SYSTEMS APPROACH AND DECISION OPTIMIZATION FOR TECHNOLOGY SELECTION IN EFD

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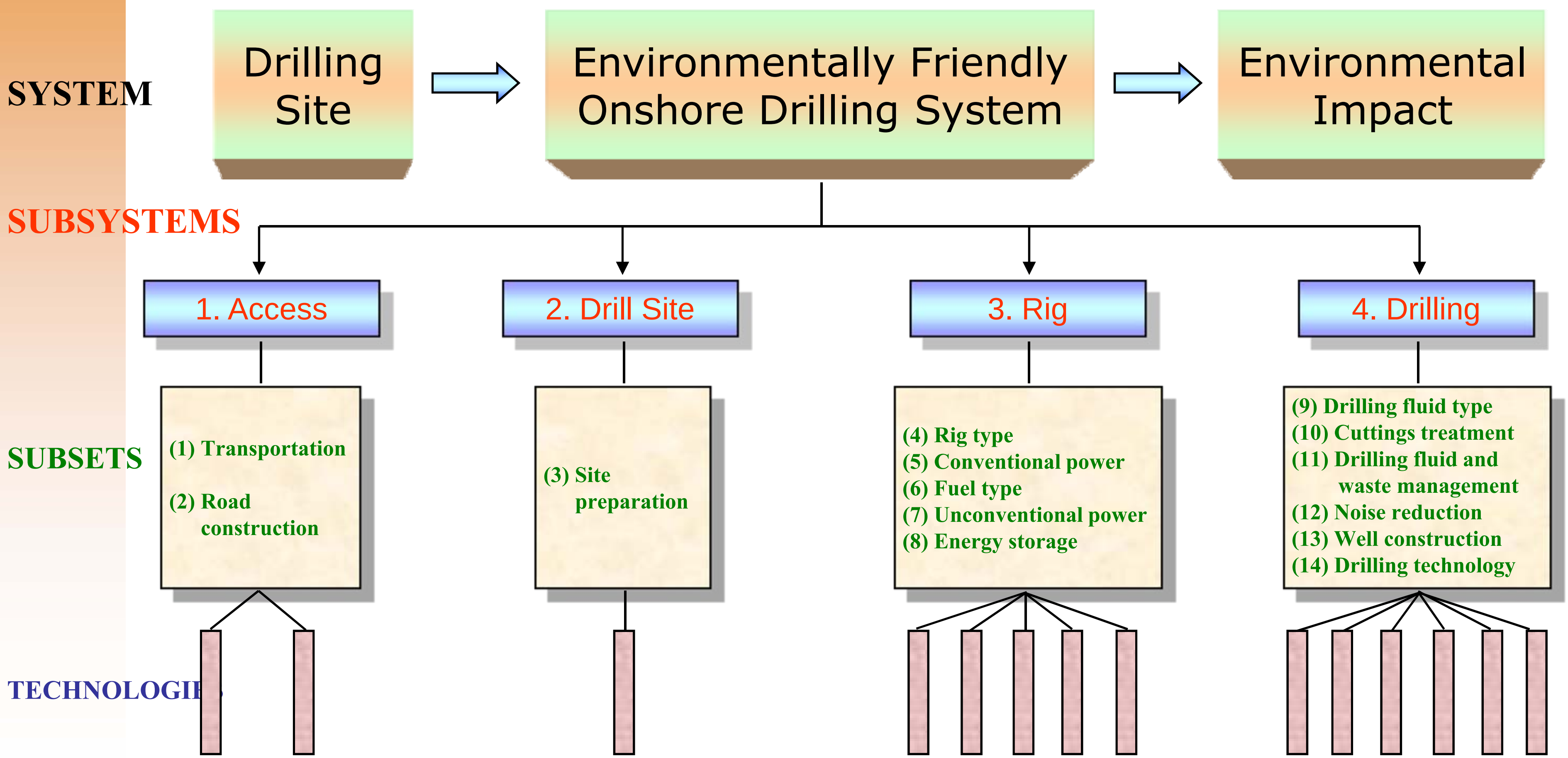
INTRODUCTION

To select the optimal system (combination of technologies) to minimize impact and maximize profit



INTRODUCTION [CONT.]

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- **Decision situation**: which system (combination of technologies) should be selected for a specific site.
- **Challenge**: there are many possible systems and many different evaluation criteria. How do we handle this in a logical way? How do we measure and select the best system?
- **Approach**: evaluate systems quantitatively and use systems analytic methods to suggest suitable systems to consider.

TECHNOLOGY SELECTION EXAMPLE

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1. Access

(1) Transportation:
- Conventional diesel truck
- Rolligon
- Helicopter

(6) technologies

(2) Road construction:
- Gravel road
- Wood mat
- Dura-Base Composite mat

(16) technologies

2. Drill Site

(3) Site preparation:
- Gravel pad
- Composite mat
- Module + driven piles

(13) technologies

3. Rig

(4) Rig types:
- Conventional rig
- Rapid rig
- LOC 250

(5) Conventional power:
- Diesel engine
- Gas turbine
- Lean-burn natural gas engine

(6) Fuel types:
- Bi-fuel system
- Bio-diesel
- Bio-gas

(7) different technologies

(7) Unconventional power:
- Fuel cells
- Photovoltaic
- Wind turbine

(8) Energy storage device:

4. Drilling

(9) Drilling fluid types:
- Oil-based mud
- Synthetic-based mud
- Water-based mud

(10) Cuttings treatment:
- Bioremediation
- Cuttings injection
- Evaporation and burial onsite

(10) different technologies

(11) Drilling fluid and waste management:
- Closed loop + container
- Open reserve pit + equipment
- Lined reserve pit + equipment

(12) Noise reduction:
- Construct a building

(13) Well construction:
- Multiple directional drilling
- Multiple horizontal drilling
- Single horizontal drilling
- Vertical drilling

(14) Drilling technology:
- Conventional overbalanced
- Underbalanced drilling
- Managed pressure drilling

Notes:
( ): Subsets

We need to be able to evaluate all possible systems and suggest an optimal system.

DEFINE ATTRIBUTE & UTILITY FUNCTION

Attribute: one of the parameters considered in the evaluation of the system (cost, land area, emission, and perception). Each attribute has an attribute scale used to score the technology on how well it meets the objective for this attribute (minimizes cost, land area, emission, and maximizes positive perception).

Utility Function: a relationship between the dimensional attribute score (e.g., $, acres, and grades) and a non-dimensional number (between 0 and 1). The utility function is used to transform all scores into non-dimensional values between 0 and 1. This allows the decision maker to make all attribute scores uniform and comparable.

RESEARCH PROCEDURE

STEP 1 : Identify main subsystems and subsets for the EFD operation.

STEP 2 : List all technologies within each subset.

STEP 3 : Define attributes and develop attribute scales to evaluate technologies.

STEP 4 : Assign scores to all technologies using the attribute scales.

STEP 5 : For each attribute, calculate the overall attribute score of a system by adding the technology scores or selecting the minimum technology score.

STEP 6 : For each attribute and in order to homogenize the scores, develop a "utility function (u_i)" to convert the overall dimensional score of a system (e.g, $, acres, and grades) into a non-dimensional utility value (between 0 and 1) of the system.

RESEARCH PROCEDURE [CONT.]

STEP 7 : Decide on a weight factor (k_i) for each attribute (i).

STEP 8 : Calculate the overall score of the system as "$\sum k_i u_i$" (multi-attribute utility function).

STEP 9 : Use optimization technique to evaluate all systems and to find the best available system for a specific site.

STEP 10 : Conduct sensitivity analysis to examine the impacts of possible changes in the attribute scales, weight factors, and utility functions on the optimal system.

STEP 11 : Suggest a small number of systems that should be particularly attractive for a given site.

ATTRIBUTES

- Technology cost (x_1)
- Ecological footprint (x_2)
- Emissions
  - Emissions of EPA and state regulated air pollutants (x_3)
  - Emissions of EPA and state regulated solid and liquid pollutants (x_4)
  - Emissions of EPA and state regulated noise pollutants (X_5)
- Perceptions
  - Government regulators (x_6)
  - Industry decision makers (x_7)
  - The general public (x_8)
- Safety (X_9)

DRAFT ATTRIBUTE SCALE: PUBLIC PERCEPTION

Description	Perception value
Support. No groups are opposed to the facility, and at least one group has organized support for the facility	A = 1.00
Neutrality. All groups are indifferent or uninterested	B = 0.75
Controversy. One or more groups have organized opposition, although no groups have action-oriented opposition (for example, letterwriting, protests, lawsuits). Other groups may either be neutral or support the facility	C = 0.50
Action-oriented opposition. Exactly one group has action-oriented opposition. The other groups have organized support, indifference, or organized opposition	D = 0.25
Strong action-oriented opposition. Two or more groups have action-oriented opposition	E = 0

Source: Adapted from Keeney (1992, P. 102)

TECHNOLOGY EVALUATION

Subsets	Total Cost ($)	Ecological Footprint		Emissions		Perceptions		
		Land Area Permanently Lost (acres)	*Type of Land Area*	*Air*	*Solid/Liquid*	*Government*	*Industry*	*Public*
(3) Rig types								
▸ Conventional rig (Reference)	$10,000,000.00	1	F	D	A	C	C	C
LOC250 from Huisman	125%	15%		C	A	B	B	B
Rapid rig from NOV	120%	20%		C	A	B	B	B
(4) Conventional power generation								
▸ Diesel engines (Reference)	$3,360,000.00	0.059137232	F	E	A	D	C	D
Diesel engines with SCR	142%	100%		D	A	C	C	C
Large scale utility turbines (combustion gas turbines)	167%	67%		C	A	C	B	C
Lean-burn natural gas engines	150%	49%		D	A	C	B	B
(5) Fuel types								
▸ Diesel (Reference)	$2,450,000.00	0	F	E	A	D	C	D
Bi-fuel system concept	120%	100%		D	A	C	B	C
Biodiesel	150%	100%		C	A	C	B	B
Biomass to liquid (BTL)	150%	100%		C	A	C	B	B
Synthetic fuels	150%	100%		B	A	A	B	B
Natural gas	70%	100%		C	A	C	C	C
Bio-gas	80%	100%		B	A	B	C	C

AN EXAMPLE SYSTEM

	Weights						
	0.4	0.2	0.05	0.05	0.1	0.1	0.1
Selected Technologies in Each Subset	**Total Cost ($)**	**Land Area Permanently Lost (acres)**	**Emissions**		**Perceptions**		
			Air	*Solid/Liquid*	*Government*	*Industry*	*Public*
(1) Hovercraft							
(2) Aluminum modules + driven piles							
(3) Conventional Rig							
(4) Lean-burn natural gas engines							
(5) Natural gas							
(6) Wind Turbine							
(7) Battery							
(8) Synthetic-based muds							
(9) Bioremediation							
(10) Selective Catalytic Reduction (SCR)							
(11) Vertical drilling							
(12) Perforated completion							
(13) Potential test							
Σ or mnimum value							
Utility Values (Risk-neutral)							

∴ **Multi-Attribute Utility Value =** ______ **(Risk-neutral)**

OPTIMAL SYSTEM FOR BASE-CASE WEIGHTS

	Weights						
	0.4	0.2	0.05	0.05	0.1	0.1	0.1
Selected Technologies in Each Subset	**Total Cost ($)**	**Land Area Permanently Lost (acres)**	**Emissions**		**Perceptions**		
			Air	*Solid/Liquid*	*Government*	*Industry*	*Public*
(1) Hovercraft	$1,268,784.00	0.365	0.600	1.000	0.500	0.500	0.500
(2) Aluminum modules + driven piles	$1,106,581.50	0.021	0.400	1.000	1.000	1.000	0.750
(3) Conventional Rig	$10,000,000.00	1.000	0.400	1.000	0.500	0.500	0.500
(4) Lean-burn natural gas engines	$3,528,000.00	0.020	0.580	1.000	0.500	0.750	0.750
(5) Natural gas	$1,200,500.00	0.000	0.720	1.000	0.500	0.500	0.500
(6) Wind Turbine	$2,184,000.00	0.212	1.000	1.000	1.000	0.750	0.750
(7) Battery	$168,000.00	0.017	1.000	1.000	1.000	0.750	0.750
(8) Synthetic-based muds	$675,000.00	0.500	1.000	0.800	1.000	1.000	1.000
(9) Bioremediation	$500,000.00	0.100	1.000	1.000	1.000	1.000	1.000
(10) Selective Catalytic Reduction (SCR)	$100,000.00	0.000	0.800	1.000	1.000	1.000	1.000
(11) Vertical drilling	$1,500,000.00	0.000	0.400	0.400	0.500	0.500	0.500
(12) Perforated completion	$500,000.00	0.000	1.000	0.800	0.500	0.500	0.500
(13) Potential test	$500,000.00	0.000	1.000	0.800	0.500	0.500	0.500
Σ or mnimum value	$23,230,865.50	2.235	0.400	0.400	0.500	0.500	0.500
Utility Values (Risk-neutral)	0.867	0.916	0.400	0.400	0.500	0.500	0.500

∴ **Multi-Attribute Utility Value = 0.720 (Risk-neutral)**

TOTAL NUMBER OF POSSIBLE SYSTEMS

1. When "Diesel engine" is selected as a conventional power generation,

Subsets	Subsystems					Π
	1. Access	2. Platform	3. Rig	4. Drilling	5. Production	
(1)	16	5	3	3	3	2160
(2)			2 *	10	4	80
(3)			5	4		20
(4)			3	3		9
(5)			4			4
					Π	124,416,000

* two types diesel engines

2. When "Gas turbine" is selected as a conventional power generation,

Subsets	Subsystems					Π
	1. Access	2. Platform	3. Rig	4. Drilling	5. Production	
(1)	16	5	3	3	3	2160
(2)			1	10	4	40
(3)			3	4		12
(4)			3	3		9
(5)			4			4
					Π	37,324,800

3. When "Natural gas engine" is selected as a conventional power generation,

Subsets	Subsystems					Π
	1. Access	2. Platform	3. Rig	4. Drilling	5. Production	
(1)	16	5	3	3	3	2160
(2)			1	10	4	40
(3)			2	4		8
(4)			3	3		9
(5)			4			4
					Π	24,883,200

∴ Total number:

124,416,000

37,324,800

24,883,200

Σ **186,624,000**

INTERVIEW PROCESS

PHASE I

STEP 1: Check the subsystems (Have we identified all subsystems?)

STEP 2: Check the subsets and technologies (We have identified 14 subsets including about 90 technologies)

STEP 3: Check the attributes and their scales (We have defined 9 attributes and scales)

STEP 4: Check the weight factors for each attribute

Have interviewed with **4 EFD experts**

PHASE II

STEP 1: Fill out the input spreadsheets (Assign scores for each technologies)

STEP 2: Refine the input scores

BENEFITS OF THIS RESEARCH

- Provide quantitative basis for suggesting appropriate drilling system.
- Explicitly evaluates alternatives against selected criteria.
- Uses best available information – both expert knowledge and data – in a coherent, logical way.
- Can help to optimize a system for a given situation and best meet the goals of those involved.

STATUS OF THE SYSTEMS WORK

- Completed preliminary framing of the decision situation.
- Constructed preliminary attributes and scales.
- Completed preliminary evaluation of technologies
- Completed preliminary sensitivity analysis with more than 420 different weight combinations (risk-neutral)
- Developed the Web-Based Decision Optimization Application

NEXT STEPS

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- Test and refine evaluation protocol with a small number of industry representatives for a specific site (**currently working**)
- Implement evaluation protocol with EFD industry representatives (**currently working**)
- Conduct optimization and sensitivity analyses, and then suggest appropriate system.
- Revise process based on feedbacks
- Modify the Web-base application

QEUSTIONS?