ENERGY

Office of **ENERGY EFFICIENCY & RENEWABLE ENERGY**

U.S. DEPARTMENT OF

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY WATER POWER TECHNOLOGIES OFFICE

Innovating Distributed Embedded Energy Prize (InDEEP) Introduction to Innovation Methods May 10, 2023

- Everyone is joined in listen-only mode
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- Q&A—Submit your questions using the chat box

Agenda

- 1. Introductions
- 2. Innovation Process
- 3. TRIZ Techniques of Inventive Problem Solving
- 4. Innovation with TRIZ in Wave Energy
- 5. Q&A

Introductions

Innovating Distributed Embedded Energy Prize



- \$2.3M prize pool
- Three phases over two years
- Incentivize progress in early-stage research
- Help solve technical challenges that could be applied to wave energy

Contributing to Leaderboard Scoring

- For questions about the prize overall, view our recorded conversation on April 12
- Participation in this webinar contributes to your final leaderboard score
- Make sure to complete the Leaderboard Eligibility Form to receive points for your participation
- If you haven't done this yet, do so now: <u>https://www.herox.com/indeep</u>



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WPTO's desired outcome for InDEEP is an understanding of the landscape of innovators and potential DEEC-Tec solutions that could be applied to wave energy devices.

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- Problem & Opportunity Statement
 - Solution agnostic formulation
 - Functions/functional requirements
 "What the system is to do"
 - Functional system
 - Functional hierarchy
 - Functional compatibility

- Ideation
 - Idea generation process
 - Driven by functional requirements
 of the problem & opportunity statement
 - Application of different idea generation methods
 - Different application approaches of a given method
 - Generation of multiple concepts
 - Generation by multiple players/teams

- Assessment
 - Formulation and application of assessment methods and tools for technology concepts and technology designs
 - Driven and expressed by Capabilities
 "What the system is to be"
 - Identifying strengths & weaknesses
 - Prioritization
 - Merging
 - Down-selection
 - Improving

- Development
 - Improving technology performance
 - Improving technology maturity
 - Iteration
 - Continuation and relation of
 - Problem & opportunity statement refinement
 - Idea generation methods and application
 - Assessment method, tools and application

Innovation Impact Levels

32% Apparent (company knowledge) Simple improvements using known knowledge	Level One
45% Improvement (industry knowledge) Adaptation of solutions used in similar systems / same industry	Level Two
Approximately 18% Fundamental change (other industries) Radical innovative new application from different industry	Level Three
Less than 4% New application (new technology) A new combination of technologies for new solutions e.g. materials	Level Four
Less than 1% Breakthrough! (new science) New Invention often based on (new) scientific effect	Level Five

TRIZ – Techniques of Inventive Problem Solving

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TRIZ – Background

- TRIZ/TIPS
 - "Teoriya Resheniya Izobreatatelskikh Zadatch" Russian acronym, TRIZ
 - "Techniques of Inventive Problem Solving" TIPS
- Genrich Altshuller, a patent officer in the Soviet Navy, examined 40,000 patents between 1945 and 1985 in order to identify a methodology of inventive problem solving based on evidence, data and pattern recognition rather than isolated spontaneous or intuitive creativity.



- Altshuller identified a finite set of reoccurring problem types and reoccurring inventive solution principles
- Followers of Altshuller have subsequently examined 3 million patents and have confirmed Altshuller's findings
- Following a strong TRIZ movement in the Soviet Union TRIZ emerged in the West in 1990 after the fall of the Soviet Union



Fundamentals of the methodology in 3 steps

- For a specific problem identify the associated typical problem in form of a root contradiction within 39 x 39 cases spanned up by 39 typical parameters
- Apply a finite number (<40) of identified and proven inventive problem-solving techniques that have shown to deliver impactful solutions for this typical problem
- Concretize the identified typical solution to find the sought specific solution

TRIZ – Methodology



Contradiction Matrix

	Worsening Feature Improving Feature	Weight of moving object	Weight of stationary object
		1	2
1	Weight of moving object		
2	Weight of stationary object		
3	Length of moving object		V
4	Length of stationary object	+	35, 28, 40, 29

Consider Using Inventive Principles:

- 28 Mechanics Substitution
- 29 Pneumatics and Hydraulics
- 35 Parameter Changes
- 40 Composite Materials



Contradiction Matrix

Contradiction Matrix

		Weight of moving othect	Weight of immetale ebject	Length of moving object	Longth of immobile object	Area of moving object	Area of imm oblic object	Volume of moving object	Volume of immebile object	Speed	Force	Ton sien, Pessure	Sh ape	Setolily of object	Strength	Durability of moving object	Durability of immobile object	Torrupor ahur o	lluninsion, Bighhess	Energy spentby moving object	Energy spentby immobile object	Po war	Waste of energy	Waste of substrace	Loss of Internation	Waste of Time	Amount of substance	Part at Miny	Accuracy of measurement	Accuracy of manufacturing	Harmhul factors acting on object	Ha mrtul side effects	Manufacturability	Corvertence of use	Repairability	A check ability	Complexity of device	Complexity of control	Level of automation	Productivity	
		1	2	3	4	5	6	7	8	9	10	-11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
1	Weight of moving object		-	15, 8, 29,34	•	29, 17, 38, 34	-	29, 2, 40, 28	-	2, 8, 15, 38	8, 10, 18, 37	10, 36, 37, 40	10, 14, 35, 40	1, 35, 19, 39	28,27, 18,40	5, 34, 31, 35	•	6, 29, 4, 38	19,1, 32	35, 12, 34, 31	-	12, 36, 18, 31	6, 2, 34, 19	5, 35, 3, 31	10,24, 95	10, 35, 20, 28	3,26, 18,31	1, 3, 11, 27	28, 27, 35, 26	28, 35, 26, 18	22, 21, 18, 27	22, 35, 31, 39	27, 28, 1, 36	35, 3, 2, 24	2,27, 28,11	29, 5, 15, 8	26, 30, 36, 34	28, 29, 26, 32	26, 35 18, 19	95, 3, 24, 37	
2	Weight of immobile object	-	+	-	10, 1, 29, 35	-	35, 30, 13, 2		5, 35, 14, 2	-	8, 10, 19, 35	19,29, 10,18	13, 10, 29, 14	26, 39, 1, 40	28, 2, 10, 27	-	2, 27, 19, 6	28, 19, 32, 22	19, 32, 35	-	18, 19, 28, 1	15, 19, 18, 15	18, 19, 28, 15	5, 8, 13, 30	10, 15, 35	10, 20, 35, 26	19,6, 18,25	10,28, 8,3	18, 28, 28	10, 1, 35, 17	2, 19, 22, 37	1,39	28, 1, 9	6, 13, 1, 32	2, 27, 28, 11	19, 15, 29	1, 10, 26, 39	25, 28, 17, 15	2,28, 35	1,28, 15,35	
3	Length of moving object	29, 34	-	+		4	-	35	-	13, 4, 8	4	1,8,35	29	34	29,34	19		10, 15, 19	32	24	-	1,95	39	4,25, 23, 10	1,24	15, 2, 29	29, 35	10, 14, 29, 40	4	10, 28, 29, 37	17, 24	17, 15	1, 224,	35, 4	10	14, 15, 1, 16	25,24	25, 24	26, 16	28,29	
4	Length of immobile object		35, 28, 40, 29	-	+	-	10,40		2,14	-	28,10	1, 14, 35	12, 14, 15,7	39, 37, 35	15, 14, 28, 26	-	1, 10, 35	3, 36, 38, 18	3,25	-		12,8	6,28	10,28, 24,35	24, 26,	30, 29, 14	20.20	15, 29, 28	32, 28,	2, 32, 10	1,18		15, 17, 27	2,25	3	1, 35	1, 26	26	11.70	30, 14, 7, 26	
5	Area of moving object	29,4	-	18,4		*		17,4		4,34	35,2	10, 15, 36, 28	29,4	13, 39	40, 14	6,3		16	19, 32, 19, 19, 19, 19, 19, 19, 19, 19, 19, 19	19,32	1	32, 18	30,26	2,39	30, 26	26,4	6,13	29,9	32, 3	2,32	28,1	18, 39	26, 24	13, 16	10, 1	15, 30	13	26,18	28, 23	34,2	
6	Area of immobile object	•	30, 2, 14, 18	-	39	-	+			-	1, 18, 35, 36	10, 15, 96, 97	1.15	2,38	40		2, 10, 19, 90	35, 39, 38	0.40	1		17,32	30	10,14, 18,39	30, 16	4,18	2, 18, 40, 4	32, 35, 40, 4	32, 3	2,25, 18,36	27, 2, 39, 35	40	40, 16	15,4	16	15, 16	1, 18, 36	2, 35, 30, 18	23	10, 15, 17, 7	
7	Volume of moving object	29,40	-	35		17	-	+	-	38, 34	36,37	36, 37	29,4	1,39	15,7	6, 35, 4		10,18	10	35	-	13, 18	13, 16	34,10	2,22	10	7	40,11	28	2,16	27, 35	40,1	40	30, 12	10	15,29	26,1	4	16,24	34	
8	Volume of immobile object	-	19, 14	19, 14	14	-		-	+	-	37	24,35	7,2,35	35,40	17, 15	-	38	35, 6, 4	10.19	-		30,6	14.90	35,34		32 18	35,3	16	38.95	25	19,27	35,4	35	99.98	1	15.10	1, 31	26		10,2	
9	Speed	13, 38	-	8		34	-	34	-	+	15, 19	38,40	18, 34	1,18	14	35,5		36,2	19	35,38	-	38,2	19, 35	28,38	13,26	10.77	29,38	27,28	1,24	32, 25	35, 23	35, 21	8,1	13, 12	28,27	26	4,34	27, 16	10, 18	1.28	
10	Force	18	1,28	9,36	28, 10	15	36, 37	12, 37	18, 37	15, 12	+	11	40,34	21	14,27	19,2		21		10	36,37	18, 37	14, 15	40,5		36	18,36	13,21	23, 24	37, 36	40, 18	36,24	18, 1	25	11	18,20	10,18	10, 19	2, 35	35, 37	
11	Tension, Pressure	37,40	10, 18	36	14, 16	36,28	36, 37	10	35,24	36	21	+	15, 10	2,40	40	27		19,2	- 12.15	10, 37		14	25	3,37		4	36	19,35	25	3,35	37	27, 18	16	11	2	25	35	37	35,24	35,37	
12	Shape	29,40	26, 3	5,4	10,7	10		15,22	7,2,35	34,18	37,40	10, 14	+	18,4	10,40	9,25	90.9	19, 32	32	14	77.4	4, 6, 2	14	3,5		34, 17	36,22	16	1	40	35	35, 1	17, 28	26	2, 13, 1	29	1,28	39	32	34,10	
13	Stability of object	2, 99	1,40	1,28	37	13	39	19, 39	35,40	28, 18	21,16	40	18,4	+	15	10, 35	35,23	32	27,16	13,19	29,18	27,31	39,6	30,40		35,27	35		13	18	30, 18	27, 39	35, 19	30	10, 16	34,2	22, 26	39,23	1, 8, 35	40,3	
14	Strength	15	27,1	35	28, 26	40,29	28	14,7	17, 15	26, 14	3,14	18,40	35,40	35	*	26		40	35, 19 2, 10, 4	10	35	35,28	35	31,40		28,10	27	11,3	16	3,27	37,1	22, 2	10, 32	25, 2	3	32	25,28	15,40	15	10,14	
15	Durability of moving object	34, 31	-	2, 19, 9	-	19	-	19,30	-	3, 35, 5	16	27	28, 25	35	10	+	-	39	35	35, 18		35, 38		3,18	10	28,18	10,40	13	3	16,40	33, 28	16, 22	27,1,4	12,27	27	13	29, 15	39,35	6,10	14, 19	
16	Durability of immobile object	-	19, 16	-	35	-		-	38	-	35.10	35.30	14.22	35,23	10.50	-	+	36,40	32.30	-		16	21.17	18,38	10	10,16	31	6,40	24		40, 33	22 22	35, 10	1	1	2	2.17	6,35	1	16,38	
17	Temperature	6, 38	32	9	9	39,18	25, 38	40,18	35, 6, 4	36, 30	3,21	19,2	19, 32	32	22,40	39	36,40	*	21, 16	3, 17	30.05	17,25	35, 38	29,31		21,18	30, 99	3,10	24	24	35,2	2,24	26, 27	26,27	16	27	16	35, 31	19, 16	35	
18	Illumination, Brightness	32	32	16	<u> </u>	26		10		19	6	20.44	32, 30	27	35, 19	2, 19, 6		19	+	19	1,15	32	1,6	13, 1	1,6	26,17	1,19	10.04	32	3,32	15, 19	32, 39	28, 26	19	13, 16	19	13	32, 15	10	16	
19	Energy spent by moving object	8,31	-	12, 28		25	-	10	-	35	21,2	25	29	17,24	35	6, 18	1	3,14	19	+		37, 18	15,24	18,5		19, 18	16,18	11,27	3, 1, 32		27	2, 35, 6	30	19,35	17,28	13, 16	27,28	35, 38	32, 2	35	
20	Energy spent by immobile object	-	27	-		-	17.99		20.6	-	36, 37	92.10	20.14	29,18	35	10.26		2.14	35, 32	-	+		10.95	18,31		56.90	31	23	32.15	<u> </u>	22, 37	18	1,4	96.96	35.9	10.17	90.10	16,25	98.9	1,6	
21	Power	38, 31	17, 27	35, 37		19,38	13, 38	38	25	2	36, 35	35	2,40	15,31	28,10,	10, 38	16	17,25	19	19,37		+	38	18,38	10,19	10,6	19	26,31	2	32, 2	31,2	18	34	10	10, 34	34	30, 34	16	17	34	
22	Waste of energy	19,28	18,9	13	6, 38, 7	17,30	30, 18	23	7	38	36, 38		20.04	39,6	26	-	27.10	7	32, 15	75.10	20.27	3,38	+	2,37	19,10	32,7	25	35	32		35,2	2,22		1	2,19	15.10	7,23	15,23	2	29,35	
23	Waste of substance	23,40	22, 32	10, 39	28,24	10, 31	39, 31	30, 36	18, 31	28, 38	18,40	37,10	3,5	30,40	31,40	3, 18	18, 38	39, 31	1, 6, 13	24, 5	12,31	18, 38	2, 31	*		35, 10	24	39,35	31, 28	24, 31	30,40	34, 29	33	2,24	34, 27	2	28, 24	10, 13	18	10,23	
24	Loss of Information	35	5	1,26	26	30,26	30, 16	2.5.24	2,22	26, 32	10.77		4.10	05.0	20.0	10	10	25.20	19	25.00		10,19	19,10	25.40	+	28, 28,	24,25,	23	24.04	24.25	1	22	32	27,22	22.4			35, 33	35	15, 23,	
25	Waste of Time	37, 35	26,5	20	14,5	16	17,4	10	32, 18	07.00	36,5	37, 36,4	34, 17	22,5	28, 18	28, 18	10, 16	21,18	26, 17	19,18	1	10,6	18,52	10,39	28, 32	4	18, 16	4	28, 32	28, 18	34	18, 39	34,4	10, 34	10	35, 28	6, 29	32, 10	35, 30	40.00	
26	Amount of substance	18, 31	18, 35	25, 14, 35, 18	15.50	29	40,4	29	0.02	34,28	30, 14,	14,3	35, 14	17,40	34, 10	10,40	31	39	** 55	16,18	3, 35, 31	35	25	24	35	18,16	+	28,40	28	33, 30	29,31	40, 39	35, 27	25, 10	10, 25	29	27,10	29, 18	8,35	3,27	
27	Reliability	40	28	14,4	28, 11	14, 16	40,4	14,24	24	11,28	10, 3	35,19	16,11	22.25	11,28	25	6,40	10	13	27, 19	36,23	26, 31	35	29,39	10,28	4	40,3	+	11, 23	1	2,40	40, 26	4.75	40	1,11	8,24	1 10, 30,	28	27	29,38	
28	Accuracy of measurement	26, 28	25, 26	5,16	3, 16	32,3	32, 3	6	25.10	32,24	32,2	32	32	13	32	32	24	28,24	6, 1, 32	3, 6, 32		3, 6, 32	20, 32, 27	31,28		28,32	2, 6, 32	23	+		22, 26	39, 10	25, 18	1, 13, 17, 34	1, 32, 13, 11	13, 35, 2	10,34	32,28	10,34	10, 34, 28, 32	
29	Accuracy of manufacturing	28, 32, 13, 18	28, 36, 27, 9	10, 28, 29, 37	2, 32, 10	28, 33, 29, 32	2, 29, 18, 36	32, 23, 2	26, 10, 35	10, 28, 32	28, 19, 34, 36	3, 35	32, 30, 40	30, 18	3,27	3, 27, 40		19,26	3, 32	32, 2		32, 2	13, 32, 2	36, 31, 10, 24		32, 26, 28, 18	32, 30	11, 32,		•	26, 28, 10, 36	4, 17, 34, 26		1, 32, 35, 23	25, 10		26, 2, 18		26, 28, 18, 23	10, 18, 32, 39	
30	Harmful factors acting on object	27, 39	13, 24	39,4	1, 18	33,28	39, 35	37, 35	19,27	25, 22, 35, 28	39, 18	37	35	30, 18	37,1	33,28	40, 33	35,2	52, 13	27	22,37	31, 2	35,2	19,40	2	35, 16, 34	29,31	2,40	23, 25	10, 18	*		2	28, 39	2	22, 31	29,40	29,40	34	13,24	
31	Harmful side offects	19, 22, 15, 39	35, 22, 1, 39	17, 15, 16, 22		17, 2, 18, 39	22, 1, 40	17, 2, 40	30,18, 35,4	35, 28, 3, 23	35, 28, 1, 40	2, 33, 27, 18	35,1	35, 40, 27, 39	15, 35, 22, 2	15, 22, 30, 31	21, 39, 16, 22	22, 35, 2, 24	19, 24, 99, 32	2,35,6	19, 22, 18	2,35,	21, 35, 2, 22	10,1, 34	10,21, 29	1,22	3,24, 39,1	24, 2, 40, 39	3, 33, 26	4, 17, 34, 26		+		0.5.40		0.40	19, 1, 31	2,21, 27,1	2	22, 35, 18, 39	
32	Manufacturability	28, 29, 15, 16	1, 27, 36, 13	12, 224, 12, 17	15, 17,	13, 1, 26, 12	16,40	13, 29, 1, 40	35	35, 13, 8, 1	35, 12	35, 19,	1, 28, 13, 27	11, 12,	32	27, 1, 4	35, 16	18	28, 24, 27, 1	28, 26, 27, 1	1,4	12,24	19, 35	33	18,16	34,4	35,23, 1,24		1, 35, 12, 18	1.07	24,2		٠	z, s, 13, 16	11,9	2, 13, 15	27, 26,	6, 28, 11, 1	8, 28, 1	35, 1, 10, 28	
33	Convenience of use	25, 2, 13, 15	6, 13, 1, 25	1, 17, 13, 12	0.15	1, 17, 13, 16	18, 16, 15, 39	1, 16, 35, 15	4, 18, 39, 31	18, 13, 34	28, 13	2,32, 12	15, 34, 29, 28	32, 35, 30	32,40, 3,28	25, 3, 8, 25	1, 16, 25	26,27, 13	13, 17, 1, 24	1, 13, 24		35, 34, 2, 10	2, 19, 13	28, 32, 2,24	4,10, 27,22	4, 28, 10, 34	12,35	17,27, 8,40	25, 13, 2, 34	1, 32, 35, 23	2, 25, 28, 39		2, 5, 12	+	12, 26, 1, 32	15, 34, 1, 16	32, 26, 12, 17		1,34, 12,3	15, 1, 28	
34	Repairability	2, 27 35, 11	2, 27, 35, 11	1, 28, 10, 25	3, 18, 31	15, 13, 32	16, 25	25, 2, 35, 11	1	34,9	1, 11, 10	13	1, 13, 2, 4	2, 35	11, 1, 2, 9	11, 29, 28, 27	1	4,10	15, 1, 13	15, 1, 28, 16		15, 10, 32, 2	15, 1, 32, 19	2, 95, 34, 27		32, 1, 10, 25	2,28, 10,25	11, 10, 1, 16	10, 2, 13	25, 10	35, 10, 2, 16		1, 35, 11, 10	1, 12, 26, 15	+	7, 1, 4, 15	35, 1, 13, 11		34, 35, 7, 13	1,32, 10	
35	Adaptability	1, 6, 15, 8	19, 16, 29, 16	25, 1, 29, 2	1, 36, 16	35, 30, 29, 7	15, 16	15, 36, 29		35, 10, 14	15, 17, 20	35, 16	18, 37, 1, 8	35, 30, 14	36, 3, 32, 6	13, 1, 35	2, 16	27, 2, 3, 35	6,22, 26,1	19, 96, 29, 13		19, 1, 29	18, 16, 1	15, 10, 2, 13		35,28	3, 35, 15	35, 13, 8, 24	35, 5, 1, 10		35, 11, 32, 31		1, 13, 31	15, 34, 1, 16	1, 16, 7,	+	15, 29, 37, 28	1	27, 34, 35	25, 28, 6, 37	
36	Complexity of device	26, 90, 34, 95	2, 26, 35, 39	1, 19, 26, 24	26	14, 1, 13, 16	6, 96	34, 26, 6	1,16	34, 10, 28	26, 16	19, 1, 35	29, 13, 28, 15	2, 22, 17, 19	2, 13, 28	10, 4, 28, 15		2, 17, 13	24, 17, 13	27,2, 29,28		20, 19, 30, 34	10, 35, 13, 2	35, 10, 28, 29		6,29	13,3, 27,10	13, 35,	2, 26, 10, 34	26, 24, 32	22, 19, 29, 40	19, 1	27, 26, 1, 13	27, 9, 26, 24	1, 13	29, 15, 28, 37	+	15, 10, 37, 28	15, 1, 24	12, 17, 28	
37	Complexity of control	27, 26, 28, 13	6, 13, 28, 1	15, 17, 26, 24	26	2, 13, 18, 17	2, 39, 30, 16	29, 1, 4, 16	2, 18, 26, 31	3, 4, 16, 35	30, 28, 40, 19	35, 36, 37, 32	27, 13, 1, 39	11, 22, 39, 30	27, 3, 15, 28	19, 29, 39, 25	25, 34, 6, 35	3, 27, 35, 16	2,24, 26	35, 38	19, 35, 16	18,1, 16,10	35, 3, 15, 19	1, 18, 10, 24	35, 33, 27, 22	18, 28, 32, 9	3,27, 29,18	27,40, 28,8	26, 24, 32, 28		22, 19, 29, 28	2,21	5, 28, 11, 29	2,5	12, 26	1, 15	15, 10, 37, 28	+	34,21	35, 18	
38	Level of automation	28, 26, 18, 35	28, 26, 35, 10	14, 13, 17, 28	23	17, 14, 13		35, 13, 16		28, 10	2,35	13, 35	15, 32, 1, 13	18,1	25, 13	6,9		26, 2, 19	8,32,	2, 32, 13		28, 2, 27	23, 28	35, 10, 18, 5	35, 33	24, 28, 35, 30	35, 13	11,27, 32	28, 26, 10, 34	28, 26, 18, 23	2,33	2	1, 26, 13	1, 12, 34, 3	1, 35, 13	27, 4, 1 35	15,24,	34, 27, 25	+	5, 12, 35, 26	
39	Productivity	35, 26, 24, 37	28, 27, 15, 3	18, 4, 28, 38	30,7, 14,26	10, 26, 34, 31	10, 35, 17, 7	2, 6, 34, 10	35, 37, 10, 2		28, 15, 10, 36	10,37,	14, 10, 34, 40	35, 3, 22, 39	29,28, 10,18	35, 10, 2, 18	20, 10, 16, 38	35,21, 28,10	26, 17, 19, 1	35, 10, 38, 19	1	35, 20, 10	28, 10, 29, 35	28, 10, 35, 23	13, 15, 23		35, 38	1,35, 10,38	1, 10, 34, 28	18, 10, 32, 1	22, 35, 13, 24	35, 22, 18, 39	35, 28, 2, 24	1, 28, 7, 10	1, 32, 10, 25	1, 35, 28, 37	12, 17, 28, 24	35, 18, 27, 2	5, 12, 35, 26	+	

40 Inventive Principles

1. Segmentation	15. Dynamics	29. Pneumatics
2. Taking out	16. Partial or	and hydraulics
3. Local quality	excessive actions	30. Flexible shells and thin
4. Asymmetry	17. Another dimension	films
5. Merging	18. Mechanical vibration	31. Porous materials
6. Universabrationlity	19. Periodic action	32. Colours changes
7. Nested doll	20. Continuity of useful	33. Homogeneity
8. Anti-weight	action	34. Discarding
9. Preliminary	21. Skipping	and recovering
anti-action	22. Blessing in disguise	35. Parameter changes
10. Preliminary action	23. Feedback	36. Phase transitions
11.Beforehand	24. Intermediary	37. Thermal expansion
cushioning	25. Self-service	38. Strong oxidants
12. Equipotentiality	26. Copying	39. Inert atmosphere
13. The other	27. Cheap short-living	40.Composite material film
way around	28.Mechanics	
14. Spheroidality	substitution	

Dissolving Contradictions

- Beyond the pareto frontier
- Beyond optimization
- Beyond compromise
- Dissolving trade-offs



TRIZ – Benefits





Reasons to use TRIZ

- TRIZ is systematic, auditable and repeatable
- TRIZ is based on proven successful patents
- TRIZ uses the world 's knowledge (systematic rather than random way)
- TRIZ closely targets and initiates the ideation process
- 40 inventive principles for solving contradictions
- 8 Trends of evolution of technology
- Ideality
- Thinking in Time and Scale
- 13 Standard creativity triggers

Innovation with TRIZ in Wave Energy

U.S. DEPARTMENT OF ENERGY OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY | WATER POWER TECHNOLOGIES OFFICE

Technology Development Framework

- Technology Readiness Levels (TRL)
- Technology Performance Levels (TPL)
- Technology Development Map
- TRL TPL Matrix



Technology Development Framework



Technology Readiness Levels (TRL)

Technology Development Cost, Time and Risk



Technology Readiness Level (TRL)

Trajectory	T1 - Conventional	T2 - Alternative	T3 - Combined
Cost [\$ m]	155	65	114
Time [y]	22	13	23
Risk [\$ y m]	165	9	39

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TRIZ has proven to work in wave energy

- New technology concepts so far are high quality
- Contradictions matrix 'feels' familiar to natural problem solvers
- Contradictions matrix sometimes leads to known solutions as well as new solutions
- Ideality concept & Ideality audit lead to auditable clarification of requirements & to new contradictions & to new ideas
- Resolution of limiting contradictions on one WEC archetype led to invention other WEC archetype – jumping archetype boundaries

TRIZ in InDEEP

- TRIZ is applicable al system levels
 - WEC farm
 - WEC unit
 - WEC sub/sub/system
 - WEC component
 - WEC operation process
- InDEEP
 - DEEC
 - DEEC-Tec meta material
 - (DEEC-Tec meta material enabled WEC)

Technology Performance Levels (TPL) come next!

Questions and Answers

Thank you!

Template

- Text
 - Text

Template

- Text
 - Text

Wrap Up & Next Steps



Save the Dates!

Competitor Support Mechanisms

- Upcoming Training Sessions:
 May 10: Innovation methods
 July 5: TPL assessment
- Provide us feedback in the webinar poll to make sure upcoming sessions are useful
- Teaming Platform
- Submission Feedback
- Mentorship in Innovation Methods and TPL Assessment
- Resources linked in Appendix C of the Rules Document





For a more in-depth look at the prize overall where these topics will be applied, please read the rules document, available here:

https://americanmadechallenges.org/ch allenges/indeep/docs/InDEEP-Prize-Rules.pdf



In DEEP Innovating Distributed Embedded Energy Prize

> OFFICIAL RULES MARCH 2023



Questions?

