Chen, Wei-Yin (chemical engineering prof, initiated SEE-Sustainable Energy and Environment Group), Suzuki, Toshio (Japan National Institute of Advanced Industrial Science and Technology); Lackner, Maximilian (Institute of Advanced Engineering Technologies) Handbook of Climate Change and Mitigation, 2nd ed. 2017

Broad support for policy action often is not linked to support for specific policies,

such as raising gas prices, which could curb behaviors related to global emissions.

However, climate change messages are effective when they are tailored to the needs

and predispositions of particular audiences to either directly challenge fundamental

misconceptions or to resonate with strongly held values.Most people prefer mitigation

of emissions over adaptation measures such as providing economic assistance and also

prefer to help people in one’s own country before people in other countries.96

Research on intertemporal discounting suggests that individuals tend to believe

future costs are much steeper than upfront costs97 and thus might see the future costs

of adaptation as lower than the current costs of mitigation. However, negative image

associations can increase risk perceptions of global warming.98 Thus, news coverage

of adaptation options could help audiences visualize the impacts of climate change

by considering adjustments needed to adapt to a warmer climate. For example,

Evans and colleagues99 found that individuals who answered questions about sea

level rise and climate change adaptation measures in their local community reported

a greater willingness to perform emission-reducing behaviors, compared to those

who had not received the questions.

Conversely, the risk compensation hypothesis suggests that remedies to reduce

the impacts of risky behaviors can unintentionally reinforce and increase those risky

behaviors. For example, drivers who feel more secure when wearing seatbelts may

compensate by driving more recklessly, leading to more traffic accidents. This

phenomenon is known as an “offsetting effect” or “compensatory behavior.”100

Adaptation news coverage could contribute to this lulling effect, if audiences see

adaptation as a remedy to a problem that can be paid for in the distant future and that

costly preventative mitigation actions are no longer needed.101 The other extreme

can occur when news coverage promotes fatalism. When the media frames climate

change impacts as a pending apocalypse or irreversible tipping point, in an effort to

convey urgency and mobilize communities to act, this reporting may have the

opposite effect by demoralizing its audiences .102

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Polls show that public understanding of climate change is low and public action

lower still. Maintaining public interest in global climate change through news

coverage is necessary for the survival of the issue. Not only is the climate change

issue widely perceived as diffuse and nonpersonal, it also has been framed in terms

of false inferences. Most Americans do not understand the difference between

weather and climate, and some news coverage, commentary, and media-sponsored

polls have led people to believe they can draw inferences about climate change just

by looking out their windows. Climate science has important things to say about the

prevalence, distribution, and dangers of rainfall and flooding. However, the connection

between reporting about high-profile flooding events and scientific understanding

of climate change is often tenuous. Responsible climate coverage elucidates

scientific details to promote intelligent debate and explains that climate change is a

long-term threat with impacts that may not be seen immediately or discernibly.134

Public engagement with climate change issues may be required to spark climate

change mitigation on any level. The public engagement model proposed by Collins

and Evans consists of three waves of public engagement with a science issue over

time: knowledge deficits, democratization of science and practice, and authorized

expertise. In the first wave, poor choices and actions are attributed to a dearth of

knowledge, reliance on “sound” science, and the need to eliminate uncertainty

before taking action. In the second wave, democratic public engagement mitigates

common “bads” and “goods” in a risk society. In the third wave, some groups and

institutions are authorized to speak about climate change while others are not.135

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Until recently, U.S. policymakers and scholars avoided discussing adaptation, out of

concern that public awareness of adaptation could reduce policy support for mitigation.

150 Victor and colleagues151 noted that “until just a few years ago, even

discussing adaptation to climate change was taboo” (p. 119). The consequences of

framing climate change as mitigation or adaptation could have important effects on

public support for policy adoption and implementation.152

Learning about adaptation may “spill over” into attitudes toward mitigation.

Negative spillover effects occur when adoption of one proenvironmental behavior

reduces the likelihood of adopting another proenvironmental action.153 This often

happens when individuals feel morally “off the hook”154 or believe the problem

already has been dealt with.155Weber’s work on single action bias found that farmers

who adapted their cultivation practices, such as crop selection, or adopted off-farm

adaptations such as investing in futures were less supportive of government intervention

to mitigate climate change.156

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The benefits of public engagement initiatives about risk-related policy issues are

difficult to establish without a rigorous evaluation of engagement processes. These

initiatives often are not evaluated at all, even though they are advocated as an

antidote to deficits in lay knowledge and other policymaking problems. Participatory

action research can be used to evaluate climate change campaigns. A grassroots

organization can be transformed through personal and collective political power,

through a process of double-loop learning. From inception to widespread grassroots

endorsement and political awareness of a proposed bill, activist groups can contribute

to legislative outcomes on climate change. Public concern about the impacts of

climate change and the federal government’s weak response was more pronounced

because of increased media coverage.141

When citizens draw the line in a science controversy, they often discuss regulation

and which conditions should be the subject of research. Ambiguities and

tensions in lay accounts can enable, rather than stifle, greater democratization of

science policy. Beyond the deficit model of science ignorance, lay people may hold

technical, methodological, institutional, and cultural knowledge. When citizens do

mobilize a stock of knowledge, it is influenced by their own social context and

perceptions of relevancy. Identifying lay people as expert in, rather than ignorant of,

the way science may shape their lives is a fundamental first step in moving toward

greater citizen participation in policy discussions.When attributing responsibility for

collective action, the media often avoid discussing scientific uncertainty, in the belief

that it might undermine the demand for collective action. Reporters are typically

responsive to the political setting in which they operate and tend to link local,

national, and transnational risks. Many British governmental publications have

advocated greater public dialogue and engagement in science issues. Moving

beyond mere sloganizing about science and democracy requires strategic message

development. Opinion-leader campaigns can catalyze wider political engagement on

climate change and sustainable consumer choices and behaviors. Combining the

recruitment of digital opinion leaders with traditional media strategies leads to

significant trade-offs, in comparison with face-to-face initiatives. However, only in

specific conditions are digital opinion leaders effective in strengthening online

interactions and real-world connections.142

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A relatively poor performance will probably also apply to the life cycle greenhouse

gas emissions linked to methane for injection into the gas grid originating in

the anaerobic conversion of energy crops in temperate climates if compared (fossil)

with natural gas. The reason for this is that, without taking into consideration the

indirect effect of expanding the cultivation of energy crops on land use, the life

cycle emission of (cleaned-up) biogas is only slightly lower than the corresponding

emission of natural gas (Jury et al. 2010). Fossil fuel inputs to achieve an elevated

optimum temperature are an important contributor to the relatively poor performance

of anaerobic conversion in temperate climates (Jury et al. 2010). In warmer

climates, anaerobic conversion may well do better. Microbial fuel cells producing

electricity have been reported to have a lifetime environmental performance and a

life cycle CO2 emission, similar to anaerobic conversion (Foley et al. 2010).

The actual greenhouse gas emissions linked to the life cycle of future biofuels, such

as ethanol, produced from lignocellulosic crops and algal biodiesel are highly uncertain.

Relatively poor yields and/or high fossil fuel inputs, which are characteristic for

current lignocellulosic ethanol and algal biodiesel production technology, are associated

with relatively high life cycle greenhouse gas emissions (Reijnders and

Huijbregts 2009; Havlik et al. 2011; Reijnders 2010). Predictions of relatively low

life cycle greenhouse gas emissions in the future are typically linked to large increases

in biofuel yield and reductions in fossil fuel input (e.g., Jorquera et al. 2010; Spatari

et al. 2010), to the use of abandoned soils for lignocellulosic crops (Havlik et al. 2011;

Reijnders 2010), or, in the case of algae, the use of “wastes” conducive to growth

(Clarens et al. 2010; Reijnders 2013). In the latter case, it is assumed that there is no

allocation to the wastes of greenhouse gas emissions associated with the process from

which they are derived. Ultimately, life cycle greenhouse gas emissions associated

with liquid biofuels produced from part of the lignocellulosic harvest residues from

no-till agriculture may be more favorable than the use of mineral oil-derived products

(Reijnders and Huijbregts 2009; Spatari et al. 2010).

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Adaption to climate change can either be planned or automatic. Plants and animals

have no plan to control over environment. For them, adaptation in response to

environmental changes is necessary for their survival else they will disappear. For

humans, in spite of being aware of the effects of climate change, it is necessary to

take measures which may not stop but at least reduce the impact of environmental

changes through specific policy framework (F€ussel and Klein 2006). Adaption can,

therefore, be taken as an option after mitigation. It implies reduction of impacts

rather than vulnerability for development (Fig. 7).

Indeed, climate change is a reality, and there is a general agreement that “we

must stop and reverse this process now or face a devastating cascade of natural

disasters that will change life on earth, as we know it.”

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Despite all efforts to stabilize and perhaps even reduce, in the long run, atmospheric

greenhouse gas concentrations, humans have already committed themselves

to decades of temperature changes and centuries of sea level rise. And, to worsen the

outlook, rising global temperatures and sea levels will be accompanied by many

other changes in our biophysical and socioeconomic environment. Since the heat

budget of the globe will be disturbed, the frequency and severity of extreme weather

events will likely increase. Disruptions in biophysical conditions will trigger, and be

triggered by, changes in ecosystems – including changes in the productivity of

managed forests and croplands, as well as changes in the distribution of pests and

diseases. The associated tightening of resource constraints will undermine the livelihoods

of people, displace populations, and inflict pain and death.

There are unlikely to be long-term winners from climate change. None of the

places already suffering from shortages in water and food, for example, or flooding

and crumbling infrastructures will, in the long run, be better off because of climate

change. Even if they do feel like “winners” temporarily – perhaps because the length

of growing seasons increases with rising temperatures or a melting of sea ice

improves shipping and boosts their economy – those benefits are fleeting. Climate

will not stop changing once optimal conditions are reached, and benefits in one

sector may already be overwhelmed by costs imposed on other parts of the economy

and society. Clearly, some form of adaptation will need to take place.

Ideally, adaptation strategies are implemented not just as climate change unfolds,

but in anticipation of any further climate change so that people, economic sectors,

cities and their infrastructures, as well as natural systems such as wetlands and

forests, are better prepared for, and perhaps even protected from, further disruptions.

But even if there were no further climate change, there already is considerable

variability in the weather conditions with which people, economic sectors, cities,

and natural systems must cope. Maintaining vital wetlands well before flooding

events will help provide natural buffers for coastal communities. Creating redundancies

in lifeline infrastructures, such as the different ways of powering businesses

and homes from centralized power plants and small-scale generators, will allow for

switching across electricity sources during extreme weather events, for example.

And promoting more efficient energy use in the first place will reduce the reliance on

some of that energy. To the extent that adaptation helps reduce already existing

inefficiencies, it can make good social, economic, and environmental sense

irrespective of the details with which future climate conditions manifest themselves.

The conclusion one may draw that “less mitigation today can be balanced by

more adaptation in the future,” however, is misleading. It suggests that the two

strategies are, at some abstract level, substitutable. In reality, though, less mitigation

today means not just a need for more adaptation in the future. Rather, less mitigation

today means more adaptation over more of our future, because even reduced

emissions continue to add to atmospheric greenhouse gas concentrations, and

because the damages that result will be cumulative in nature – heat waves, droughts,

and flooding events, for example, will continuously undermine our wealth and

welfare and require ever larger diversion of resources to address the causes and

effects of climate change. Understanding the role of mitigation and choosing the

proper mitigation strategies is, therefore, an essential forebear to anything else we

may be doing about climate change. Recognizing the urgency for preparedness,

given the extent to which humanity has already committed itself to a changing

climate, is central to motivating investment in new technologies, changes in behaviors,

and deployment of infrastructures that can better withstand the vagaries of the

climate.

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Article: Fusion Energy Hiroshi Yamada, Department of Helical Plasma Research, National Institute for

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Fusion research was started as classified military research about 60 years ago. Then,

global scientific research activity toward a peaceful use of fusion energy was

launched by declassification at the second United Nations Conference on the Peaceful

Uses of Atomic Energy in Geneva in 1958. Tabletop-sized experiments demonstrated

proof of principle of physical ideas, and medium-sized experiments with the major diameter of up to 3 m extended plasma parameters to the order of ten million

\_C. Then three large-scale tokamaks, TFTR (Hawryluk et al. 1998), JET (http://

www.jet.efda.org/; Pamera and Solano 2001), and JT-60U (Ohyama et al. 2009),

with the diameter of about 6 m and the plasma volume of several tens to more than

100 m3 were constructed in the 1980s to demonstrate scientific feasibility of fusion.

As an alternative line, a helical system is catching up with tokamak by large

facilities, LHD (http://www.lhd.nifs.ac.jp/en/; Yamada et al. 2009; Komori

et al. 2010) and Wendelstein 7-X (http://www.ipp.mpg.de/ippcms/eng/pr/

forschung/w7x/; Bosch et al. 2010). In parallel with convergence to the first demonstration

of burning plasma on ITER, a variety of experimental project are being

conducted to resolve unresolved issues and create innovation by worldwide efforts

as shown in Fig. 18.

Although the fusion power plant has not been realized like a fission power plant,

the progress in these 50 years is remarkable (Meade 2010). For example, the most

typical index to describe performance of fusion plasma, the fusion triple product of

temperature, density, and energy confinement time, has been improved in the same

speed as the density of an integrated circuit, which refers to the famous Moore’s law

(doubled in 18–24 months) (see Fig. 19) (Webster 2003). Figure 20 is the so-called

Lawson diagram, which shows the performance of fusion plasmas on the plane of the

product of central ion density and energy confinement time, and temperature. Recent

experiments on JET (Team 1992) and JT-60U (Ishida et al. 1999) achieved the

breakeven condition Q = 1 in the 1990s. It should be noted that the breakeven

conditions have been equivalently satisfied by using only deuterium. Also more than

10 MWof real fusion power generation has been demonstrated using deuterium and

tritium on TFTR (Bell et al. 1995) and JET (Gibson 1998) even for a short time

period as long as a few seconds (see Fig. 21). These two major achievements,

breakeven and DT burning, have motivated the next generation of a tokamak

experimental reactor.

Based on accumulated achievements by worldwide tokamaks (Ikeda et al. 2007),

fusion power development is stepping up the stage. Seven leading parties of fusion

research, China, EU, India, Japan, Korea, Russia, and the USA, have jointly started

construction of the International Thermonuclear Experimental Reactor (ITER)

(http://www.iter.org/) in Cadarache, France. For this distinguished international

project, the ITER Organization was formally established on October 24, 2007,

after ratification of the ITER Agreement in each member party. ITER will be built

largely (90 %) through in-kind contribution by the domestic agencies of

seven parties. ITER is the largest tokamak ever built. Its plasma volume is close to

1,000 m3 (see Fig. 22), and the total weight reaches 23,000 t. The goal of ITER is the

demonstration of control of burning plasma and engineering feasibility of a fusion

reactor. ITER plans to demonstrate 500 MW of fusion power production by DT

fusion reaction at the temperature of 150 million \_C for 500 s in the 2020s. This

amount of fusion power is expected to be ten times larger than the external heating

power put into the plasma, which means Q = 10. Figure 23 is the schedule of ITER

(Ikeda 2010). The latest argument suggests an updated schedule that is a bit behind.

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Article: Fusion Energy Hiroshi Yamada, Department of Helical Plasma Research, National Institute for

Fusion Science, Toki, Gifu, Japan

Fusion is an energy source of the sun, and controlled fusion as an energy source for

human beings has been developed intensively worldwide for this half a century. A

fusion power plant is free from concern of exhaustion of fuels and production of CO2

and has an advantage to a nuclear fission power plant in terms of high-level

radioactive waste. Therefore it has a very attractive potential to resolve global

warming and to be an eternal fundamental energy source. On the other hand,

unresolved issues still remain. It will take another several decades to realize a fusion

power plant by integration of advanced science and engineering such as control of

high-temperature plasma exceeding 100 million \_C and breeding technology of

tritium by generated neutrons. The research and development has just entered the

phase to start the project to extract 500MWof thermal energy from fusion reaction in

the 2020s. The demonstration of electric power generation is targeted in the 2040s.

Even the first-generation fusion demonstration reactor will produce electricity of one

million kW

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Article: 3rd-Generation Biofuels: Bacteria and Algae as Sustainable Producers and Converters

Maximilian Lackner (Institute of Advanced Engineering Technologies)

Biofuels are one option for renewable energy; they cannot be the only one, as Fig. 20

below suggests.

Wind energy needs less space than biomass, and renewable electricity has proven

to be very efficient. Hartmut Michel writes in (http://onlinelibrary.wiley.com/doi/10.

1002/anie.201200218/pdf. Accessed 4 May 2015): “Commercially available photovoltaic

cells already possess a conversion efficiency for sunlight of more than

15 %, the electric energy produced can be stored in electric batteries without major

losses. This is about 150 times better than the storage of the energy from sunlight in

biofuels. In addition, 80 % of the energy stored in the battery is used for the

propulsion of a car by an electric engine, whereas a combustion engine uses only

around 20 % of the energy of the gasoline for driving the wheels. Both facts together

lead to the conclusion that the combination photovoltaic cells/electric battery/

electric engine uses the available land 600 times better than the combination

biomass/biofuels/combustion engine.”

The author argues that the most sensible utilization of biomass is for the generation

of base chemicals for syntheses purposes. He sees the future for car propulsionin electricity. However, by replacing conventional fossil fuels with advanced

biofuels in the short and medium terms, environmental benefits can be achieved.

Biofuels have their advantage in high energy densities and compatibility with

existing (liquid) fuel handling systems. Hence, they are a viable option for the

transportation sector, being an important “ingredient” in the mix of renewable

technologies.

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For instance, for crop production, land is needed, and land use change (LUC) can

negatively affect the climate (Panichelli and Gnansounou 2015), as the N2O emissions

from fertilizer production and use (Crutzen et al. 2008). Air pollution from

biofuel combustion, e.g., SOx, NOx, and dust, has to be taken into account as well

(Lackner et al. 2013). Note: Apart from combustion, certain biofuels, after purification,

can be used in fuel cells. Another aspect is water consumption (see the concept

of virtual water). A valuable tool is life cycle assessment (LCA) or life cycle impact

assessment (LCIA). Figure 7 below compares several biofuels in terms of GWP

(greenhouse warming potential), smog formation, and eutrophication (i.e., excessive

fertilizer usage).

It has to be noted that the different biofuels have not yet reached their maximum

sustainability potential, as sometimes the technologies are not mature yet or economies

of scale are missing. Nonetheless, a good indication can be derived, showing,

e.g., that methane from manure has a high GWP reduction potential.