History of the First ILC Value Engineering Workshop

Value Engineering

- In November ‘07 a three day “Formal” Value Engineering Workshop was held at Fermilab.

Charge

- Conduct a workshop that will comprehensively examine the power and cooling system requirements and design solutions. Concentrating on the largest power user, the Main Linac, examine all aspects of the technical equipment and conventional equipment as it relates to power and cooling.

- Participants

US Corp of Engineers OVEST Team
Richard Lambert, Facilitator, Keith Ellmers, John Mathis
Main Linac and High level RF
Mike Neubauer (SLAC), Chris Jensen (Fermilab),
Shigeki Fukuda (KEK), Keith Jobe (SLAC)
Consultants :
Larry Hanson PE Burns and Mc Donnell, Robert Knoedler Hanson Engineering
Tracy Lundin Hanson, Venkat Kumar, University of Chicago
Javier Sevilla, SLAC
Conventional Facilities and Siting
Vic Kuchler, Marc Ross, Emil Huedem, Lee Hammond, Maurice Ball,
Tom Peterson, Tom Lackowski,
Observer: Bakul Banerjee

Agenda

- **Workshop Agenda:**
- **Tuesday Nov. 27, 2007 1:00 to 5:30**
- 1:00 **Information Phase**
- Welcome and Introductions — Tom Lackowski
- Opening remarks — Vic Kuchler
- ILC Project Overview — Marc Ross
- ILC Conventional Construction — Tom Lackowski
- VM Process Overview — Richard Lambert – OVEST
- Main Linac Equipment power and — Mike Neubauer
- cooling Criteria
- 3:00-3:30 Coffee break
- 3:30-5:30 **Function Analysis Phase**
- Shaft 7 CF&S supplied Power and Cooling — Emil Huedem
- HVAC — Lee Hammond
- Power — Tom Lackowski
- FAST Diagram — Richard Lambert
- 5:30 Adjourn
- **Wed. Nov. 28, 2007 9:00 to 5:30**
- 9:00-10:30 **Speculation Phase** — Richard Lambert
- 10:30-11:00 Coffee Break
- 12:30-1:30 Lunch
- 1:30-3:00 **Speculation Phase Continued**
- 3:00-3:30 Coffee Break
- 3:30-5:30 Speculation Phase Continued or Start Analysis Phase
- 5:30 Adjourn
- **Thursday Nov. 29, 2007 9:00 to 5:30**
- 9:00-10:30 **Analysis Phase**
- 10:30-11:00 Coffee Break
- 11:00 -12:30 **Development Phase Planning**
- 12:30-1:30 Lunch
- 1:30-3:00 **Development Phase Planning Continued**
- Presentation Phase Planning
- Workshop Close Out — Tom Lackowski
- 3:00-3:30 Coffee Break
- 3:30-5:30 **Development of EDR Work Packages**
- 5:30 Adjourn

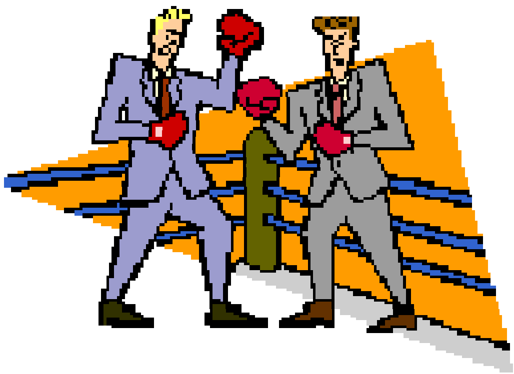
- The following slides are from Richard Lambert of the US Army Corp of Engineers.
- I will quickly run through these slides, stopping at some of the key points.
- Summarize the experience.
- Provide some ideas for improvement.

Value Engineering

What is it?

What Value Engineering Is Not!

- Cost Cutting
- Design Review
- Project Elimination
- Scope Reduction
- Quality Reduction
- Detailed Cost Estimating
- Redesign



An organized study of FUNCTIONS to satisfy the USER'S NEEDS with a QUALITY PRODUCT at the LOWEST LIFE CYCLE COST through APPLIED CREATIVITY

Definition of Value Engineering

- **Terms used to describe "Value Engineering"**
  - Value Methodology
    - **This is the "official" term used by SAVE International. It describes the overall body of knowledge.**
  - Value Analysis
    - **This was the first term used when the process was originally developed for manufacturing**
  - Value Engineering
    - **The term "engineering" was used to identify the process as it is applied to design and construction**
  - Value Management
    - **This less commonly used term refers to its application to business processes**

Definition of Value Engineering

- **The value of a function is defined as the relationship of cost to performance**

$$Value^{max} = \frac{Performance^{max}}{Cost^{min}}$$

Definition of Value Engineering

- **"Good" Value is the lowest cost to reliably provide the required function with essential performance.**

- **Value is always increased by decreasing costs while maintaining essential performance.**

- **Value may also be increased if the customer needs, wants, and is willing to pay for greater performance.**

Range of Application

- VE applies to everything because every project or process has a function
- VE can be applied at any point of the design or process
- VE is a problem solving technique
- VE can be used as a technique for developing design criteria

Reasons for Poor Value…

- Lack of and/or poor coordination among designers
- Failure to network with customer – poor definition of needs and wants
- Design based on habitual thinking or mistaken beliefs
- Not enough time for project formulation and/or design
- Failure to utilize latest technologies
- Negative attitudes

More Reasons for Poor Value…

- **Poor communication in developing project scope**
- **Lack of consensus among project stakeholders with regard to project scope**
- **Outdated or inappropriate design standards**
- **Incorrect assumptions based on poor information**
- **Fixation with previous design concepts**
- **Honest wrong beliefs**

Common Misconceptions

- **"VE is something we do all the time."**
  - No it isn't. VE requires the application of a specialized body of knowledge at the right time with the right people.
- **"VE degrades project performance."**
  - If applied properly, its should maintain or improve project performance.
- **"VE is just another management fad."**
  - VE was developed in 1943. It is required by federal and many state laws. It has a professional society and maintains professional standards and accreditation.
- **"VE is really just cost cutting."**
  - Really?

VE vs. Cost Cutting/Reduction

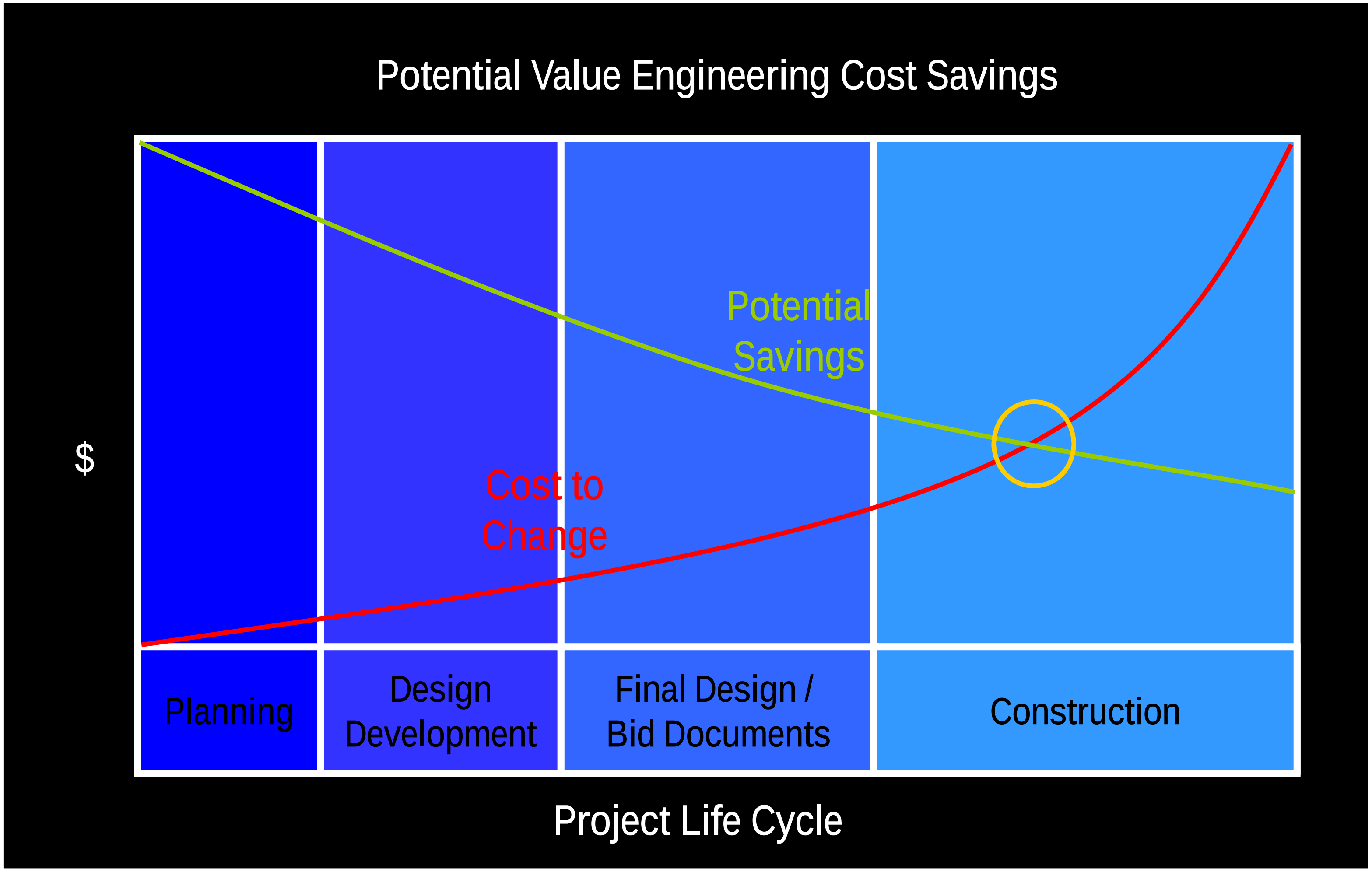
- VE seeks to maintain or improve performance while reducing TOTAL costs.
- VE is a pre-planned allocation of time and effort.
- VE is a highly structured process using a formal methodology.
- VE utilizes an objective, multi-disciplined team and a trained facilitator.
- VE provides an organized follow-up, implementation and reporting program.

- ⇨ Cost reduction seeks to cut INITIAL costs, often at the expense of project quality.
- ⇨ Cost reduction is usually a reaction to budget overruns.
- ⇨ Cost reduction is an informal process.
- ⇨ Cost reduction generally involves only a few management personnel.
- ⇨ Cost reduction does not.

Value Engineering Quality

Value Engineering is a tool/method to enhance QUALITY

Timing the VE Effort

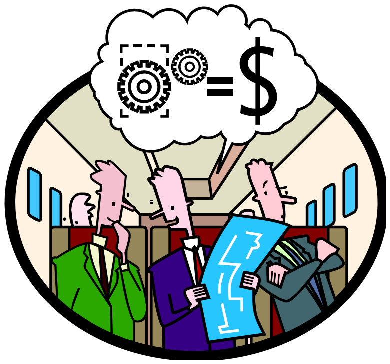


Some VE Study Objectives

- **Performance Improvement**
- **Significant Cost Savings/Avoidance**
- **Optimization of Resources (Time & Money)**
- **Review (Technical, QA) – Optional Objective**
- **Coordination (In- House & Users)**
- **Transfer Innovative Technologies**
- **Have Fun!**

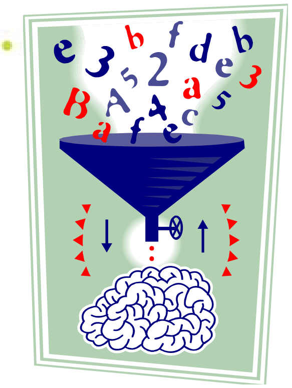
The Value Engineering Job Plan

- **Provides a systematic approach**
- **Divides the study into distinct work elements**



Value Engineering Is:

Information Phase



Purposes

- **To determine user needs**
- **To gather and tabulate information concerning the item as presently designed**
- **To build team knowledge and understanding of the project**
- **To completely understand the specific use of function requirements of the item**
- **To visit the site (preferable)**
- **Process continues throughout remainder of the study**

Information Phase

Techniques

- **Get all the facts from the best possible sources (e.g. design team)**
- **Develop cost models**
- **Determine and evaluate the function(s) of the present design**
- **Prepare a *FAST* diagram**
- **Identify & define project Performance Criteria**
- **Develop project Performance Ratings**
- **Determine present design objectives & constraints**
- **What does the customer want?**

USE GOOD HUMAN RELATIONS

Why is Functional Analysis Important?

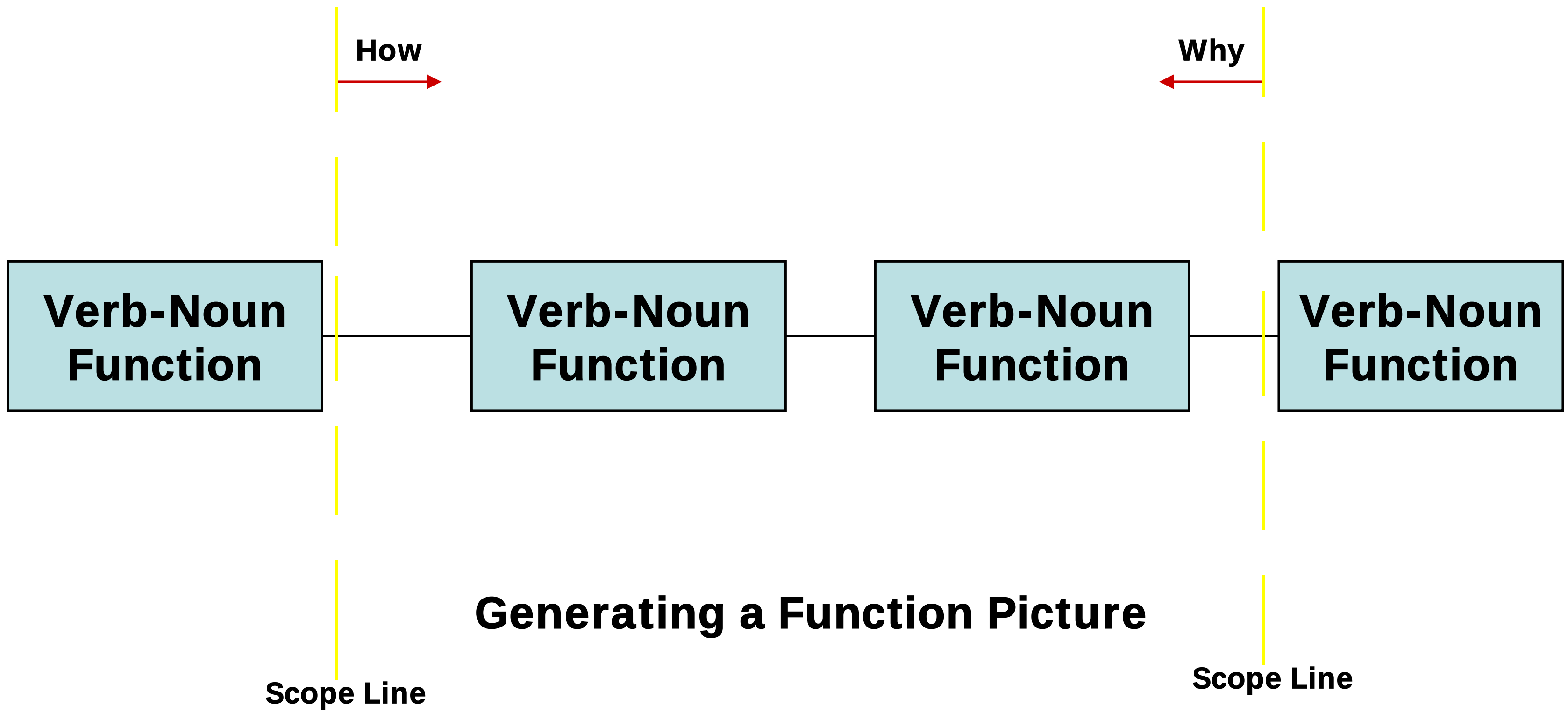
- You can't always get what you want!
- You can't always get what you want!
- You can't always get what you want!
- BUT – if you try, somehow you just might , from time to time, get what you need!
- Function Analysis defines user's needs through verb-noun pairings

Function – The

- **Specific purposes or intended use of an item (What is this? What is it supposed to do? What else can it do?)**
  - Function is that which makes a product, process or project work or sell.
  - All cost is for function.
  - Primary functions posses value and are required to make a product work or sell.
  - Secondary functions have no value and are present due to the current design of the product.
- **That characteristic that makes a product or service have value**
- **Determine by considering the user's actual needs**

FAST Diagram

Function Analysis System Technique



The Purpose of a *FAST* Diagram is

- Show specific relationships of all functions with respect to each other
- Deepen the understanding of the problem to be solved
- Promote discussion and information gathering – team building
- Support the process of creativity

FAST Diagrams

HOW?

WHY?

Design Objective

"All The Time" Function

Higher Order Function

Primary Function

Secondary Function

Secondary Function

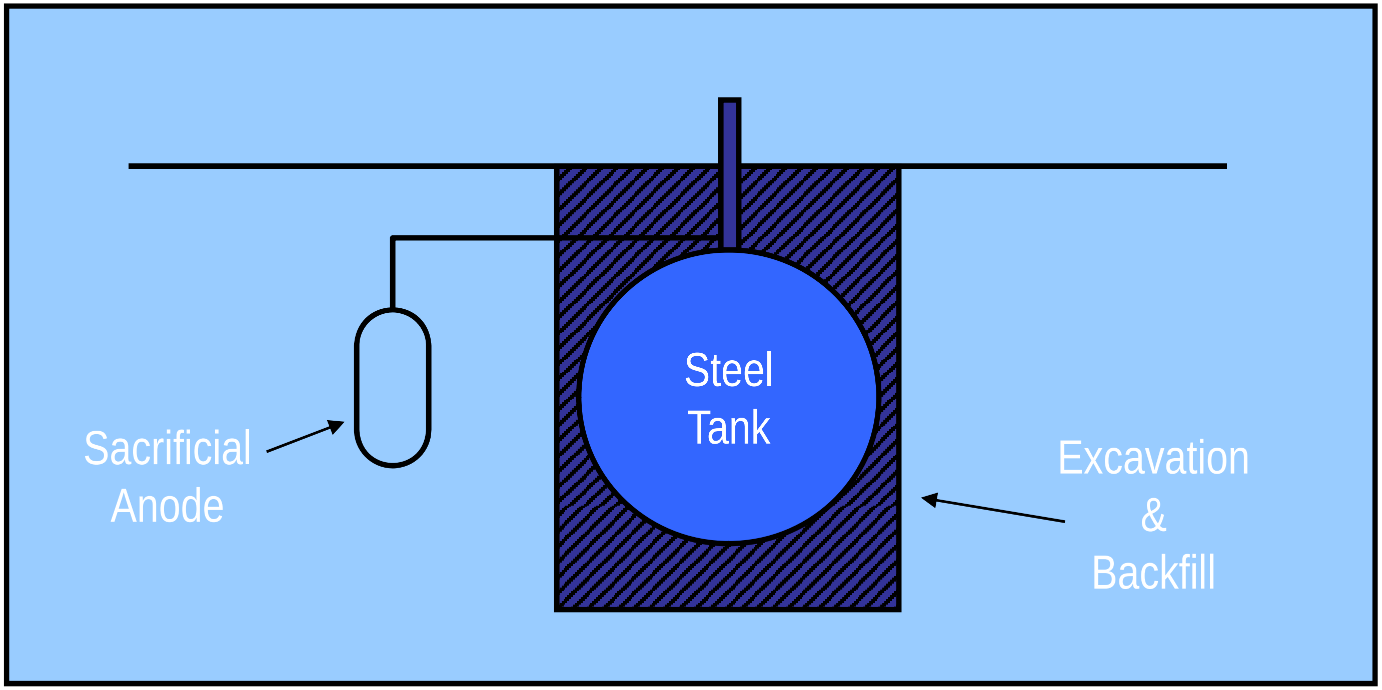
Assumed Function

WHEN?

Required Secondary Function

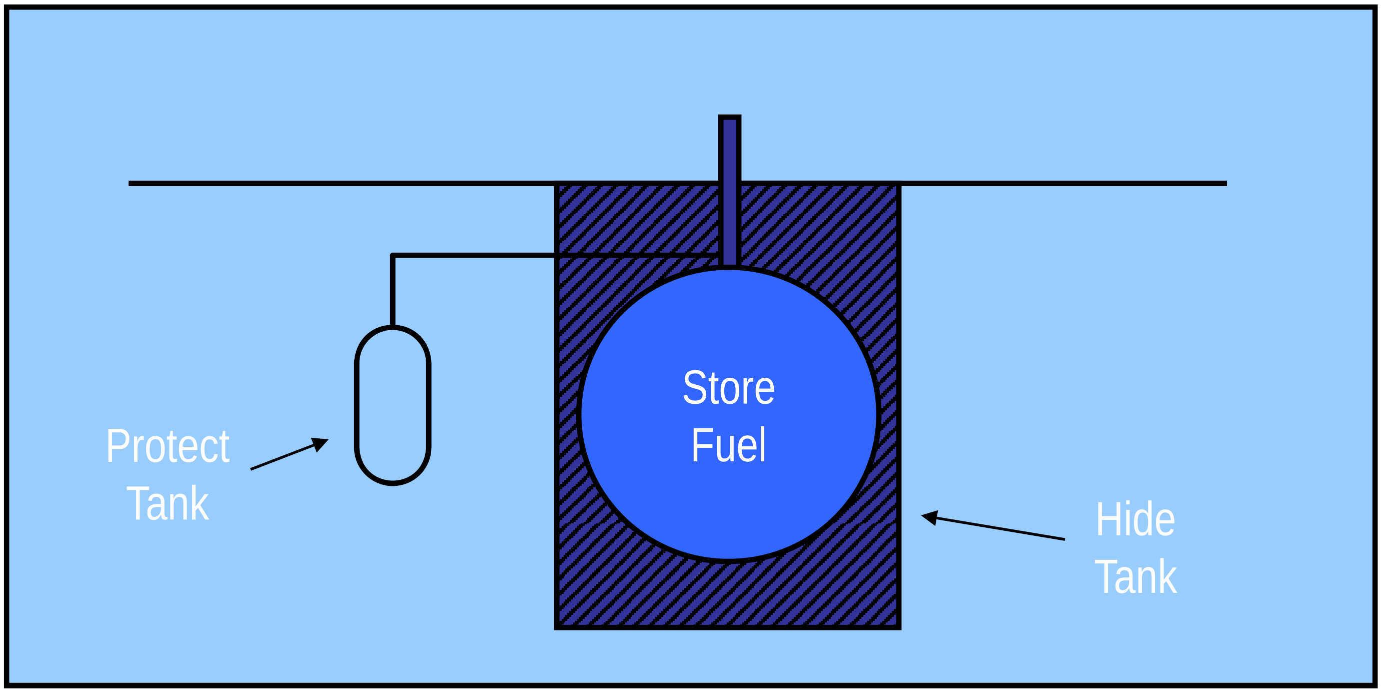
Function Analysis

- **Fuel Storage System**



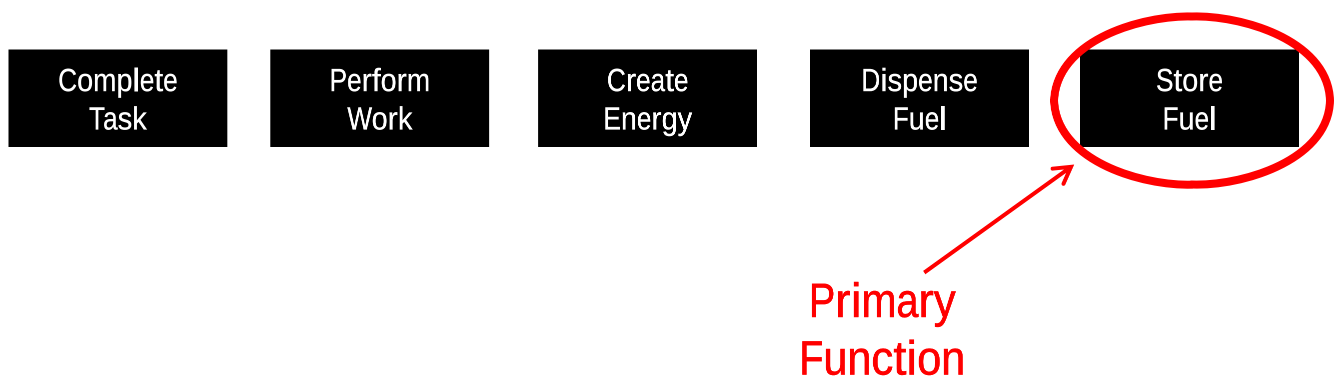
Function Analysis

- **Identify the functions**



Function Analysis

- **Identify the “scope”**



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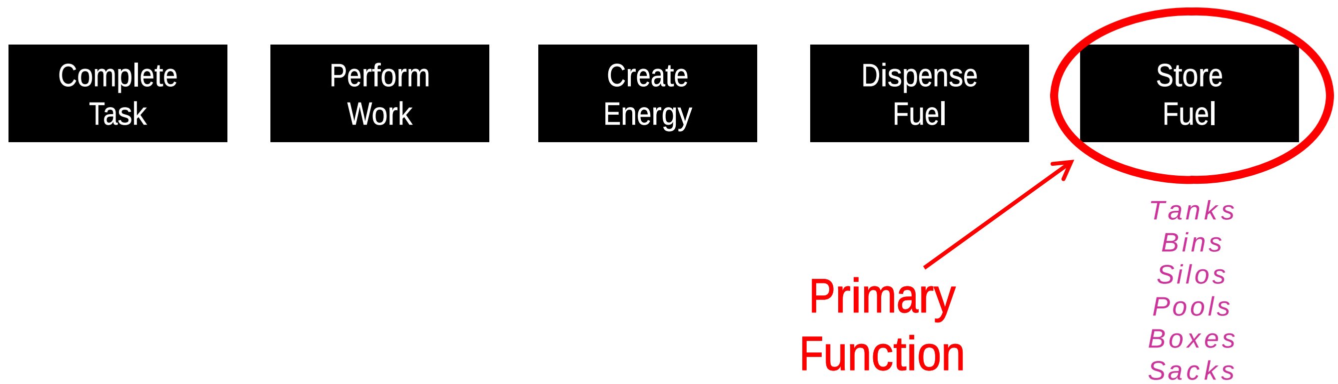

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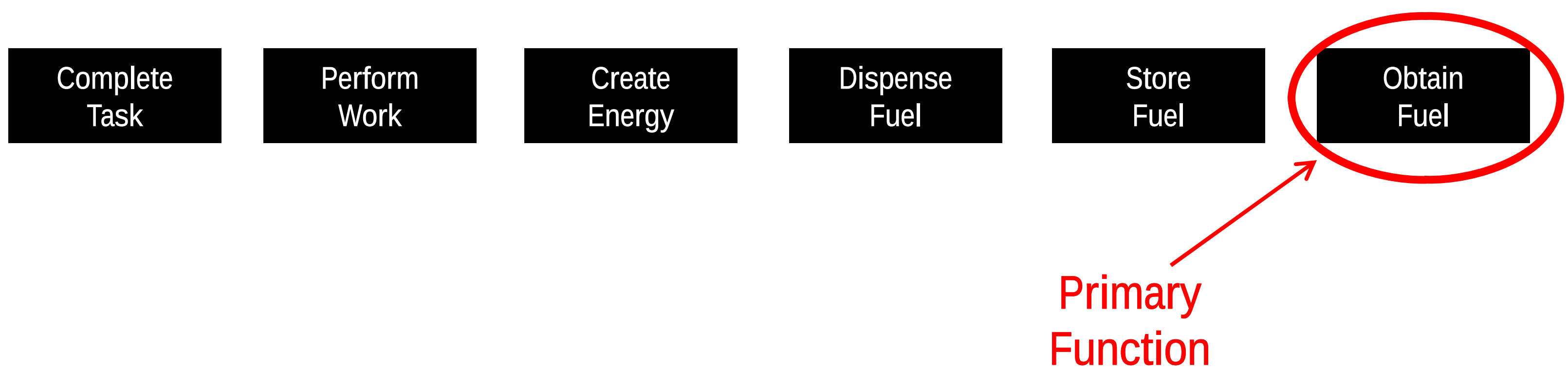

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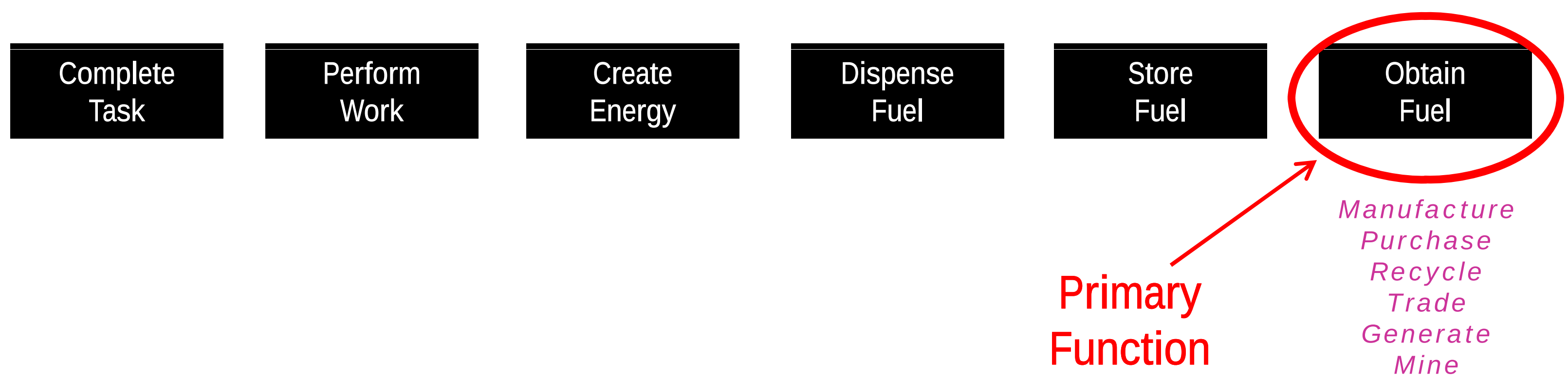

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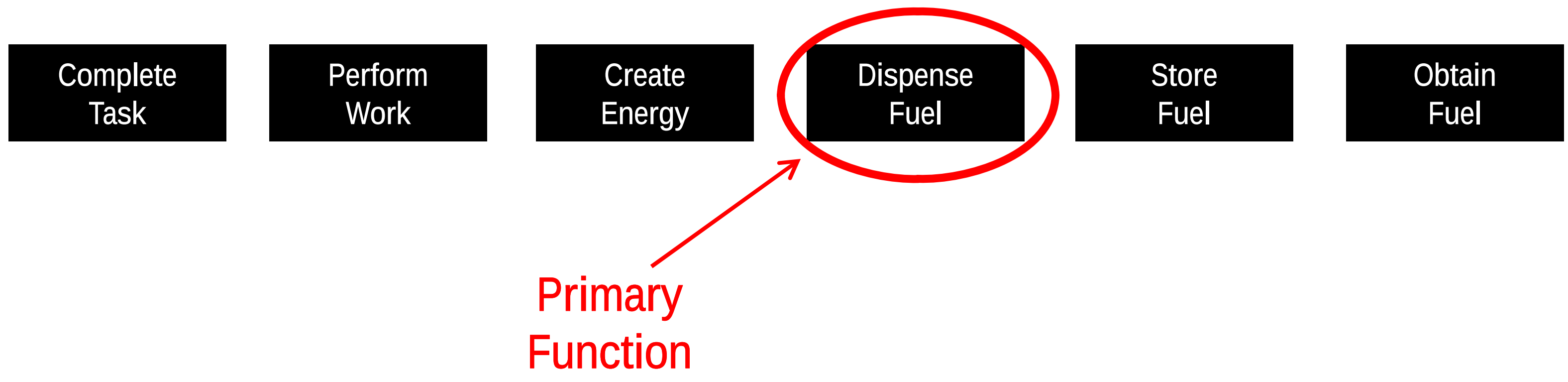
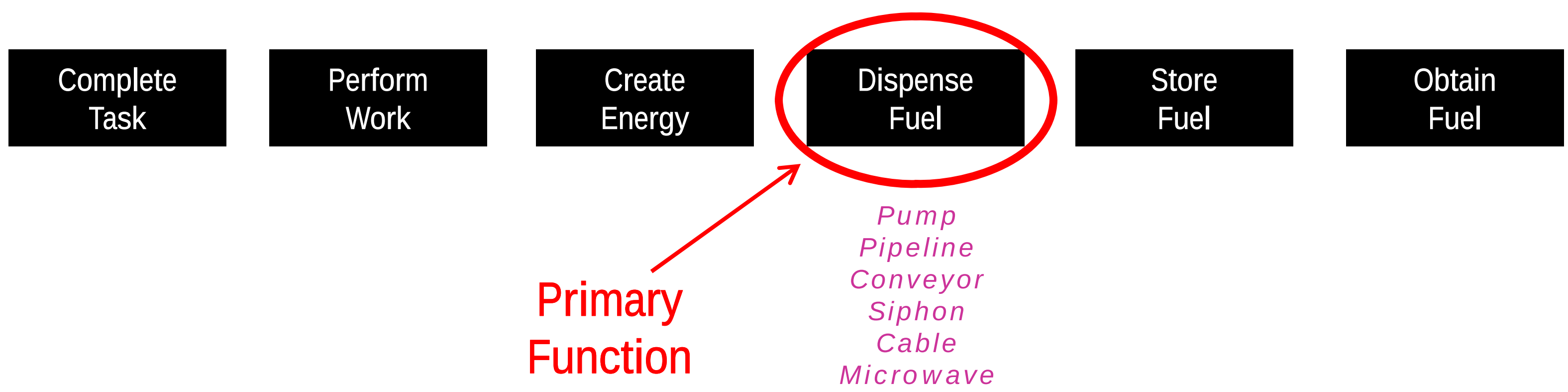


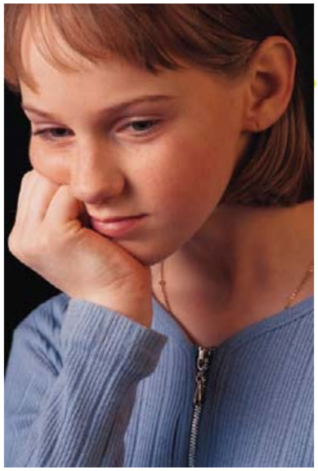
Function Analysis

- **Identify the "scope"**



Speculation Phase

Purposes



- **To generate a large number of alternatives that provide the item's basic function(s) without considering their practicality**

Speculation Phase

Techniques

- Use creative thinking
- No rules – no limits
- Forget about scope, speculate on the FUNCTION - not on the item
- Don't let regulations or people control your thinking
- If you don't look for the *second* right answer, you won't find it
- Eliminate/simplify: modify and/or combine alternatives
- Think – get out of the comfort zone and enjoy it!
- Keep talking, keep generating, let the juices flow!
- Its about **CHANGE!**

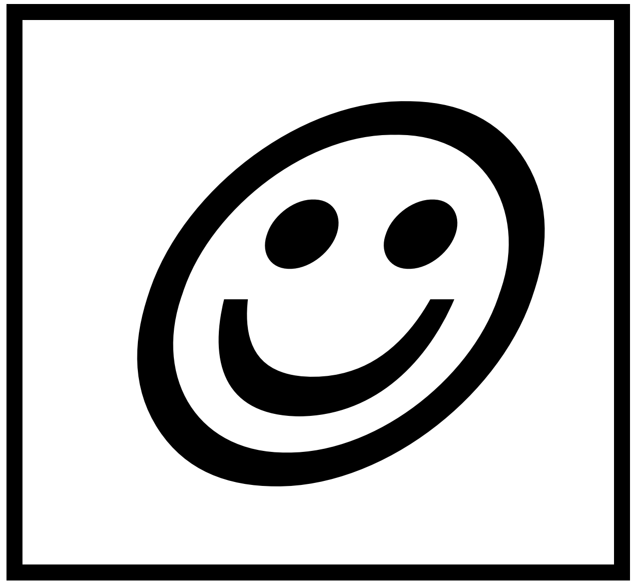
USE GOOD HUMAN RELATIONS

We'all'in's never done it that way before!!

?

?

Regulations and Guidelines are sacred!



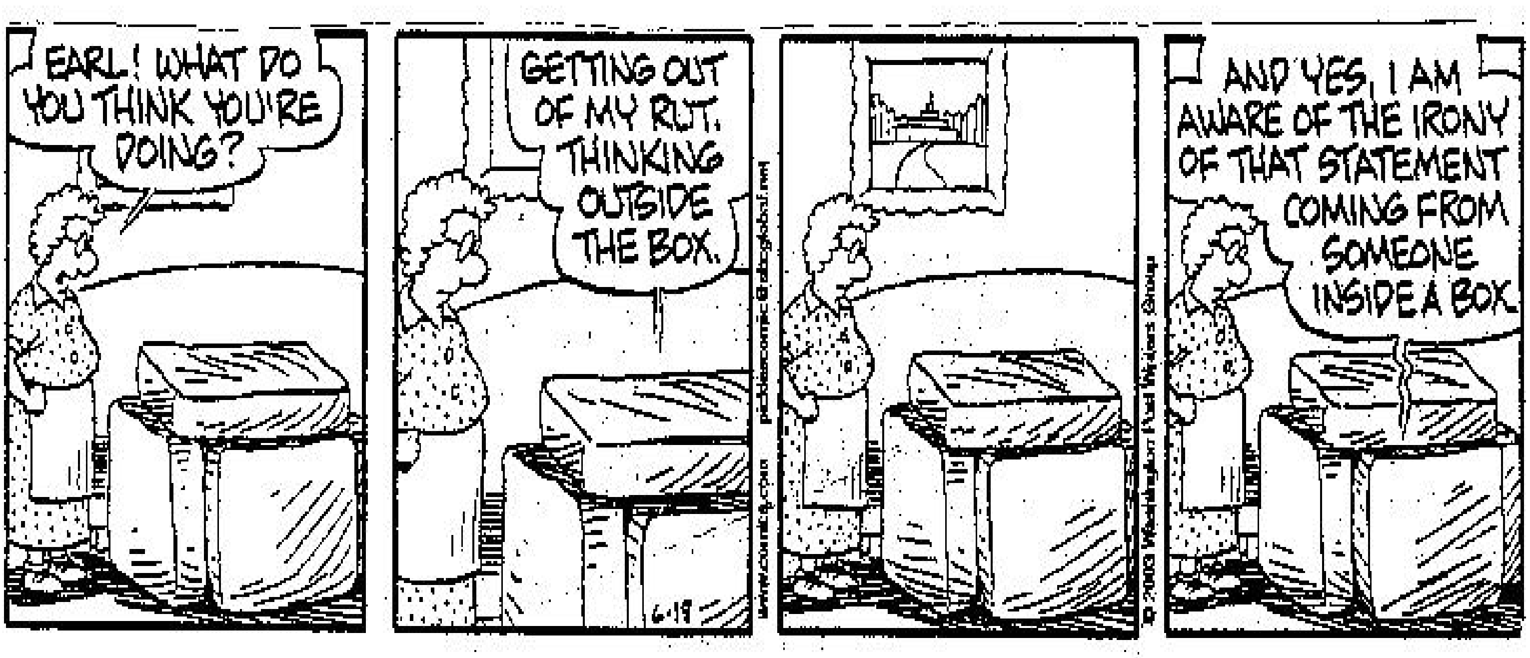
What will my boss think?

?

What if it doesn't work?

?

Creativity


EARL! WHAT DO YOU THINK YOU'RE DOING?
GETTING OUT OF MY RUT. THINKING OUTSIDE THE BOX.
AND YES, I AM AWARE OF THE IRONY OF THAT STATEMENT COMING FROM SOMEONE INSIDE A BOX.

Creativity

Brainstorming Rules & Objectives…

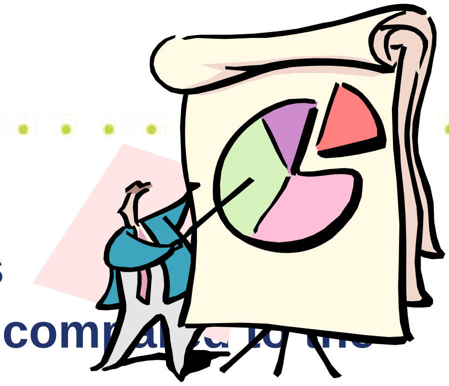
- **Criticism/evaluation is prohibited (at this time)**
- **Free-wheeling is welcomed and encouraged – be uninhibited and think as a child**
- **Be spontaneous – rapid fire 'gut feels'**
- **Quantity is desired over quality – cover the walls**
- **Combine and add to ideas**
- **Build upon another person's ideas**
- **How do others solve similar problems**
- **Record <u>all</u> ideas**

There Are No Dumb Ideas!

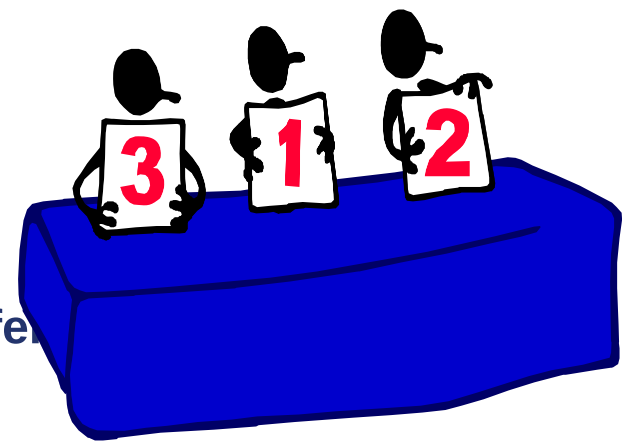
OK, so some of the ideas were dumb!
Which leads us to…….

Analysis Phase

Purposes



- **To evaluate, criticize, and rank alternatives**
- **Identify advantages and disadvantages as com… baseline project**
- **Which alternatives offer the best combination of:**
  - Design-ability
  - Construct-ability
  - Operational ease
  - Quality assurance
  - Customer satisfaction
  - And… low life-cycle cost
- **To develop alternatives that offe… value**



Analysis Phase

Techniques

- **Prior experience**
- **Collective 'Gut" feels**
- **Stakeholder input**
- **Use cost references**
- **Apply matrix techniques**
  - Define performance measures
  - Weight and rank measures
  - Evaluate alternatives
- **Make sketches**
- **Consult experts**
- **Use your own judgment**

USE GOOD HUMAN RELATIONS

You gotta also consider…
Life Cycle Cost Analysis! (LCC)

- **A definition…**
  "The systematic evaluation of alternative designs and the comparison of their projected development/design, construction, operation/maintenance and disposal costs or salvage value over a specified time period."

In other words, LCC is…

- Simply put… Consider all the costs!
- Total LCC = Initial Cost + Ownership Cost + Salvage value/disposal costs
- Deceptive… For example, security was typically a minor cost, but can now be a major consideration.
- LCC gives decision makers a complete awareness of Big Picture

Development Phase

Purposes

- **To select the best alternative(s)**
- **To develop complete written and oral proposals**

Development Phase

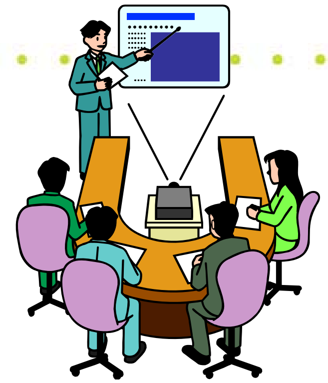
Techniques

- **Recommend specifics, not generalities**
- **Make sure your report describes the disadvantages as well as the advantages**
- **Gather convincing facts**
  - Assure technical adequacy
- **Spend your client's money as you would your own**
  - Complete order-of-magnitude cost estimate w/LCC
- **Prepare Proposal**
  - Finalize *FAST* diagram for proposal
  - Sell the idea through the justification
  - You *are* selling something uncomfortable to most people – CHANGE!
- **Misteaks will cast doubt on your validity**

USE GOOD HUMAN RELATIONS

Presentation Phase

Purposes



- **To present value engineering study proposal(s) to the decision makers/stake holders**
- **To obtain approval/support**
- **To enhance potential implementation**

Presentation Phase

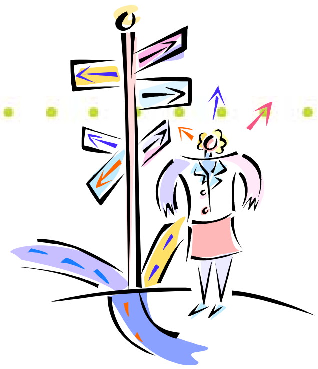
Techniques

- Again, you are selling **CHANGE!**
- Your enthusiasm will sell your proposal
- Use *FAST* diagram as a communication tool – Are the most important functions satisfied?
- Be brief, pertinent and convincing
- Keep it simple

USE GOOD HUMAN RELATIONS

Presentation Phase

Techniques



- **Anticipate/remove road blocks – understand their point of view**
- **Network with people and gain support**
- **BUT – you can't please everybody**
- **AND – don't overload the cart with too much information**

USE GOOD HUMAN RELATIONS

How to find out more about VE...

SAVE INTERNATIONAL

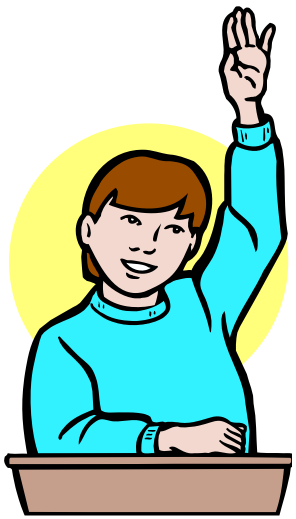
- A Value Engineering Professional Society
- Information about becoming a Certified Value Specialist
- Professional journals, annual conference
- Web site lists local chapters
- Also lists VE consultants and specialists

Important Links

- **SAVE International**
  - www.value-eng.org

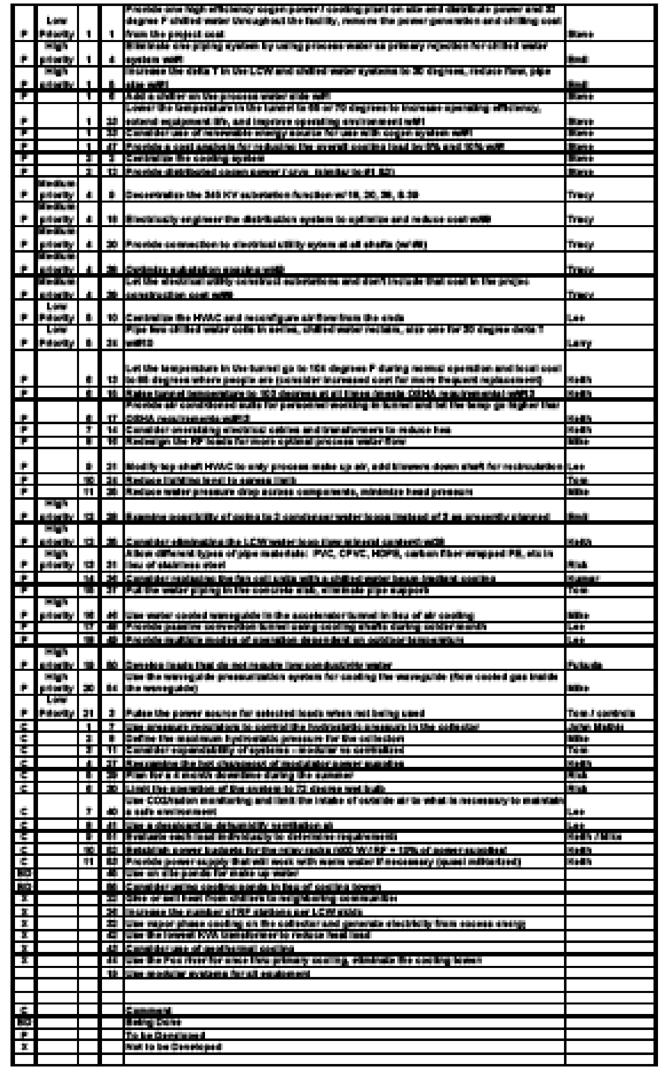
Questions

Don’t be shy!



Results of VE Workshop

- Our first VE study had 55 total Proposal that fit into 20 groups
- Resources ran dry before the proposals could be evaluated.



VALUE ENGINEERING COMMENTS

1. ***Provide Distributed Cogeneration Power/Cryo (Speculation List Item No 12).***

Current ILC design leans toward providing under the project construction costs all mechanical and electrical services to the accelerator from several utility plants distributed among 7 main sites along the tunnel. This idea considers using an alternative financing mechanism (e.g. ESPC, etc.) to transfer the construction costs of cogeneration to the project's future operating cost stream (without increase) where it can be amortized out of energy cost savings, thus practically eliminating the current costs for utility plants from the project construction. In other countries the ESPC concept might likely be replicated through investment loans. This idea would provide separate cogeneration plants at each of the 7 main sites. The cogeneration plants could likely provide cooling for the cryogenic, chilled water and process water systems and heat for desiccant dehumidifier regeneration, in addition to electrical power for the accelerator. Plant operation and maintenance is typically handled by the ESPC contractor and is also paid for out of the energy cost savings stream.

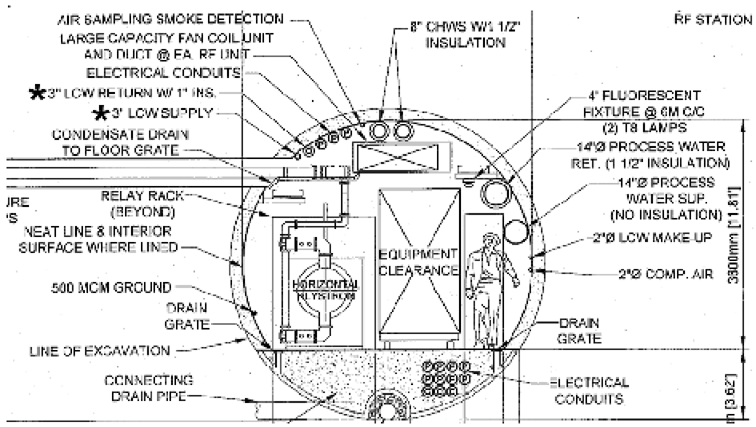
The use of ESPCs (Energy Savings Performance Contracts) and similar alternative financing vehicles for retrofits and new construction is currently being heavily promoted by DOE in the United States. For example, a memorandum dated August 3, 2007 was circulated by the Executive Office of the President – Council on Environmental Quality entitled "Substantially Increasing Federal Agency Use of Energy Savings Performance Contracting". DOE's Federal Energy Management Program also features the use of ESPCs for new construction on GSA's Gulfport Courthouse at this link:

http://www1.eere.energy.gov/femp/newsevents/fempfocus_article.cfm/news_id=7287

It seems probable that something like 150MW of cogeneration will provide all 65,000 tons of cooling usable at the ILC, leaving the remaining power to likely be purchased from suppliers or generated by other means.

Some of the construction and operating cost benefits from using cogeneration under this idea are discussed in Speculation List Items #6, #23 & #47. This arrangement of 7 distributed cogeneration plants might likely provide 45F (7C) chilled water from waste heat absorption chillers for use in a combined Chilled/Process Water main system that would also cool cryogenic compressor heat through a heat exchanger in lieu of cooling towers. The higher delta-T in the Process Water system would allow this entire load to be carried in the current 14" main size and eliminate the current 8" chilled water mains completely. The current arrangement of water mains in the tunnel that is being discussed above is shown in the drawing in the next page.

14" main size plus the current 8" chilled water mains. The current arrangement of water mains in the tunnel that is being discussed above is shown in the drawing below



The diagram below schematically illustrates a typical cogeneration plant conceptually. This plant would use the alternate steam to drive low temperature refrigeration compressors to lower the absorption chillers supply water temperature from 45F (7C) to the brine temperature needed to produce 33F (1C) chilled water in the tunnel via heat exchanger.

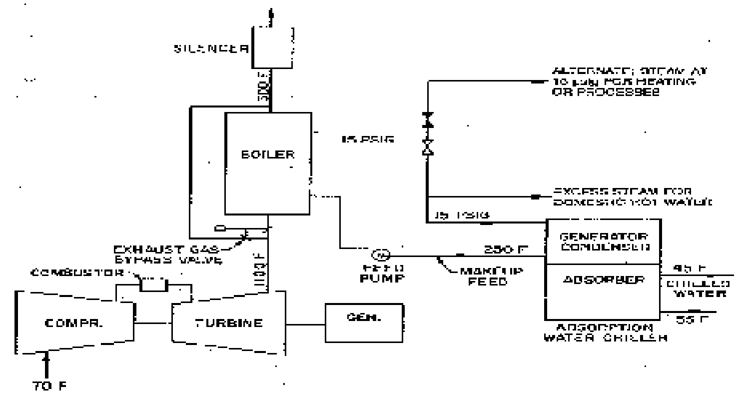


Fig. 4 Typical Heat Recovery Cycle for Gas Turbine

Proposal #12 Description

Cost escalation projections from the 2007 annual Supplement to the National Institute of Standards and Technology (NIST) Handbook 135 used by DOE are shown below for electric power and natural gas (a possible cogeneration plant fuel source). They indicate a continuing cost advantage from using natural gas over electricity in the industrial market for the Illinois area over the next 30 years, which further supports cogeneration here.

Table Ba-2. FEMP UPV* Discount Factors adjusted for fuel price escalation, by end-use sector and fuel type.

[illegible]

Typical costs (to be amortized under ESPC) for various types of cogeneration (CHP) plants are shown below for reference only.

Table 2. Summary of Cost and Performance Parameters for Distributed Generation Technologies

Technology	Size Range (kW)	Installed Cost ($/kW) (2)	Heat Rate (Btu/kWh)	Approx. Efficiency (%)	Variable O&M ($/kWh)	Emissions (1) (lb/kWh) NO	
						NO_x	CO_2
Diesel Engine	1–10,000	350–500	7,000	35	0.025	0.017	1.7
Natural Gas Engine	[illegible]	450–1,100	[illegible]	35	0.025	0.0059	0.97
Natural Gas Engine w/CHP (3)	[illegible]	575–1,225	9,700	35	0.027	0.0059	0.97
Dual Fuel Engine	[illegible]	625–1,000	9,200	37	0.022	0.01	1.2
Microturbine	25–500	950–1,700	12,500	30	0.014	0.00049	1.10
Microturbine w/CHP (3)	[illegible]	[illegible]	12,500	30	0.014	0.00049	1.10
Combustion Turbine	500–10,000	550–1,700	11,000	31	0.024	0.0012	1.15
Combustion Turbine w/CHP (3)	500–10,000	700–1,900	11,000	31	0.024	0.0012	1.15
Fuel Cell	100–250	5,500	8,450	40	0.01–0.05	0.000015	0.86
Photovoltaics	[illegible]	[illegible]	–	N/A	0.002	0.0	0.0
Wind Turbine	[illegible]	[illegible]	–	N/A	0.010	0.0	0.0
Battery	[illegible]	1,100–1,800	–	[illegible]	0.010	(4)	(4)
Flywheel	[illegible]	[illegible]	–	[illegible]	0.004	(4)	(4)
SMES	750–5,000	[illegible]	–	[illegible]	0.020	(4)	(4)
Hybrid Systems	[illegible]	(5)	(5)	(5)	(5)	(5)	(5)

(1) [illegible] NO_x and 1.32 lb/kWh of CO_2.
(2) [illegible]
(3) Although [illegible] CHP significantly improves the fuel utilization [illegible]
(4) Storage devices [illegible] However, the emissions associated with the production of this [illegible]
(5) [illegible]

Additional Option for Consideration:

An option to be kept in mind is that the cryogenic compressors might be driven by steam turbines from the cogeneration plant rather than electric motors. This would decrease the electric power load for ILC and find more use for waste heat simultaneously, which would lower the gap between cogeneration power and the total ILC power needs. This may be easier to implement in a distributed cogeneration arrangement than a centralized one, as the cryogenic plants are also distributed under the current plan.

Conclusion

The distributed cogeneration concept has the potential to possibly reduce ILC project construction costs significantly, while enhancing operations and reducing environmental emissions. It should be compared against the centralized cogeneration concept in Speculation List Item #1 for conceptual optimization. Although similar to the centralized cogeneration concept and possibly simpler to design, it seems to lack some of the features and flexibility of the other Item, and still requires substantial industrial plants (vapor plumes, etc.) to be built in the communities outside of the central site, as does the current design.

Cost Proposal Example

	COST ESTIMATE WORKSHEET				
	Speculation Item # 13				
	DELETIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	4" dia sch 10 stainless steel LCW pipe	LF	2,600	$59.00	$153,400
	3" dia sch 10 stainless steel LCW pipe	LF	6,500	$48.50	$315,250
	(Shaft 7)				$0
					$0
					$0
			Total Deletions		$468,650
	ADDITIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	4" diameter CPVC LCW pipe	LF	2,600	$42.00	$109,200
	3" diameter CPVC LCW pipe	LF	6,500	$31.50	$204,750
	Additional hangers	LS			$20,000
	(Shaft 7)				$0
					$0
					$0
			Total Additions		$333,950
			Net Cost Decrease		$134,700
			Mark-ups	18.00%	$24,246
			Total Cost Decrease		$158,946
	Markup includes GC overhead and profit				

Comments on Following VE Workshop

- The Formal VE process has the benefits over informal continuous VE during the normal design process.
  - **Various viewpoints provided.**
  - **Fresh eyes**
  - **Documentation**
  - **Challenges the statue quo**
- A workshop leader is needed to keep movement in a productive direction. Attending a workshop provides enough of a understanding of the process to lead a workshop.

Comments on Following VE Workshop

- Planning is very important. Review the list or participants with all of the stakeholders. Having gaps in the needed technical expertise is frustrating.
- Use both webex and video should be used for those not attending in persons.
- Budget adequate resources.
  - Preparation and Participation of project personnel
  - Consultants (Industry or lab personnel not on the project)
    - Time
    - Travel and expenses
  - Proposal Development