Development and assessment tools for LCS policy systems

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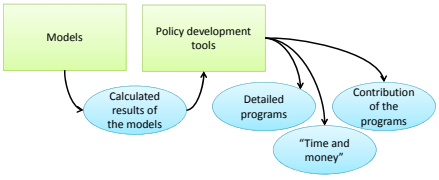
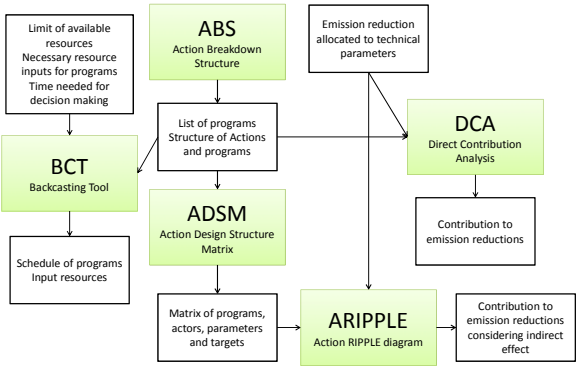
Objective

Despite a cumulative effort of modeling engineers and policy makers, still there is a gap between modeling and policy making for low-carbon society (LCS).

The objective of this study is to propose a series of tools to fill the gap, namely "LCS Policy Development Tools" (LCS-PDT).



Overview of LCS-PDT



Action Breakdown Structure (ABS)
- Hierarchical structure of LCS policies
- To organize a large number of programs

Direct contribution analysis (DCA)
- Primary method to estimate contribution of policies to emission reduction

Action Design Structure Matrix (ADSM)
- To show mutual relationship of emission reductions, technical parameters, programs and its measurements, and actors.

Action ripple diagram (ARIPPLE)
- To calculate contribution of "entities" to the target

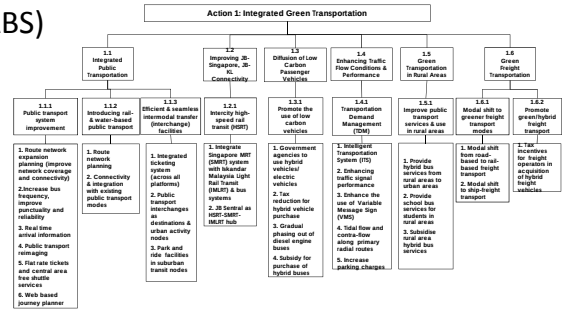
Backcasting Tool (BCT)
- To project a roadmap of programs under constraints of time and input resources

Action Breakdown Structure (ABS)

An application of "work breakdown structure" used in project management

Hierarchical structure of LCS policies
- Action: The largest group of policies. 5 to 12.
- Sub-action
- Measure
- Program: Implementable activity

"MECE": Mutually exclusive and correctly exhaustive
- Duplication must be avoided
- It must cover all of the activities which should be implemented to achieve LCS goal



Direct mitigation Contribution Analysis (DCA)

Calculate contribution of policies based on parameter – policy correspondence

Decomposition analysis in ExSS
- Allocate the emission reduction to the related parameters
- EE improvement, Fuel shift, Energy service reductions in each sector and in each services

Action design structure matrix (ADSM)

A matrix which shows relations and interactions among programs in ABS and crucial parameters/variables/ output measure which influence the quantified targets of LCSRs, with compact, easily scalable, and intuitively readable representation.

Domains
- Actor/Stakeholder (AS)
- Program (PG)
- Performance measure (PM)
- Quantitative target (QT)

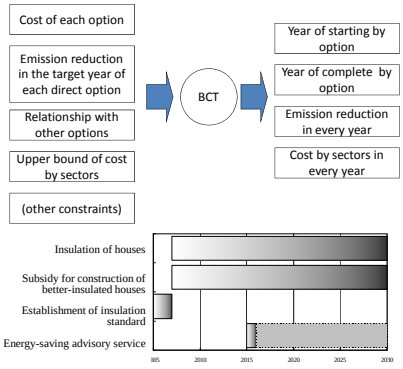
"Entities": elements of the domains

- Column elements act to row elements, i.e. column elements cause effects to row elements
- Elements of matrix denote relation between column elements and row elements

et \ et1	AS1	AS2	PG1	PG2	PM1	PM2
AS1	1					
AS2		1				
PG1	0.5			0.5		
PG2		1				
PM1			1			
PM2				1		
QT					1	

Backcasting tool (BCT)

- Describes implementation of all related activities ("options")
- All options are fully implemented by the target year
- Considers direct cost of the sectors (government, industries, households, etc)
- Formulated as a mixed integer problem (programming language is GAMS)



Action ripple diagram (ARIPPLE)

Quantify contribution of one entity to another entity in DSM

Can be used to analyze contribution of
1) Program to targets
2) Actor to programs / targets

in a consistent framework.

"output" x and "self-input" f

Output x : Input of resources, degree of implementation, the size of itself.
Standardized to 0 – 1 in ARIPPLE

Self input f: output which is automatically realized without effect of the other entities.

ARIPPLE calculates contribution of f_{et1} (self-input of entity *et1*) to x_{et} (output of entity *et*)

Linear function of the output (*LIN*)

$$x_{et} = \frac{p_{et} \cdot f_{et} + \sum_{et1 \in ET \cap et1 \neq et} p_{et,et1} \cdot x_{et1}}{p_{et} + \sum_{et1 \in ET \cap et1 \neq et} p_{et,et1}}$$

f_{et}: Standardized self-input ot entity *et*
x_{et}: Standardized output of entity *et*
p_{et}: Parameter for f_{et}, diagonal element of ADSM
$p_{et,et1}$: Parameter for x_{et}, element of ADSM

Non-linear function of the output(*MUL*)

$$x_{et} = f_{et} \frac{p_{et} + \sum_{et1 \in ET \cap et1 \neq et} p_{et,et1} \cdot x_{et1}}{p_{et} + \sum_{et1 \in ET \cap et1 \neq et} p_{et,et1}}$$

f_{et}: Standardized self-input ot entity *et*
x_{et}: Standardized output of entity *et*
p_{et}: Parameter for f_{et}, diagonal element of ADSM
$p_{et,et1}$: Parameter for x_{et}, element of ADSM

(1)Define a and b from ADSM

$$a_{et,et1} = \frac{p_{et,et1}}{p_{et} + \sum_{et1 \in ET \cap et1 \neq et} p_{et,et1}}$$

$$b_{et} = \frac{p_{et}}{p_{et} + \sum_{et1 \in ET \cap et1 \neq et} p_{et,et1}}$$

$a_{et,et1}$: Standardized parameter for x_{et}. Relative influence between different entities.
b_{et}: Standardized parameter for f_{et}. Relative influence of self-input.

(2)solve for x (LIN)

$$\vec{x} = A \cdot \vec{x} + \vec{f} \cdot B$$

$$\vec{x} = [I - A]^{-1} \cdot B \cdot \vec{f}$$

$$IMP = [I - A]^{-1} \cdot B = \{imp_{et,et1}\}$$

$A = \{a_{et,et1}\}$
B={diagonal elements: b_{et}, the other elements: 0}
IMP: Parameter matrix considering both $a_{et,et1}$ *and* b_{et}.

(3)Contribution (LIN)

$$\{x_{et}\} = \vec{x} = IMP \cdot \vec{f} = \left\{ \sum_{et1} imp_{et,et1} \cdot f_{et1} \right\}$$

$$IMP \cdot \vec{f} = imp_{et,et1} \cdot f_{et1}$$

Standardized relative contribution of *et1* to *et* with a given f

(4)Contribution (MUL)

$$imp1_{et,et1} \cdot f_{et1} = I^{(0.5)}_{et,et1} \cdot b_{et1} \cdot f_{et1}$$

$$imp2_{et,et2,et1} \cdot f^{MUL}_{et2} \cdot f_{et1}$$

$$= 0.5 \cdot b_{et1} \cdot \left(\sum_{et3} I^{(1)}_{et,et2} \cdot a_{et2,et3} \cdot I^{(0)}_{et3,et1} \right) \cdot f^{MUL}_{et2} \cdot f_{et1}$$

$imp1_{et,et1}$:Contribtuion of *et1* alone
$imp2_{et,et2,et1}$: Combined contribution of *et1* and *et2*