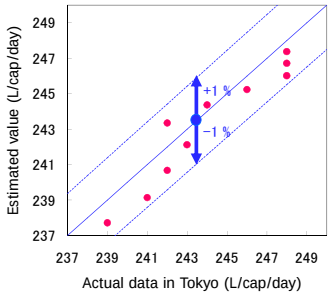


Comparison of the estimates and the actual data in Tokyo (1998-2007)



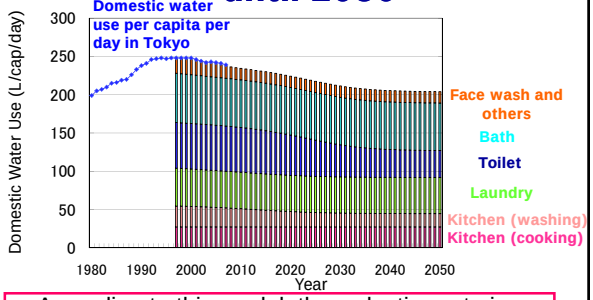
Domestic water use (L/cap/day) $= \sum_{i=1}^{n} [\{b_i \times (1-a_i) + (1-b_i)\} \times Q_i]$

Accuracy of estimated value



Estimated values are within ±1 % difference

Estimated domestic water use until 2050



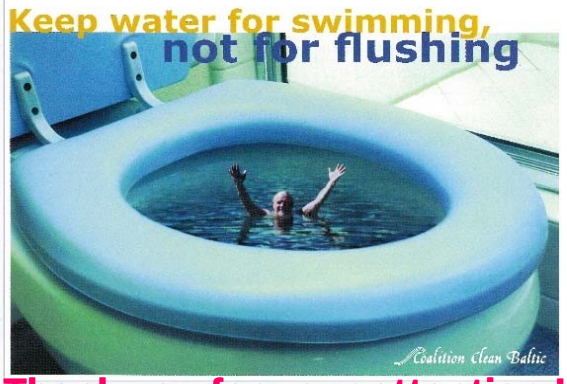
According to this model, the reduction rate is assumed to be 12 % until 2025 and 18 % until 2050 with 1997 set as the base year.

Conclusions

- In this study, the decreasing trend of the amount of domestic water use per capita in recent years was analyzed and expressed by modeling the introduction of advanced water-saving appliances.
- As a result, the reduced rates were assumed to be 12 % until 2025 and 18 % until 2050 with 1997 set as the base year according to the present trend of the usage rate of water related appliances.

Acknowledgements

- This research presents the results of the research project “Solutions for the water-related problems in Asian metropolitan areas” supported by the Tokyo Metropolitan Government.
- The authors are grateful to the members of the Tokyo Waterworks Bureau and TOTO LTD for providing valuable data.



Thank you for your attention !