ENGR 333 Presentation

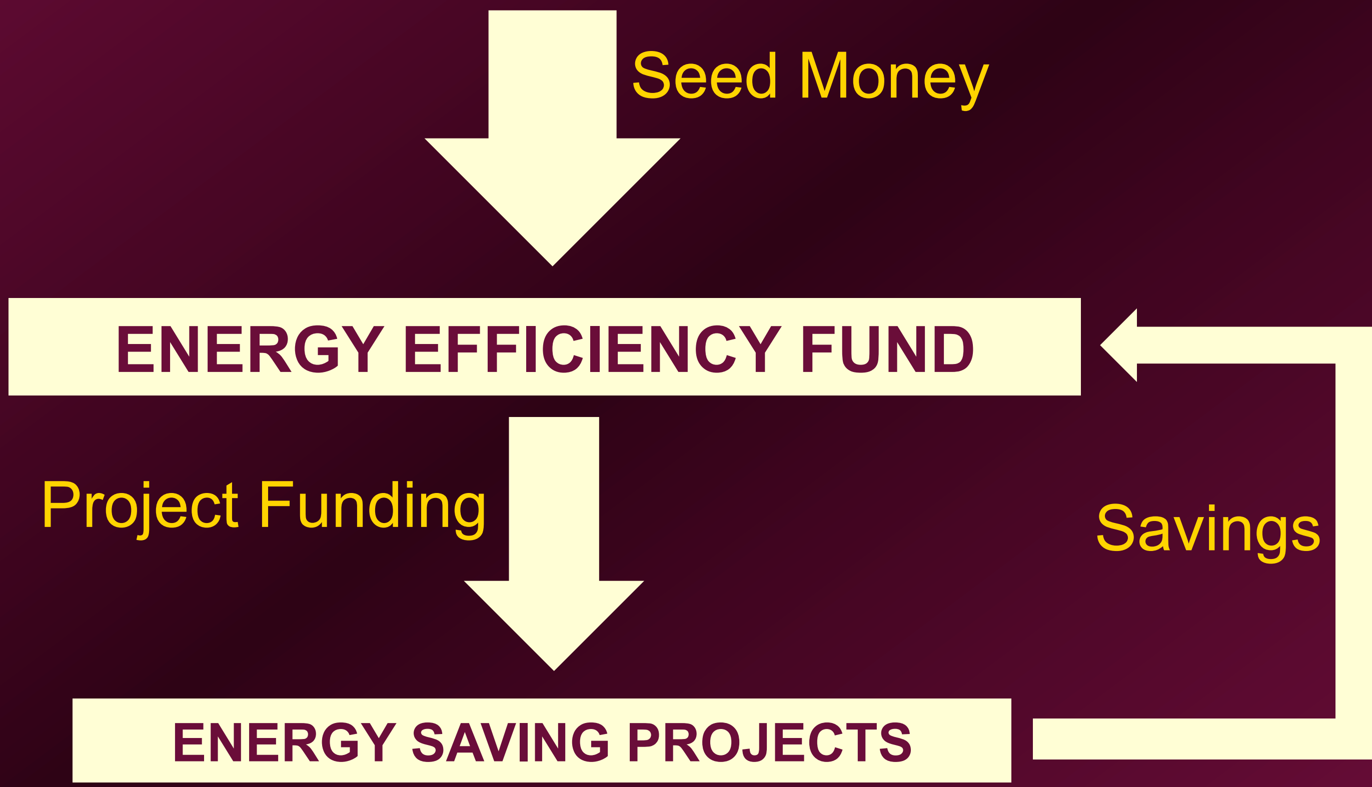
What would it take for Calvin to implement an energy efficiency fund?

Calvin Energy Efficiency Fund

CALVIN College

MY HEART I OFFER TO YOU LORD • PROMPTLY AND SINCERELY •

What is an Energy Efficiency Fund?



What Colleges Have This Type of Fund?

- **Harvard University**
  - Green Loan Fund
    - Savings ~$900,000 (30% ROI)
- **University of Michigan**
  - Energy Conservation Measures Fund
    - Projected savings of $5.7 million
- **UC Berkeley**
- **Macalester College**

Source: Diebolt, Asa. *Creating a Campus Sustainability Revolving Loan Fund: A Guide for Students ©2007*

Why is this Type of Fund Important?

- Conserves energy and money
- Educates about sustainability and fiscal responsibility
- Improves record and visibility of creation care
- Recycles savings to make change

The Question

What would it take for Calvin to implement an energy efficiency fund?

Answering the Question

Policy Group

- Develop structure and policies to govern the Calvin Energy Efficiency Fund (CEEF)

Technical Groups 1-3

- Research and analyze proposed CEEF projects for energy savings

Financial Group

- Analyze financial cash flows of CEEF and proposed projects

Policy Group

- Mission Statement
- Management
- Project Types
- Project Life Cycle
- Cost Responsibilities
- Allocation
- Project Hand-off

CEEF Mission Statement

Energy

“We continually investigate new technologies for *improved energy systems* and *more efficient use of energy resources*.”

“Promote linkage between *energy conservation* effort with programs to *reduce carbon dioxide emissions* and contributions to global warming.”

Calvin Energy Efficiency Fund

“…starting points for education and action.”

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CEEF Mission Statement

The purpose of the Calvin Energy Efficiency Fund is to pursue our calling to be stewards of God's creation by implementing a process through which Calvin's Campus can promote and realize a goal of *energy stewardship* and accommodate *renewable and sustainable energy- and cost-saving* projects.

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CEEF Management

CEEF Board

- Final project approval
- Allocates finances

CEEF Intern

- Liaison b/w Board & Club
- Leads CEEF Club

CEEF Club

- Conducts research and savings analysis

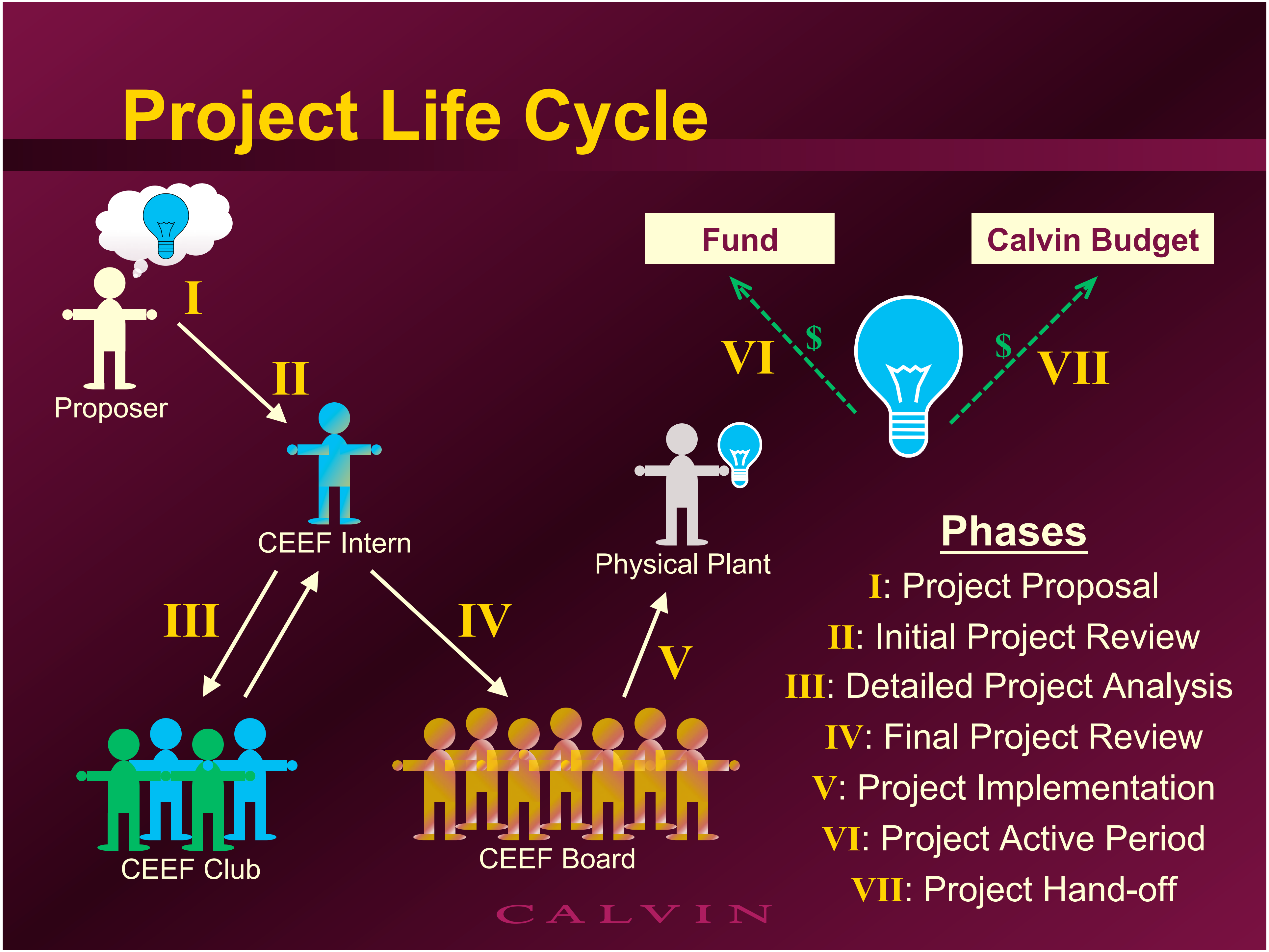
CEEF Project Types

Blue Projects

- Short term energy efficiency projects
  - ≤ 10 yr payback

Green Projects

- Reduce carbon emissions
- Raise awareness for sustainability and renewable energy
- Long term energy efficiency projects
  - > 10 yr payback


Project Life Cycle
Proposer
I
II
CEEF Intern
III
IV
CEEF Club
CEEF Board
V
Physical Plant
Fund
Calvin Budget
VI
$
$
VII
Phases
I: Project Proposal
II: Initial Project Review
III: Detailed Project Analysis
IV: Final Project Review
V: Project Implementation
VI: Project Active Period
VII: Project Hand-off
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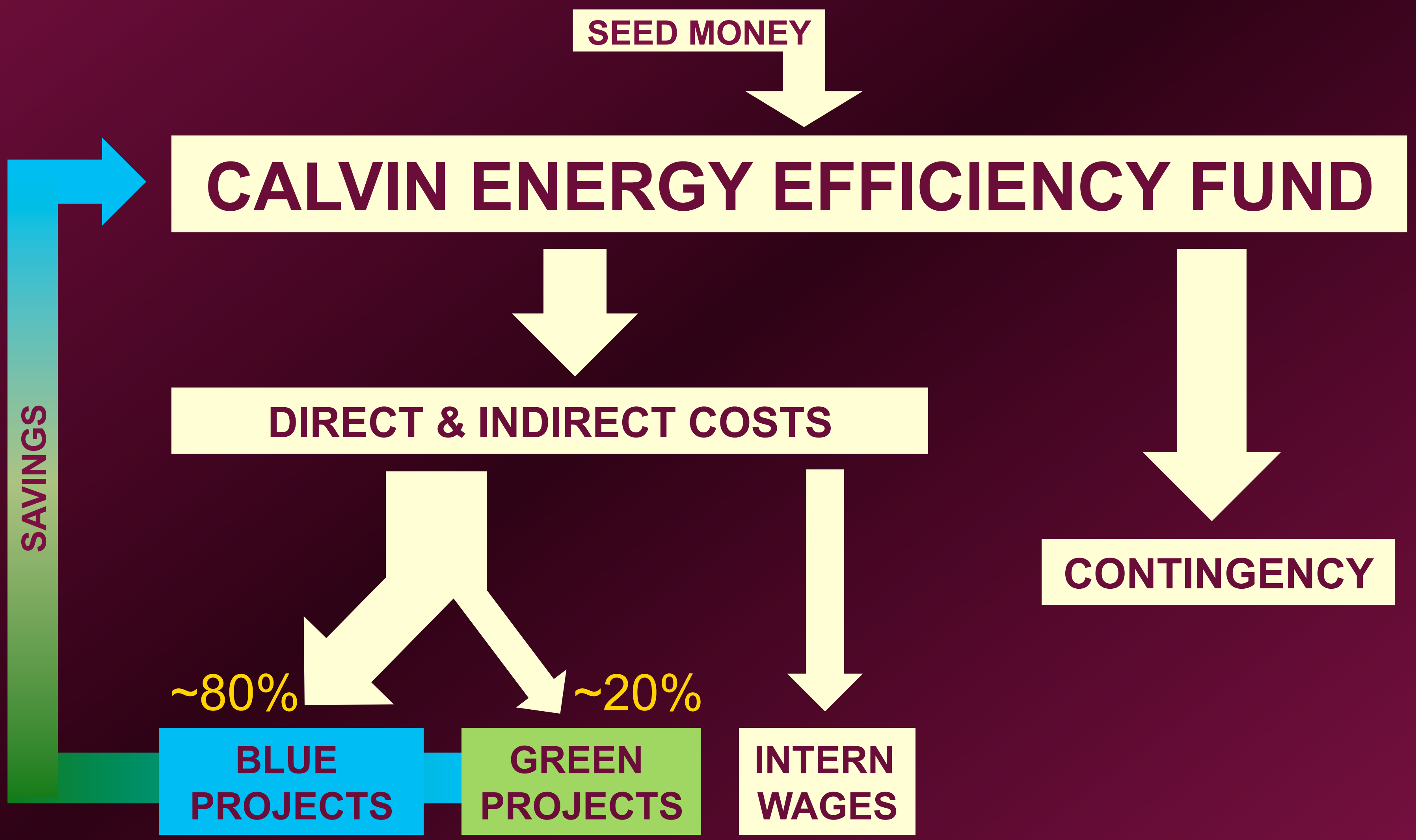
Cost Responsibilities

- Direct Costs
  - Differential Project Costs
    - Labor
    - Materials
    - Maintenance
- Indirect Costs
  - CEEF Intern Wages

CEEF Allocation



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CEEF Project Hand-off

- Release of Project from CEEF
  - 5 years after complete payback period
    - In out-year dollars
  - All costs and savings assumed by Calvin College

CEEF → CALVIN COLLEGE BUDGET

Proposed CEEF Projects

1. Solar path lights / switch to LEDs
2. Get rid of food trays in dining halls to cut down on dish washing and food costs
3. Decrease mowing / lawn care costs with more gardens / wooded areas
4. Add radiator thermostats to each dorm room (regulate dorm heating better)
5. Hand dryers in restrooms instead of paper towels
6. Isolate air conditioning to offices and labs in the summer
7. More efficient dryers in dorms or promote use of clothes lines for drying laundry instead
8. Consolidate or ban mini-fridges in dorms and replace with large kitchen fridge system
9. Use exhaust heat from the dining hall ovens and/or wash/dry cycle to heat the dining hall and/or nearby buildings
10. Recycle rain and snow melt water for irrigation
11. Disable handicap doors when button is not pressed so door shuts quicker during normal operation
12. Recycle drinking fountain waste water
13. Reroute Sem. Pond to produce hydro-electric power
14. Bookstore textbook reservation boxes that can be returned and reused
15. Food scrap composting bins in the dining hall
16. Install push button sink faucets and/or showers in dorms
17. Professors use electronic distribution and submission of assignments, notes, etc.
18. Students pay for trash (especially at move-out time)
19. More efficient toilets (less water used in flushing)
20. Campus safety on bikes, hybrid cars or Segways (decrease campus safety car usage in general)
21. Provide incentive for students and professors to walk, take the bus, or ride bikes to campus
22. More efficient dining hall ovens and/or dish washers/dryers.

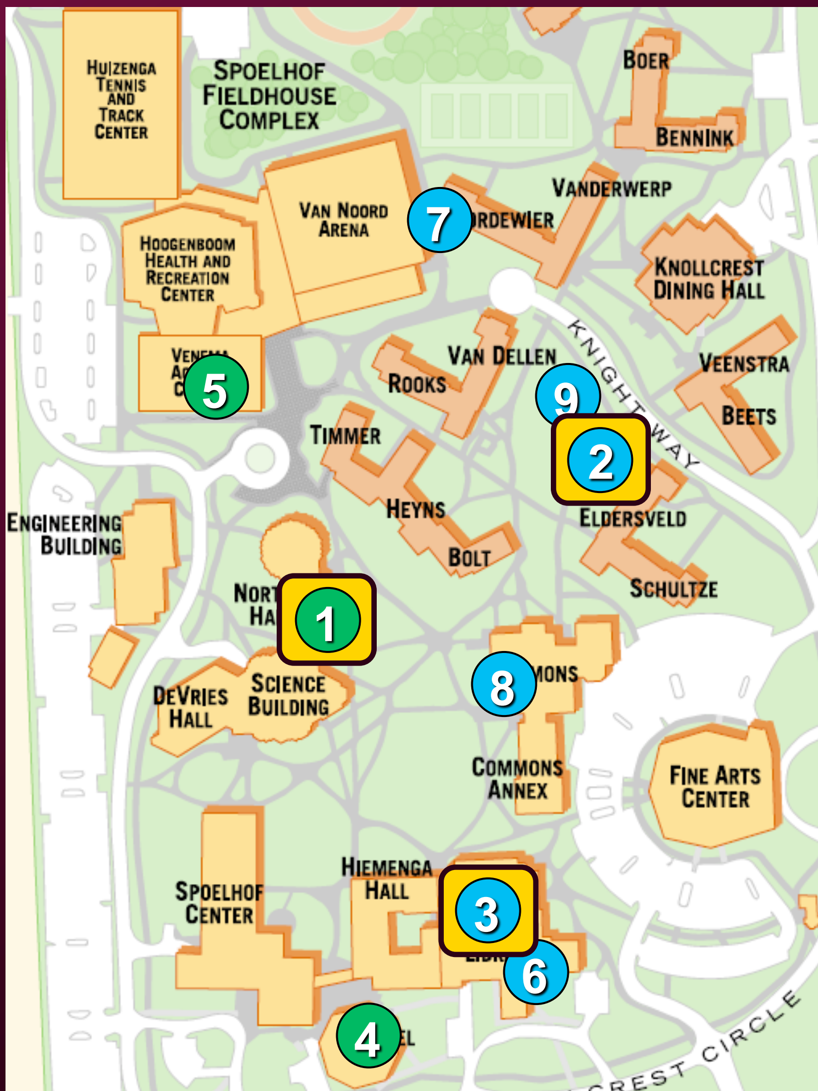
Proposed CEEF Projects

1 2 3 4 5 6 7 8 9

Project Specifics:

- Proposed Project
- Project Details
- Energy Savings
- Upfront Costs

Proposed CEEF Projects



Tech Group 1
1. Light Replacement
2. Motion Sensors
3. Light Harvesting

Tech Group 2

4. Chapel Airlock
5. Solar Water Heating
6. Forced Computer Shutdown

Tech Group 3

7. Dorm Tunnel
8. CDH Windows
9. Dorm Hall Lights

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Tech Group 1 Project Overviews

Descriptions:

1. **North Hall - Light Replacement**

   T12 → T5

2. **Res. Hall Basements - Motion Sensors**

   Study, Laundry, Common (x2 wings)

3. **Hekman Library - Light Harvesting**

   Automatic sensors – switch off lights based on light coming from windows

   (5th Floor)

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Tech Group 1 Analysis Results

ENERGY SAVINGS / UPFRONT COSTS

	Project Location	Energy Savings [kWh/yr]	1st Year Cost Savings [$]	Upfront Costs [$]	Payback Period [yr]
1	**North Hall** – Light Replacement	45,220 (±22%)	$3,920	$59,420 (±10%) + $87.92/yr (ongoing)	**12**
2	**Residence Hall Basements** – Motion Sensors	86,420 (±18%)	$7,500	$25,900 (±10%)	**3**
3	**Hekman Library** – 5th Floor Light Harvesting	12,320 (±7%)	$1,070	$4,320 (±10%)	**3**

Note: All $ amounts are in 2008 values.

Tech Group 1 Project Details

1 North Hall - Light Replacement

Current: T12 lamps and fixtures, magnetic ballasts

Upgrade: T5 lamps, RT5 fixtures, electronic ballasts

Tech Group 1 Project Details

1 North Hall - Light Replacement

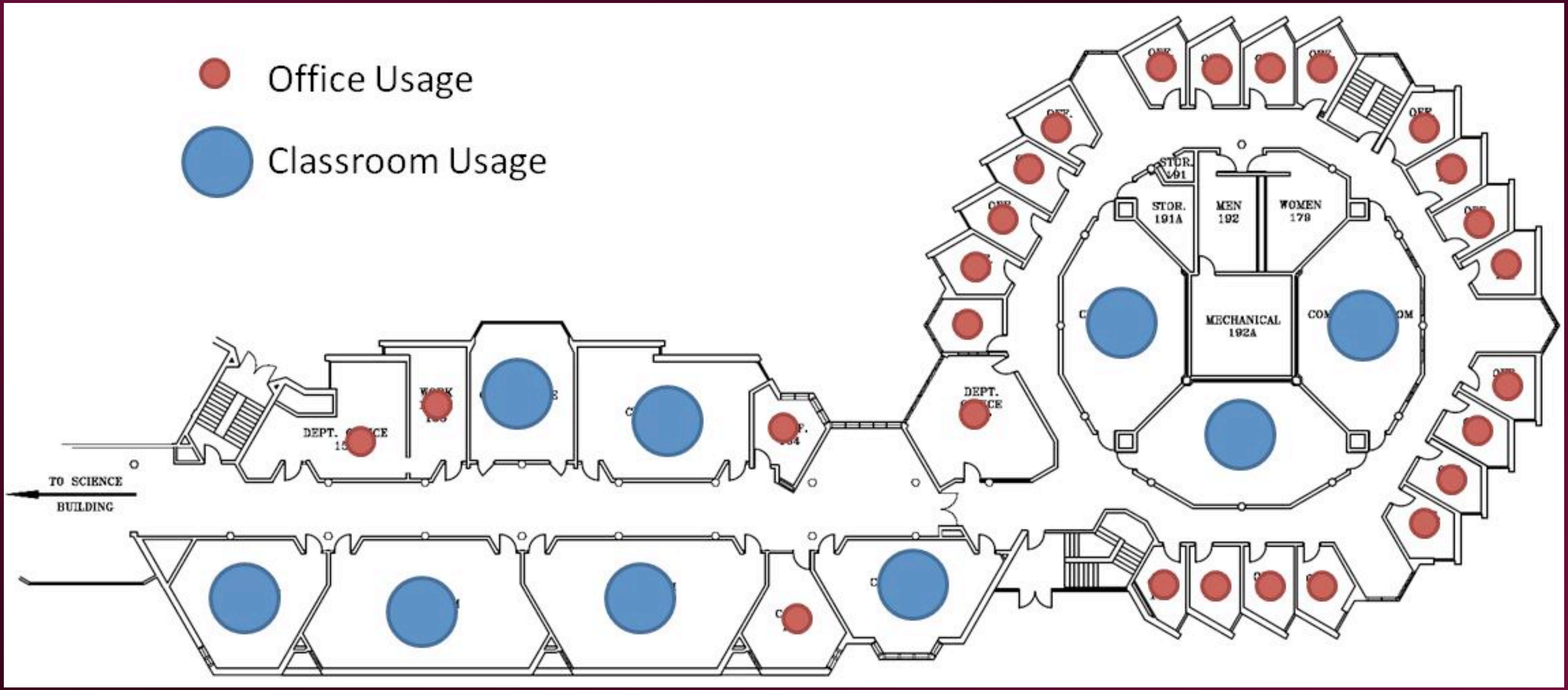


Figure: North Hall – Ground Floor Light Usage Zones

Source: Don Levy, Physical Plant

Tech Group 1 Project Details

1 North Hall - Light Replacement

Energy Consumption

Existing	Proposed
0.75 A	0.5 A
0.09 kW	0.06 kW
460 fixtures	352 fixtures
88,030 kWh/yr	42,810 kWh/yr

Energy Savings: **45,220 kWh/yr**

1st Year Cost Savings: **$3,920**

Tech Group 1 Project Details

1 North Hall - Light Replacement

Upfront Costs

- T5 lamp: $5.21 (2 per fixture)
- Electronic ballast: $35.92 (1 per fixture)
- RT5 fixture: $84.00 ea (352 fixtures)
- Other materials: $2500 per floor
- Labor: $6,160 (½ hour labor per fixture at $35/hr)

TOTAL: **$59,420.00**

Ongoing Costs

- T5 Lamp replace: ~$4.00 ea (life = 8-10 yr)

TOTAL ONGOING: **$87.92 / year**

Tech Group 1 Project Details

2 Residence Halls – Motion Sensors

Install motion detectors in all residence hall basement common areas:

- Study room
- Common room
- Laundry room

"Dual Technology"

ultrasonic + infrared

Figure: WattStopper DT-300 (Ceiling Mounted)

Source: www.wattstopper.com

Tech Group 1 Project Details

2 Residence Halls – Motion Sensors

Common Room: 4 sensors (DT-300 ceiling mounted)

Study Room: 1 sensor (DT-300 ceiling mounted)

Laundry Room: 1 sensor (DT-200 wall mounted)

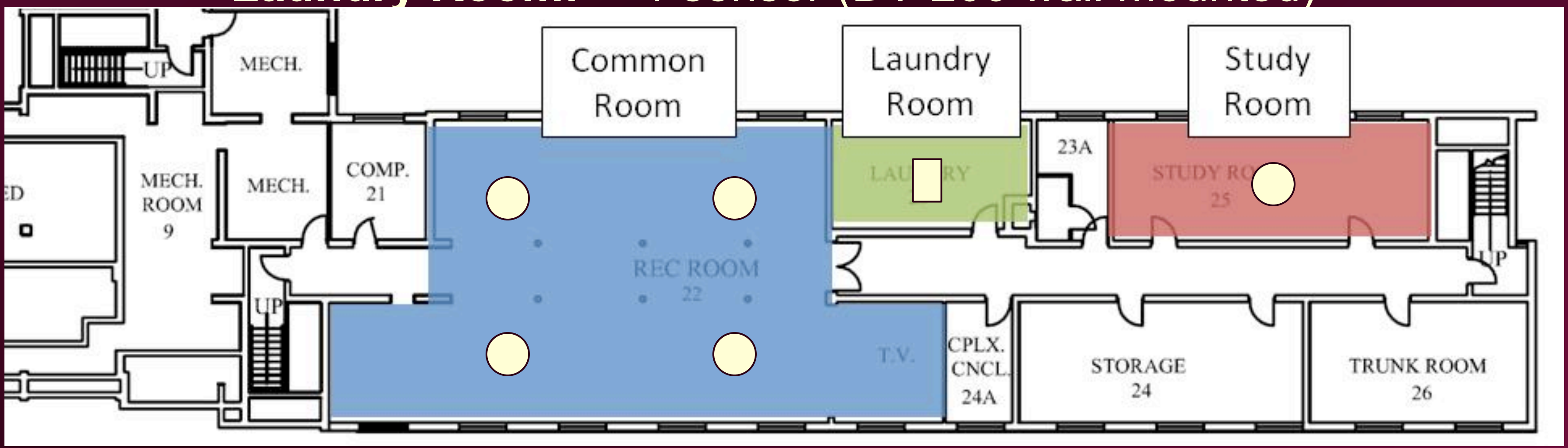


Figure: Vanderwerp Basement – Motion Sensor Rooms

Source: Don Levy, Physical Plant

Tech Group 1 Project Details

2 Residence Halls – Motion Sensors

Energy Consumption

- Usage Hours

Room	Existing	Proposed	
Study	16 hrs/day	10 hrs/day	(20 fixtures)
Laundry	12 hrs/day	4 hrs/day	(12 fixtures)
Common	24 hrs/day	16 hrs/day	(30 fixtures)

Assumption: 243 days/year (lights off in the summer)

Tech Group 1 Project Details

2 Residence Halls – Motion Sensors

Energy Consumption

Room	Existing [kWh/yr]	Proposed [kWh/yr]
Study	3,920	2,450
Laundry	2,650	880
Common	8,820	5,880
TOTAL (all 14 wings)	215,350	128,940

Energy Savings: **86,420 kWh/yr**

1st Year Cost Savings: **$7,500**

Tech Group 1 Project Details

2 Residence Halls – Motion Sensors

Upfront Costs

- DT-300 (ceiling): $150 ea (study + common)
- DT-200 (wall): $50 ea (laundry)
- Material/Labor

Study	$300/room
Laundry	$150/room
Common	$600/room

TOTAL (all wings): **$25,900**

Tech Group 1 Project Details

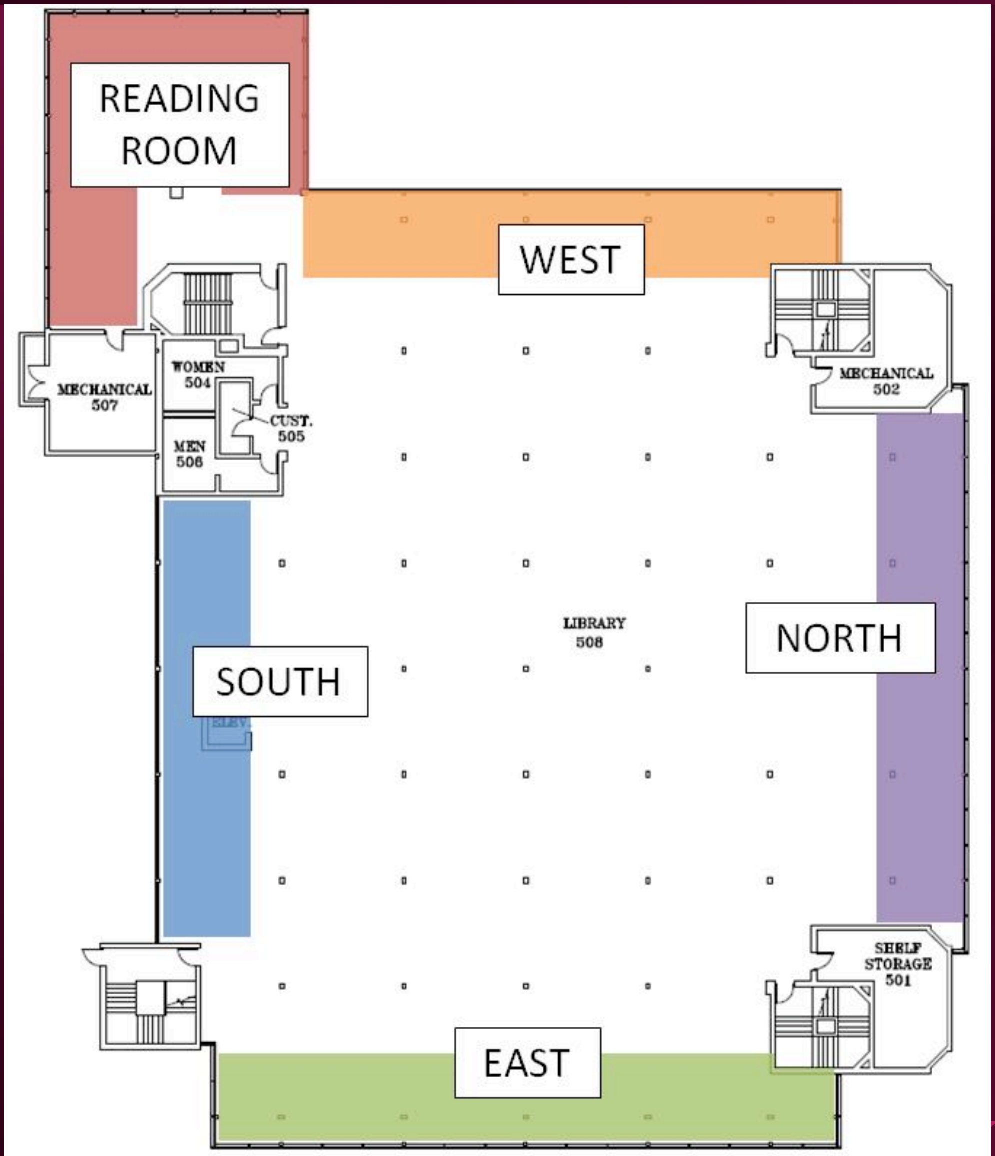
3 Hekman Library – Light Harvesting

Install "light harvesting" system on 5th Floor

Current: T8 fluorescent lamps and fixtures
0.42 A per fixture

Upgrade: Add daylight photosensors
121 fixtures in five "zones"

Tech Group 1 Project Details



3 Hekman Library

Lighting zones
- 15 ft from windows
- Five zones, controls

Light levels
- Minimum: ~ 50 fc

Simplicity
- on/off only

  no dimming!

Source: Don Levy, Physical Plant

Tech Group 1 Project Details

3 Hekman Library – Light Harvesting

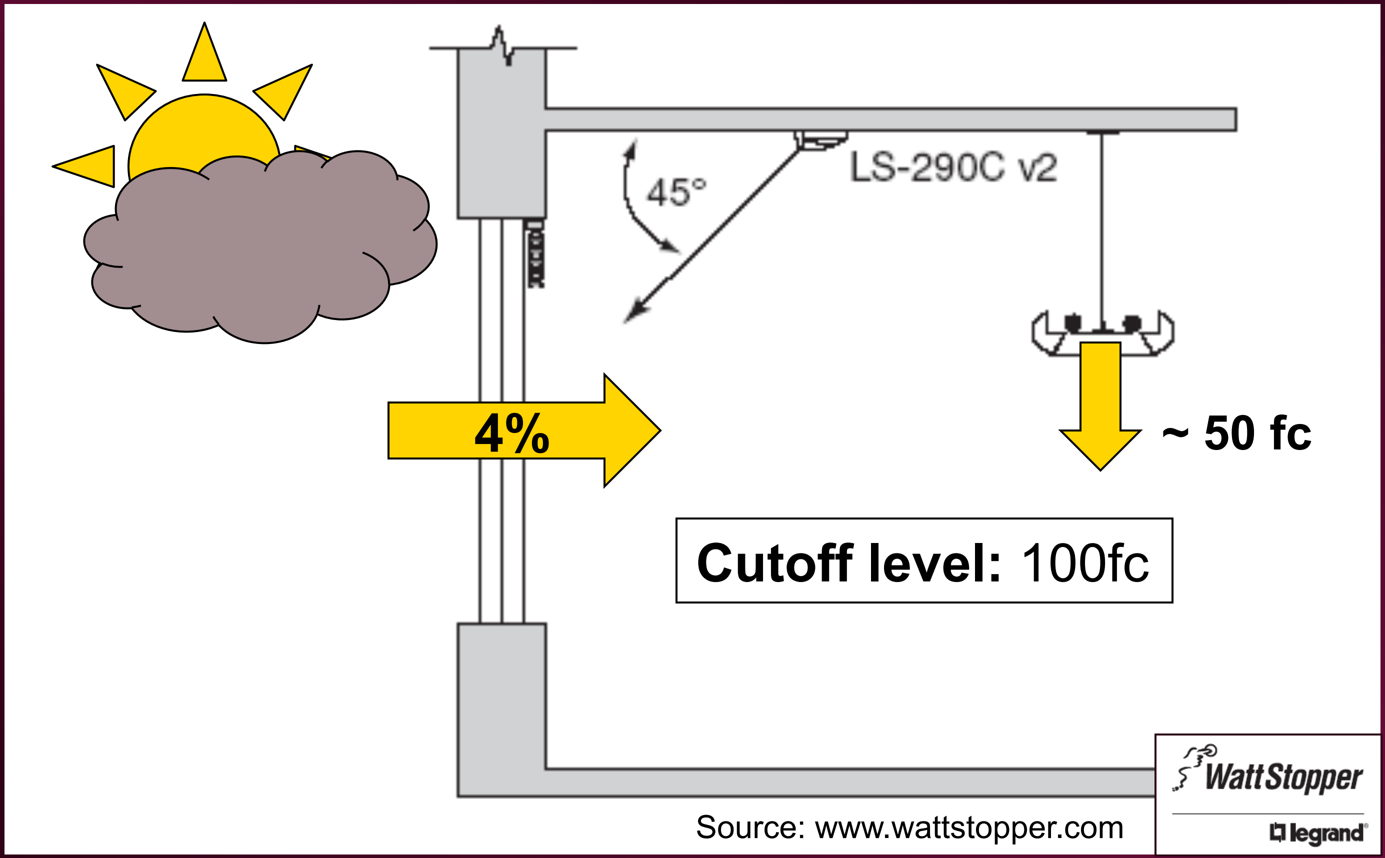


Figure: WattStopper Photosensor – LS-290C v2

Tech Group 1 Project Details

3 Hekman Library – Light Harvesting

Energy Consumption

Zone	Existing [kWh/yr]	Proposed [kWh/yr]	
North	6,930	3,670	(32 fixtures)
East	4,120	2,180	(19 fixtures)
South	3,680	1,950	(17 fixtures)
West	4,550	2,410	(21 fixtures)
Reading Room	6,930	3,670	(32 fixtures)
TOTAL	26,200	13,880	(121 fixtures)

Energy Savings:
12,325 kWh/yr

1st Year Cost Savings: **$1,070**

Tech Group 1 Project Details

3 Hekman Library – Light Harvesting

Upfront Costs

- Sensor Package: $500 ea (x5 zones)
- Other materials: $420
- Labor: $1,400 (8 hours per zone at $35/hour)

TOTAL: **$4,320**

Dimming Ballasts (option)

- Dimming Ballast: $100 ea (121 fixtures)
- Added Labor: $2,120 (1/2 hr per fixture)

TOTAL (w/ dimming): **$18,600**

Tech Group 1 Analysis Results

ENERGY SAVINGS / UPFRONT COSTS

	Project Location	Energy Savings [kWh/yr]	1st Year Cost Savings [$]	Upfront Costs [$]	Payback Period [yr]
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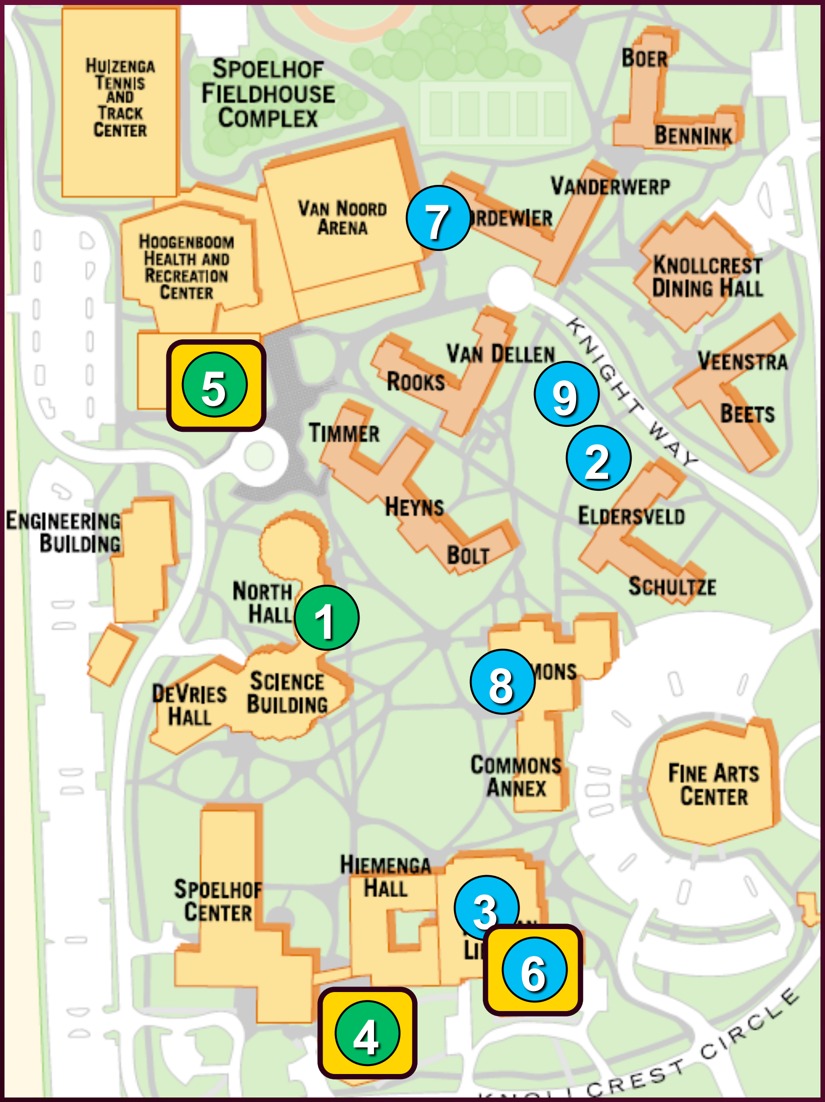
Proposed CEEF Projects



Tech Group 1
- 1 Light Replacement
- 2 Motion Sensors
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Tech Group 2
- 4 Chapel Airlock
- 5 Solar Water Heating
- 6 Forced Computer Shutdown

Tech Group 3
- 7 Dorm Tunnel
- 8 CDH Windows
- 9 Dorm Hall Lights

Tech Group 2 Project Overviews

Descriptions:

4 **Chapel – Chapel Airlock**

Vestibule on main entrance

5 **Fieldhouse – Solar Water Heating**

Solar collectors on roof to heat water

6 **All Campus – Forced Computer Shutdown**

Program to turn-off Calvin owned computers

Tech Group 2 Analysis Results

ENERGY SAVINGS / UPFRONT COSTS

	Project Location	Energy Savings	1st Year Cost Savings [$]	Upfront Costs [$]	Payback Period [yr]
4	**Chapel** – Chapel Airlock	1640 [therms/yr] (+20%/-50)	$1,400	$18,000 (±15%)	**11**
5	**Fieldhouse** – Solar Water Heating	98,800 [therms/yr] (±10%)	$81,800	$3,530,000 (+5%/-20)	**26**
6	**All Campus** – Forced Computer Shutdown	348,600 [kWh/yr] (±7%)	$30,300	$20,600 (±10%)	**0**

Note: All $ amounts are in 2008 values.

Tech Group 2 Project Details

4 **Chapel** – **Chapel Airlock**

Existing: Single bank of doors

Proposed: Double door airlock

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Tech Group 2 Project Details

4 Chapel – Chapel Airlock

Energy Savings

- Summer vs. Academic Year
- Savings based on MIT study using
  - Traffic rate (100 people/hr)
  - Pressure differential (0.01” water)
  - Number of doors (6)

Energy Savings: **1,640 therms/yr**

1st Year Cost Savings: **$1,400**

Assumption: Doors will not be held open

Auditing: Compare data to historical data

Tech Group 2 Project Details

4 Chapel – Chapel Airlock

Upfront Costs

- Construction: $18,000*

TOTAL :	**$18,000**

*This is based on a quote that will need to be updated if project is approved

Tech Group 2 Project Details

5 **Fieldhouse – Solar Water Heating**

Figure: Thermo Technologies 30 Tube Solar Collector

Tech Group 2 Project Details

5 Fieldhouse – Solar Water Heating

Figure: Installation at Kalamazoo D.O.T.

Tech Group 2 Project Details

5 Fieldhouse – Solar Water Heating

Energy Savings

- Can be incorporated to heat the pool or campus hot water supply
- Solar energy data taken from Thermo Technologies
- Assumes 1,000 collectors on south side of Fieldhouse roof (max capacity)

Energy Harvested: **98,800 therms/yr**

1st Year Cost Savings: **$81,800**

Auditing: Controller unit records energy savings

Tech Group 2 Project Details

5 Fieldhouse – Solar Water Heating

Upfront Costs

- Solar Collector: $3,450* ea (x 1000**)
- Pump: $1,700
- Heat Exchanger: $31,300
- Piping: $14,300 (18$/ft)
- Labor: $45,500 (35 $/hr, 1.3 hr/collector)

TOTAL: **$3,540,000**

* This is based on a quote for a single panel, a discount can be expected for a large order

** The system is scalable. 1000 collectors is the max

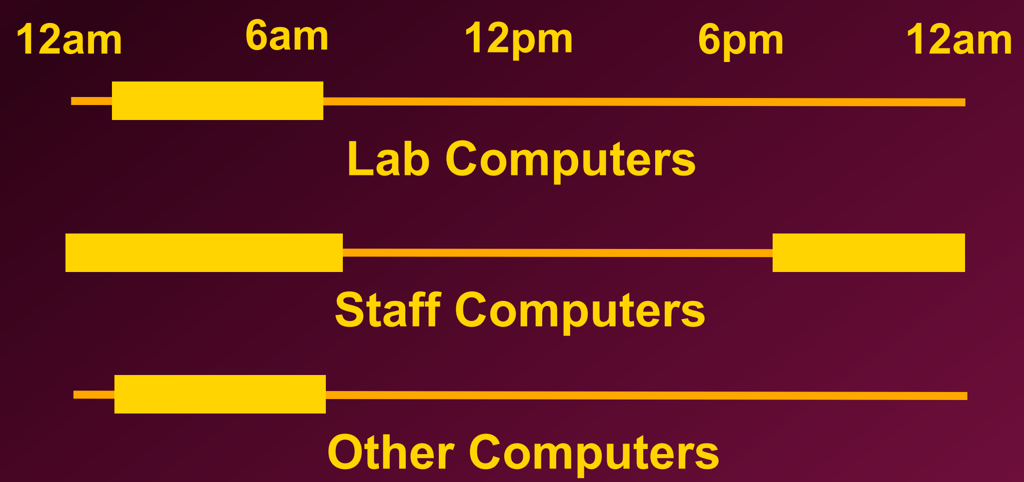
Tech Group 2 Project Details

6 All Campus - Forced Computer Shutdown

Projected Energy Savings

Existing:

Proposed:



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Tech Group 2 Project Details

6 All Campus - Forced Computer Shutdown

Projected Energy Savings

	Days/Yr	Shutdown Hours	Energy Savings [kWh/yr]
Lab Computers	200	1 am-7 am	36,697
Staff Computers	300	6 pm-7 am	198,449
Other Computers	200	1 am-7 am	113,455

Energy Savings: **348,600 kWh/yr**

1st Year Cost Savings: **$30,300**

Auditing: Software calculates energy savings

Tech Group 2 Project Details

6 All Campus - Forced Computer Shutdown

Upfront Costs

• **Labor**:	**$175**	**(5 hrs @ $35/hr)**
• **Licensing Cost :**	**$20,434**	**($7.20 per station)**

No Renewal Fee

Software is an add-on to Deep Freeze

TOTAL: **$20,600**

Tech Group 2 Analysis Results

ENERGY SAVINGS / UPFRONT COSTS

	Project Location	Energy Savings	1st Year Cost Savings [$]	Upfront Costs [$]	Payback Period [yr]
4	**Chapel –** Chapel Airlock	1640 [therms/yr] (+20%/-50)	$1,400	$18,000 (±15%)	**11**
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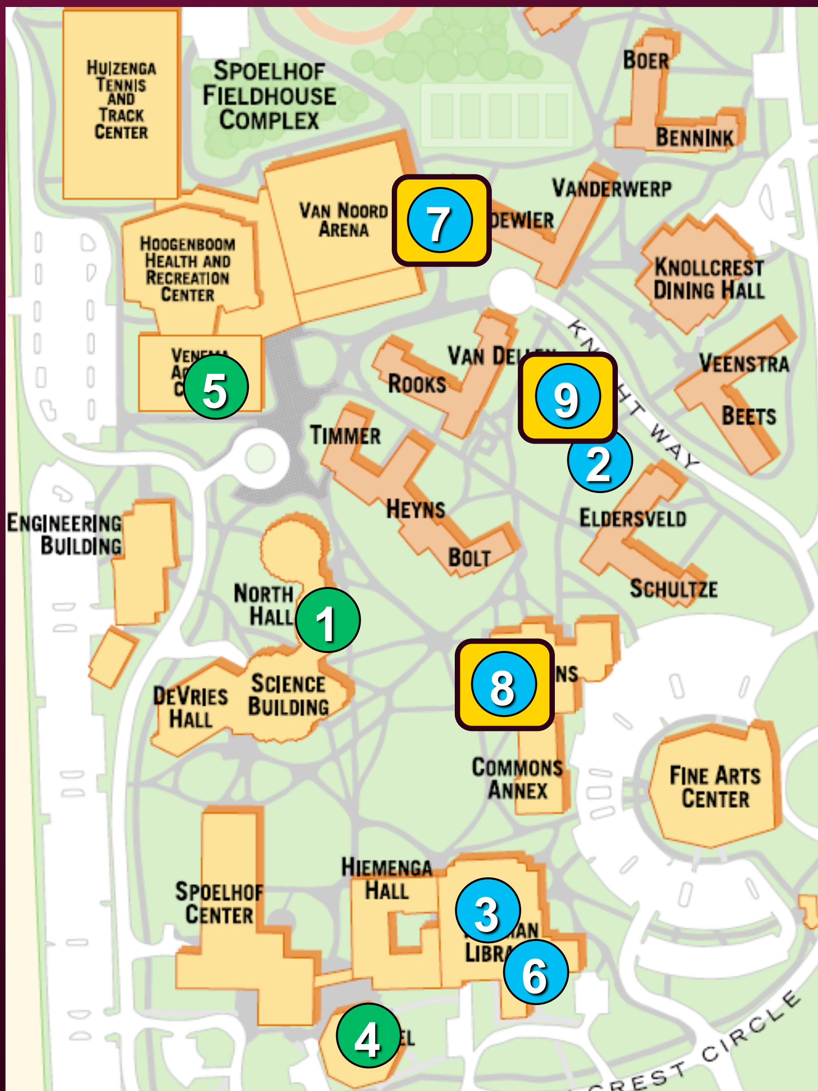
Proposed CEEF Projects



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Tech Group 3 Project Overviews

Descriptions:

7 **Underground – Dorm Tunnels**

Tunnels to re-route HVAC piping and disconnect steam boilers

8 **Commons Dining Hall – Windows**

Replace single for double paned windows

9 **Res. Halls – Dorm Hall Lights**

Shut-off hall lighting at additional times

Tech Group 3 Analysis Results

ENERGY SAVINGS / UPFRONT COSTS

	Project Location	Energy Savings	1st Year Cost Savings [$]	Upfront Costs [$]	Payback Period [yr]
7	**Underground –** Dorm Tunnels	51,105 (±10%) [therms /yr]	$42,330	$83,500 (±11%)	**1**
8	**Commons Dining Hall –** Windows	24,800 [therms/yr] + 2,370 [kWh/yr] (±10%)	$17,710	$165,000 (±10%)	**8**
9	**Residence Halls –** Lights	18,542 (±10%) [kWh/yr]	$1,610	$35 (±20%)	**0**

Note: All $ amounts are in 2008 values.

Tech Group 3 Project Details

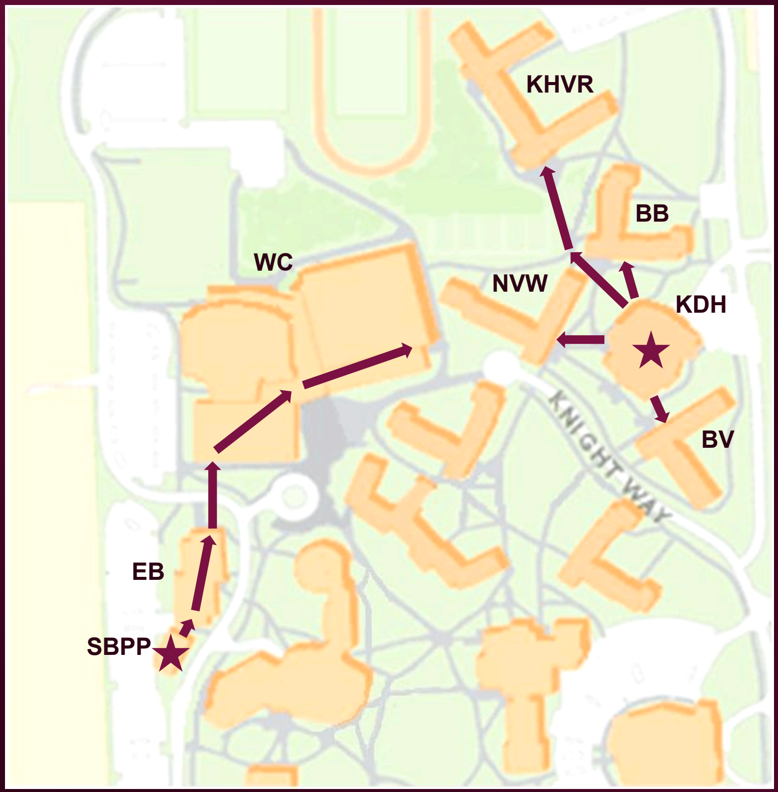
7 **Underground** – Dorm Tunnels

Existing: Steam boilers in KDH (~63% efficient)
(Supply to 4 dorms and KDH)

Proposed: Connect via tunnel to hot water boilers in SB plant (~92% efficient)
(Supply most of Campus)

Tech Group 3 Project Details

Current Heating Loop



Proposed Heating Loop

Tech Group 3 Project Details

7 Underground – Dorm Tunnels

Energy Consumption:

- Heating load only

Existing	Proposed
~ 63% efficient	~ 92% Efficient
162,000 [therms/yr]	111,000 [therms/yr]

Energy Savings: **51,000 therms/yr**

1st Year Cost Savings: **$42,330**

Assumptions: 75% of natural gas supplied to steam boilers is used for heating

Auditing: Monitor yearly changes in natural gas supply

Source: Paul Pennock, Physical Plant

Tech Group 3 Project Details

7 Underground – Dorm Tunnels

Upfront Costs:

- Tunneling and Piping: $83,500

  200 feet tunneling

  Includes all labor and materials for:
  excavation, concrete work and sealing,
  heating pipes and fixtures, backfill, seed

  Hot water pipes through dorm connecting systems

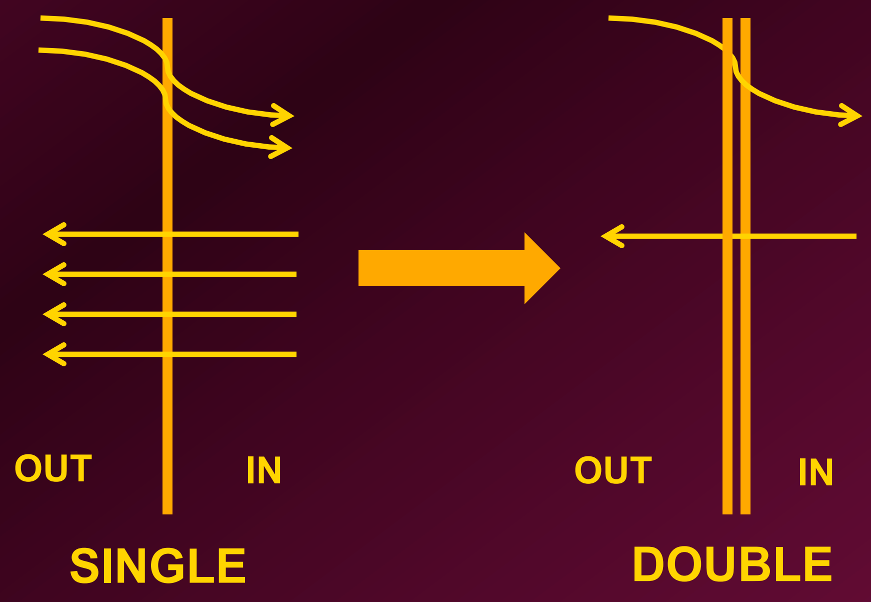
Additional Benefits:

Space provided in tunnel for addition of cooling pipes

Tech Group 3 Project Details

8 **Commons Dining Hall – Windows**

Existing:	Single Pane Windows
Proposed:	Double Pane Windows



Tech Group 3 Project Details

7 Commons Dining Hall – Windows

Energy Consumption:

	Existing	Proposed
Heating	5120 [therms/yr]	1840 [therms/yr]
Cooling	73300 [kWh/yr]	72300 [kWh/yr]

Energy Savings:

24,759 therms/yr + 2,373 kWh/yr

1st Year Cost Savings: **$17,710**

Tech Group 3 Project Details

8 Commons Dining Hall – Windows

Upfront Costs:

$165,000

Includes: Labor and Material

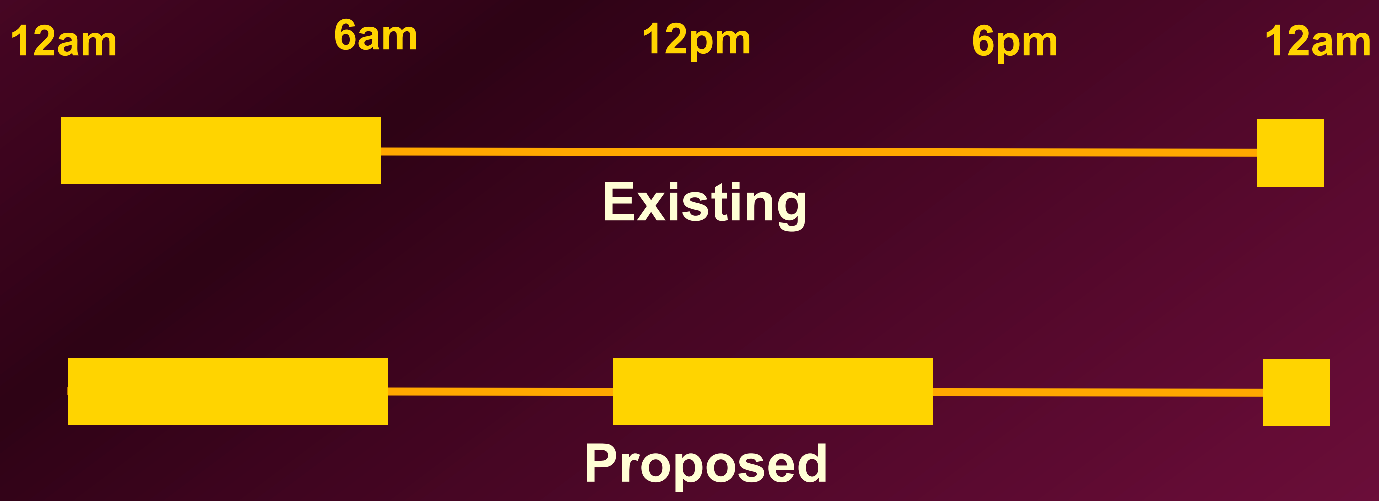
Source: Vos Glass

Tech Group 3 Project Details

9 Residence Halls – Dorm Hall Lights

Current: Shut off ½ lights 11pm – 6am

Upgrade: Shut off ½ lights 11pm – 6am
& 11am – 4pm



Tech Group 3 Project Details

9 Residence Halls – Dorm Hall Lights

Energy Consumption

Existing	Proposed
7 hours off	12 hours off
162,000 [kWh/yr]	143,000 [kWh/yr]

Energy Savings: **19,000 kWh/yr**

1st Year Cost Savings: **$1,610**

Upfront Costs:

$35 (1 hour labor)

Tech Group 3 Analysis Results

ENERGY SAVINGS / UPFRONT COSTS

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Note: All $ amounts are in 2008 values.

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Financial Group

- Energy Projections
  - Electrical Cost Outlook
  - Natural Gas Cost Outlook
- Project Evaluation Approach
  - Project Cash Flow Diagrams
  - Project Payback Periods
- Project Implementation Dates
- Financial Considerations
- Pessimistic & Optimistic Cases
- Fund Cash Flow Diagram

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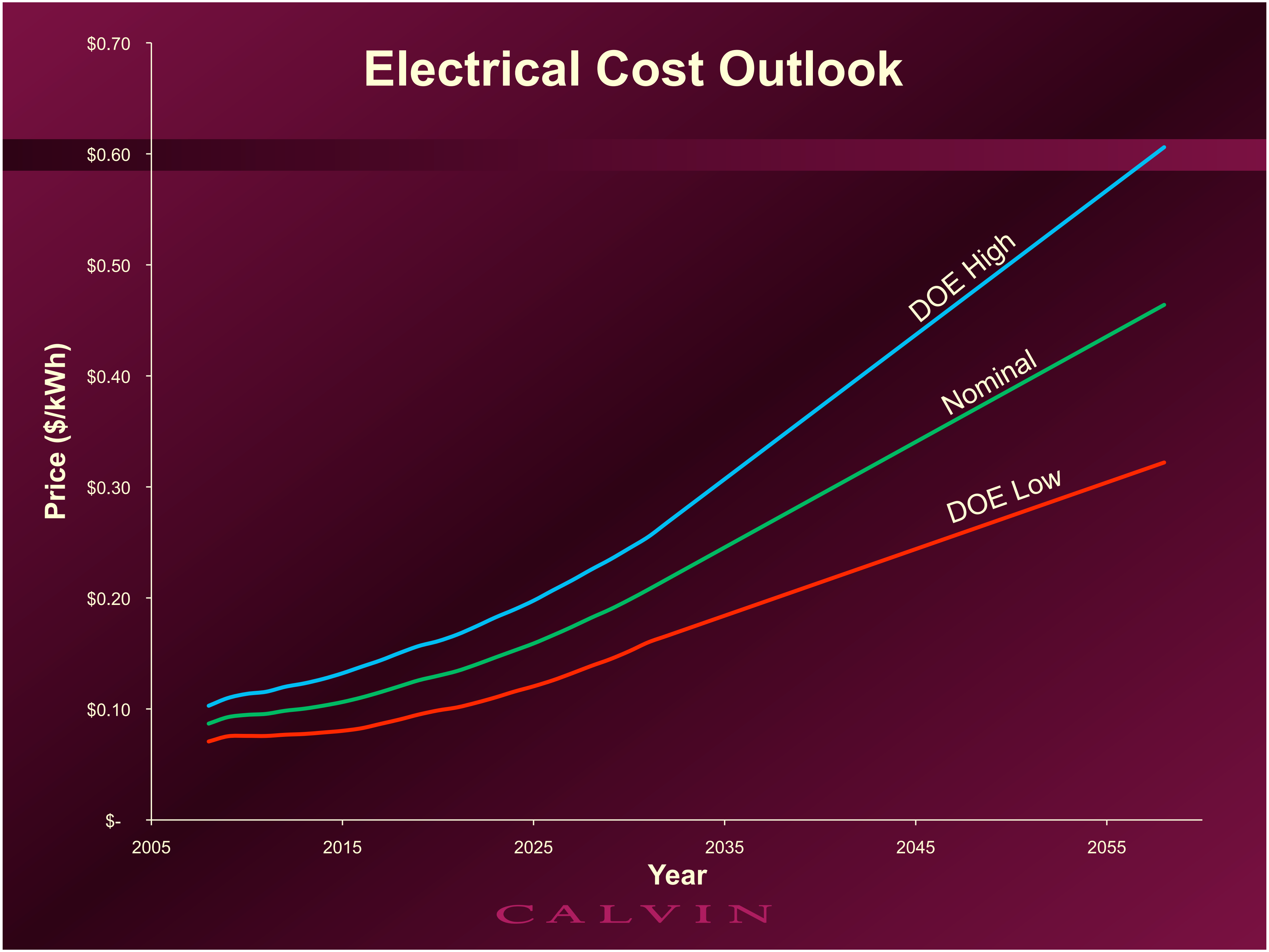
Energy Projections

US Department of Energy Annual Energy Outlook (2008)

- **Modeled until 2030**
- **Linear projection beyond 2030**

DOE Assumptions:

- **Oil & gas supplies have 20% exponential decline**
  - **Shallow water natural gas supplies have 30% exponential decline**
- **Costs to produce renewable energy decline**



Electrical Cost Outlook
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$-
Price ($/kWh)
2005
2015
2025
2035
2045
2055
Year
DOE High
Nominal
DOE Low
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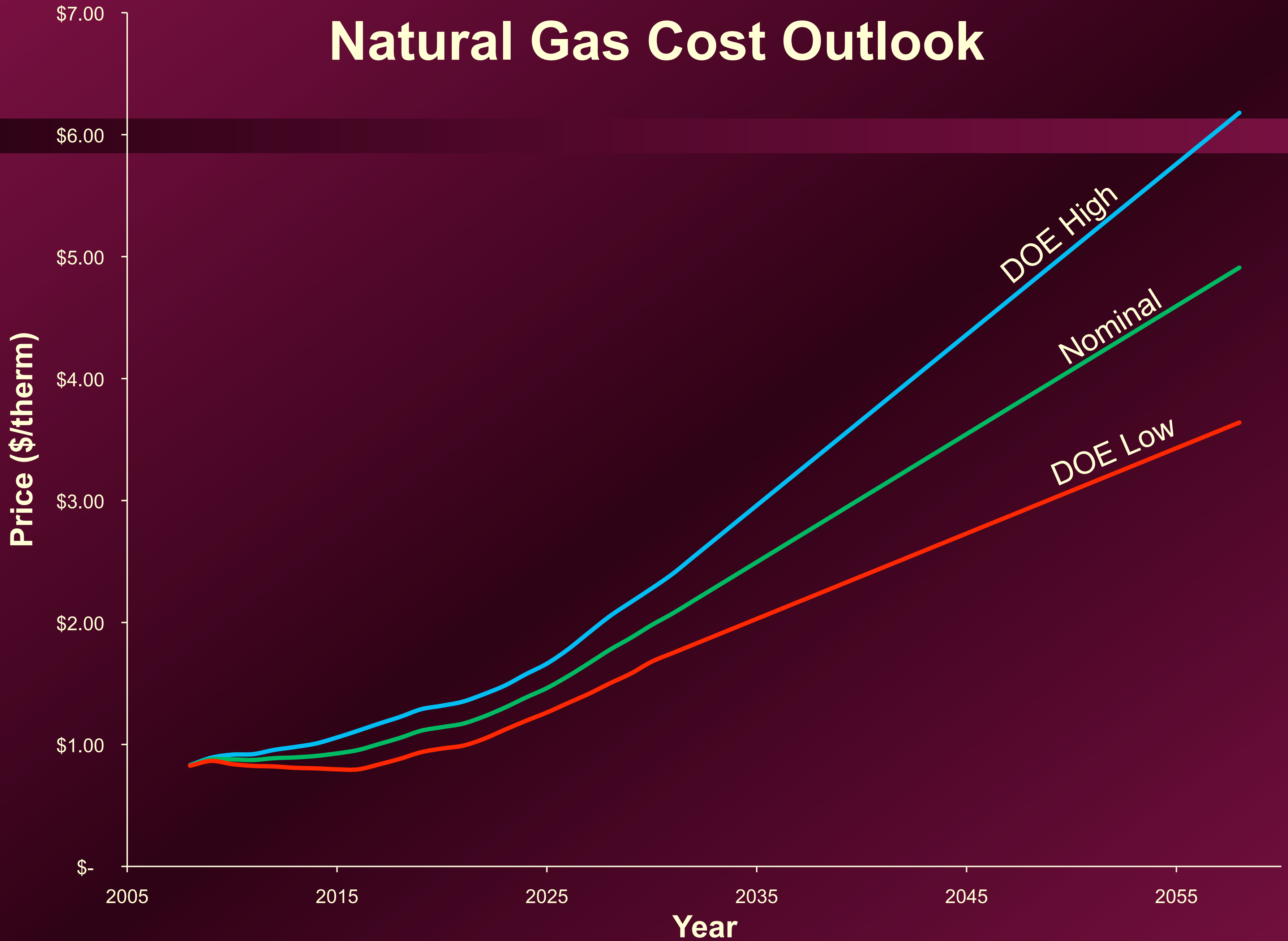
Natural Gas Cost Outlook



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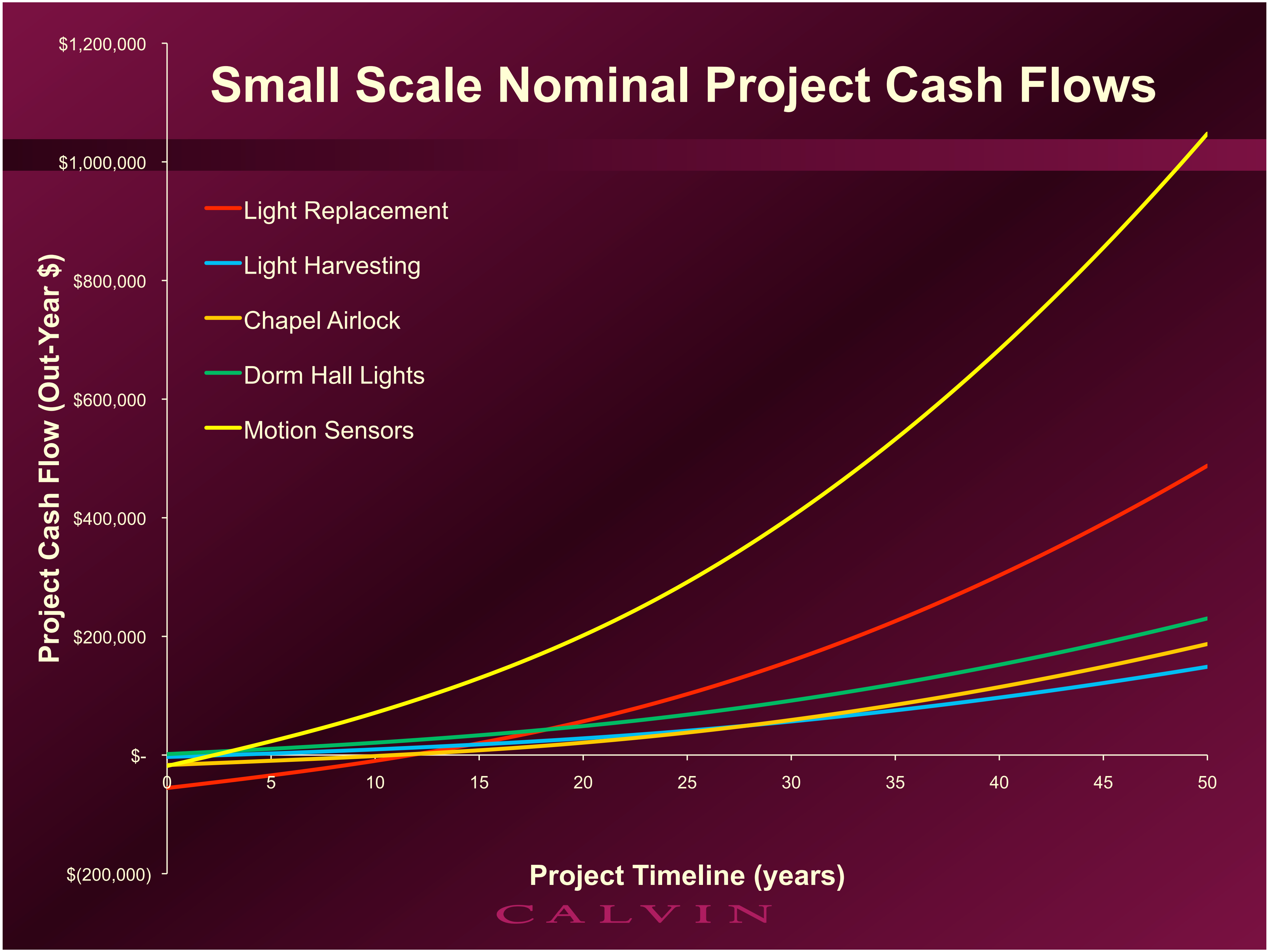
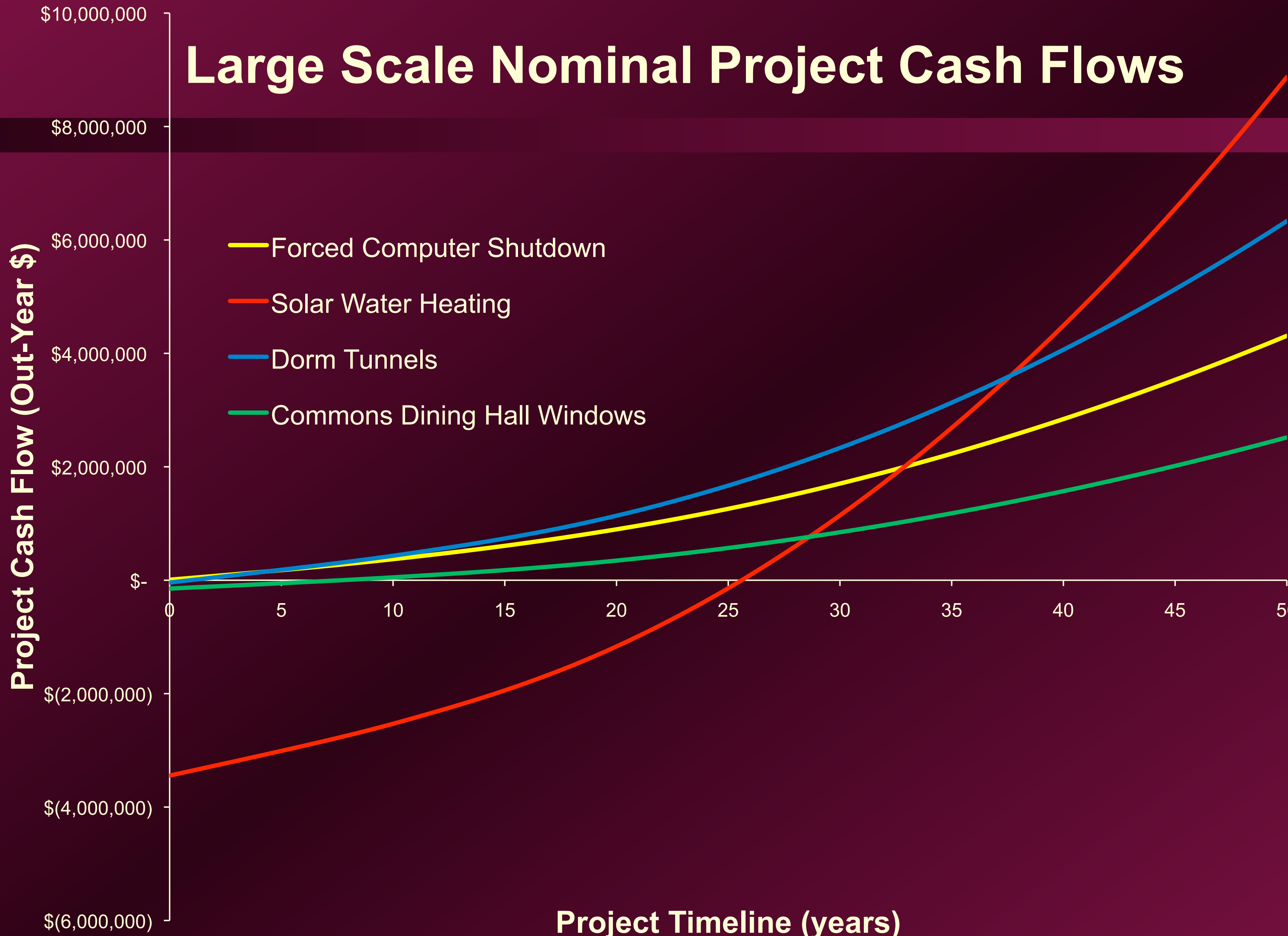
Project Evaluation Approach

- Evaluated based on immediate installation
- Compared against an opportunity cost of capital of 6% (nominal case)
- Evaluated in out-year dollars
- Requested nominal, pessimistic, optimistic values to create multiple scenarios



Small Scale Nominal Project Cash Flows
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$-
$(200,000)
Project Cash Flow (Out-Year $)
0
5
10
15
20
25
30
35
40
45
50
Project Timeline (years)
Light Replacement
Light Harvesting
Chapel Airlock
Dorm Hall Lights
Motion Sensors
CALVIN

Large Scale Nominal Project Cash Flows



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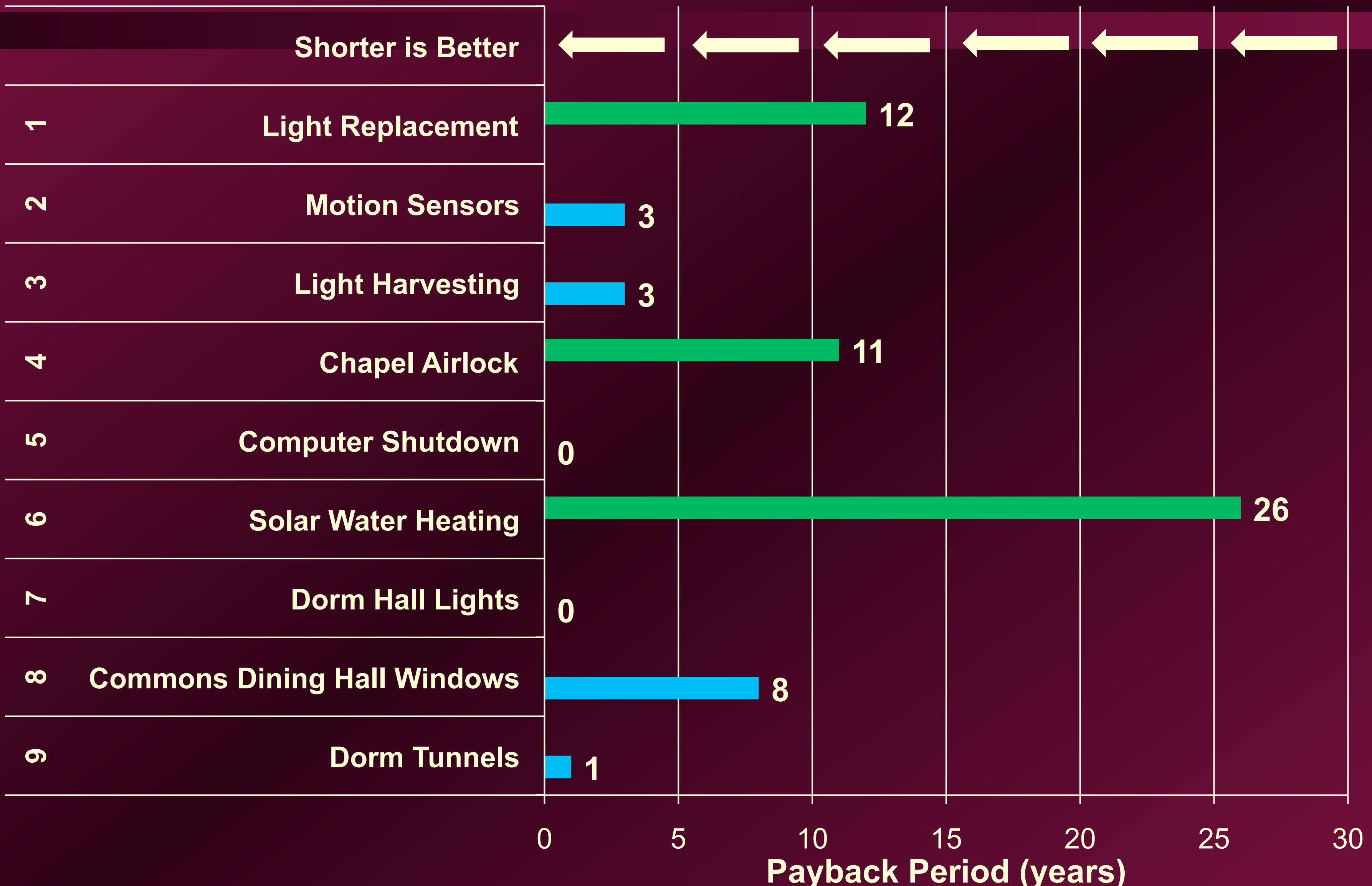
Project Payback Periods



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Project Implementation Dates

2009

- 5 Forced Computer Shutdown
- 7 Dorm Hall Lights
- 9 Dorm Tunnels

2010

- 2 Motion Sensors
- 3 Light Harvesting
- 4 Chapel Airlock

2011

- 1 Light Replacement

Not Scheduled

- 6 Solar Water Heating
  - scale beyond fund
- 8 Commons Windows
  - high upfront costs, but could be integrated into the Commons remodel

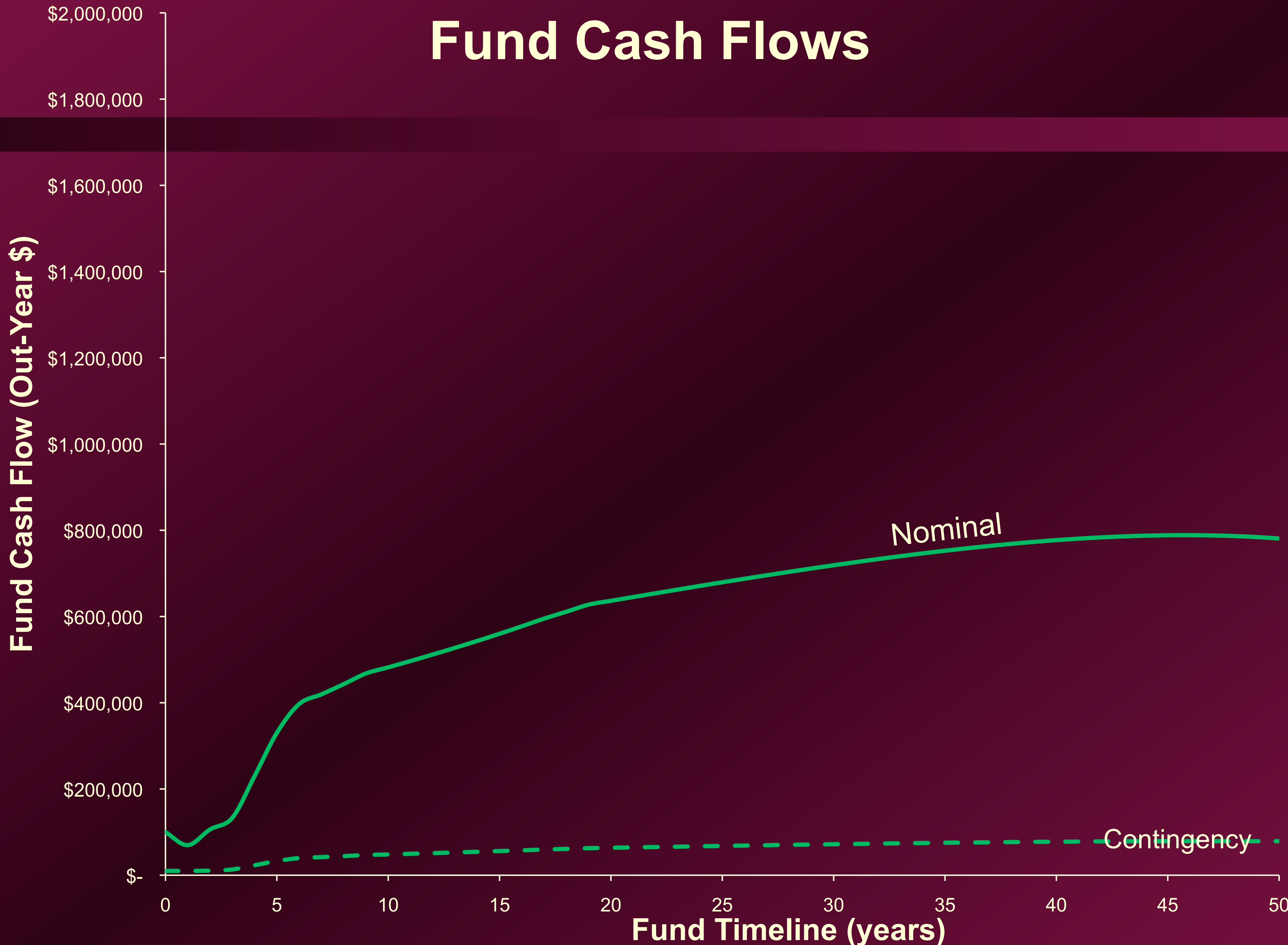
Financial Considerations

- **Intern Wages**
    - $8/hr, 10-15 hr/week, 32 weeks/yr
- **Upfront and ongoing costs projected on inflation only**
    - 4.1% inflation (nominal)
    - Technological advances & scarcity issues not considered
- **Savings & costs balanced annually**

Pessimistic & Optimistic Cases

	Pessimistic	Nominal	Optimistic
Upfront Costs	High ↑	Nominal -	Low ↓
Ongoing Costs	High ↑	Nominal -	Low ↓
Energy Savings	Low ↓	Nominal -	High ↑
Energy Cost Projection	Low ↓	Nominal -	High ↑
Opportunity Cost of Capital	High ↑	Nominal -	Low ↓
Inflation Rate	High ↑	Nominal -	Low ↓
Fund Investment	Low ↓	Nominal -	High ↑
Intern Costs	High ↑	Nominal -	Low ↓

Fund Cash Flows



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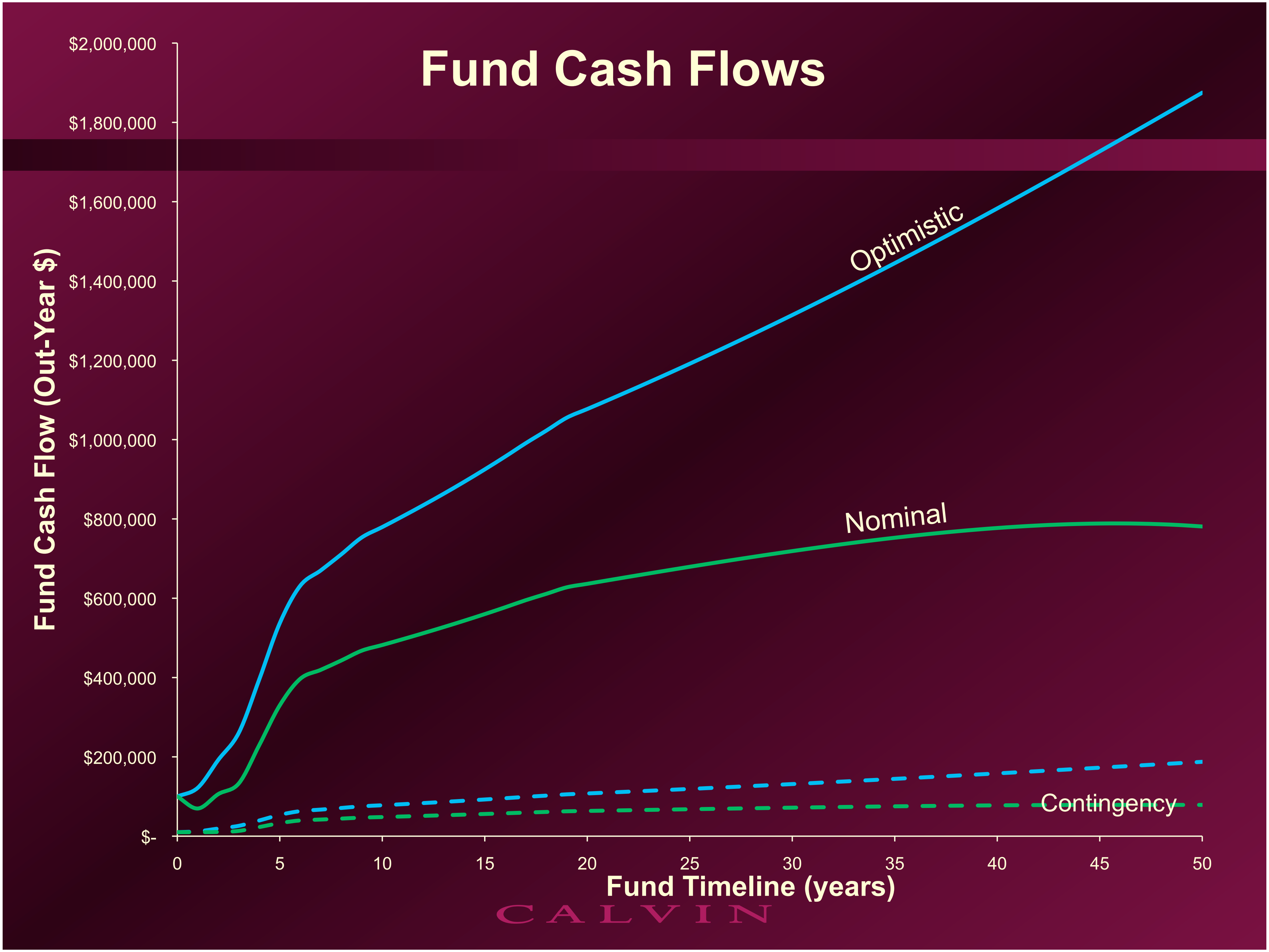
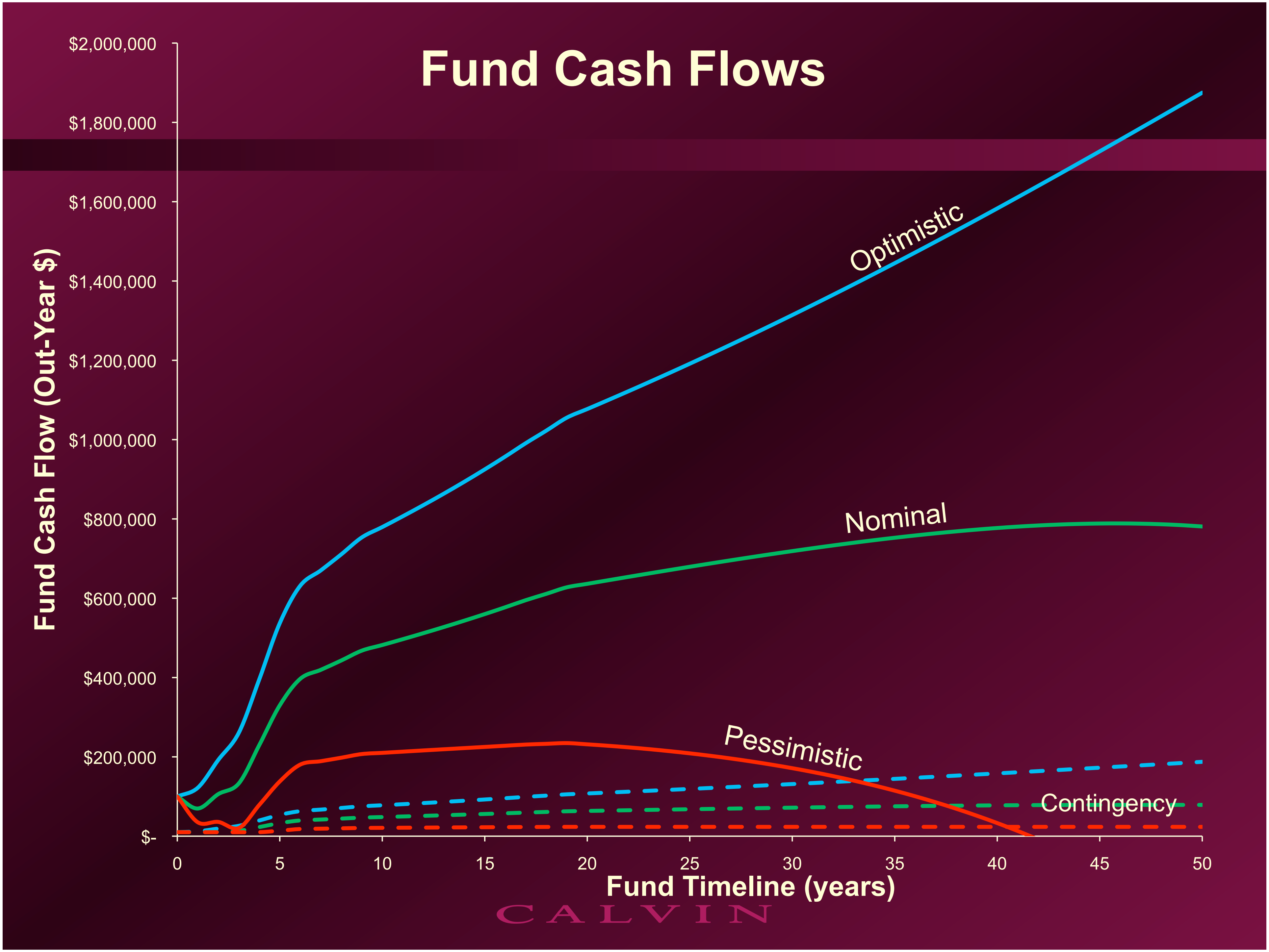


Fund Cash Flows
$2,000,000
$1,800,000
$1,600,000
$1,400,000
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$-
Fund Cash Flow (Out-Year $)
Optimistic
Nominal
Contingency
0
5
10
15
20
25
30
35
40
45
50
Fund Timeline (years)
CALVIN


Fund Cash Flows
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Fund Cash Flow (Out-Year $)
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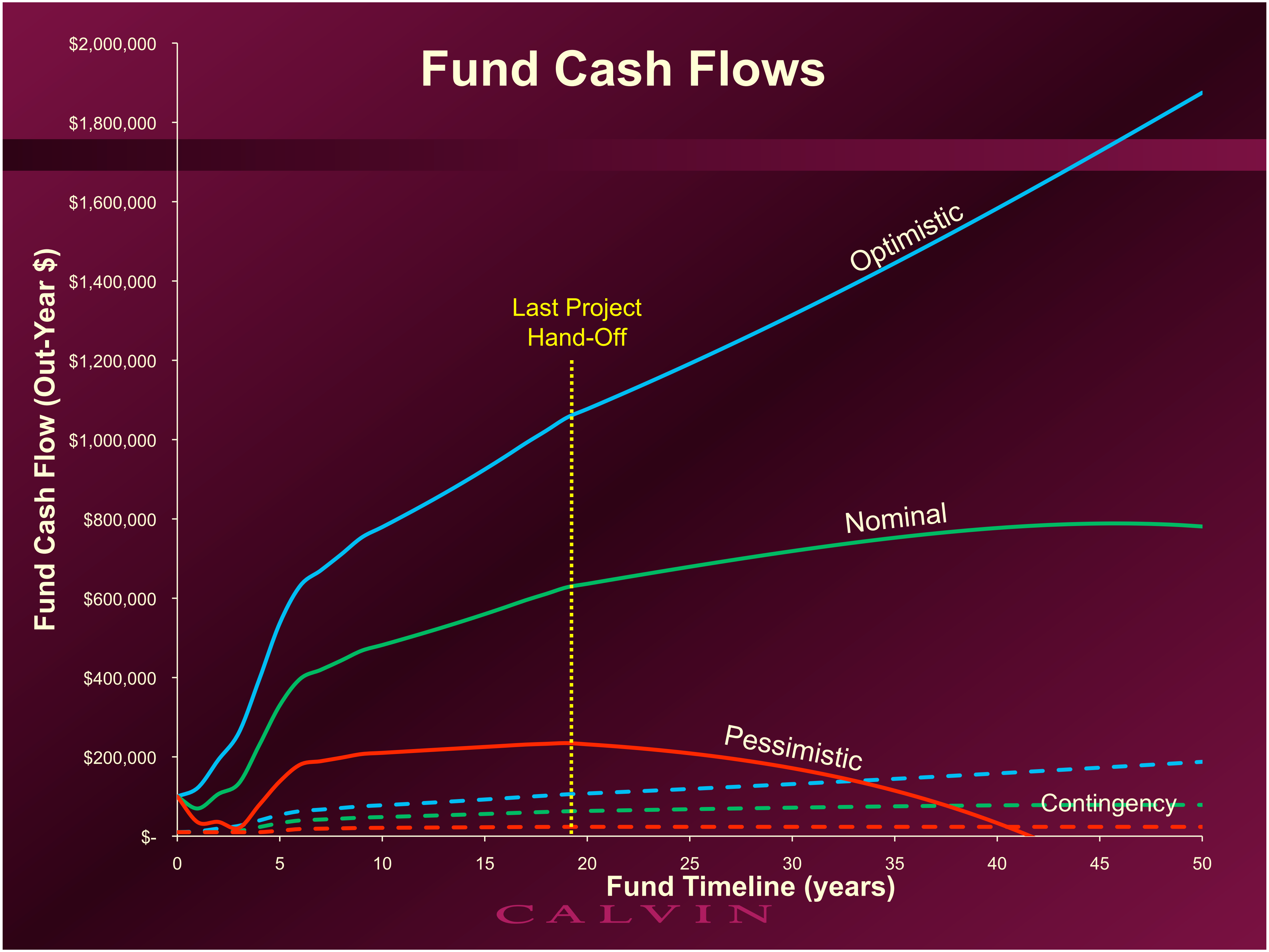
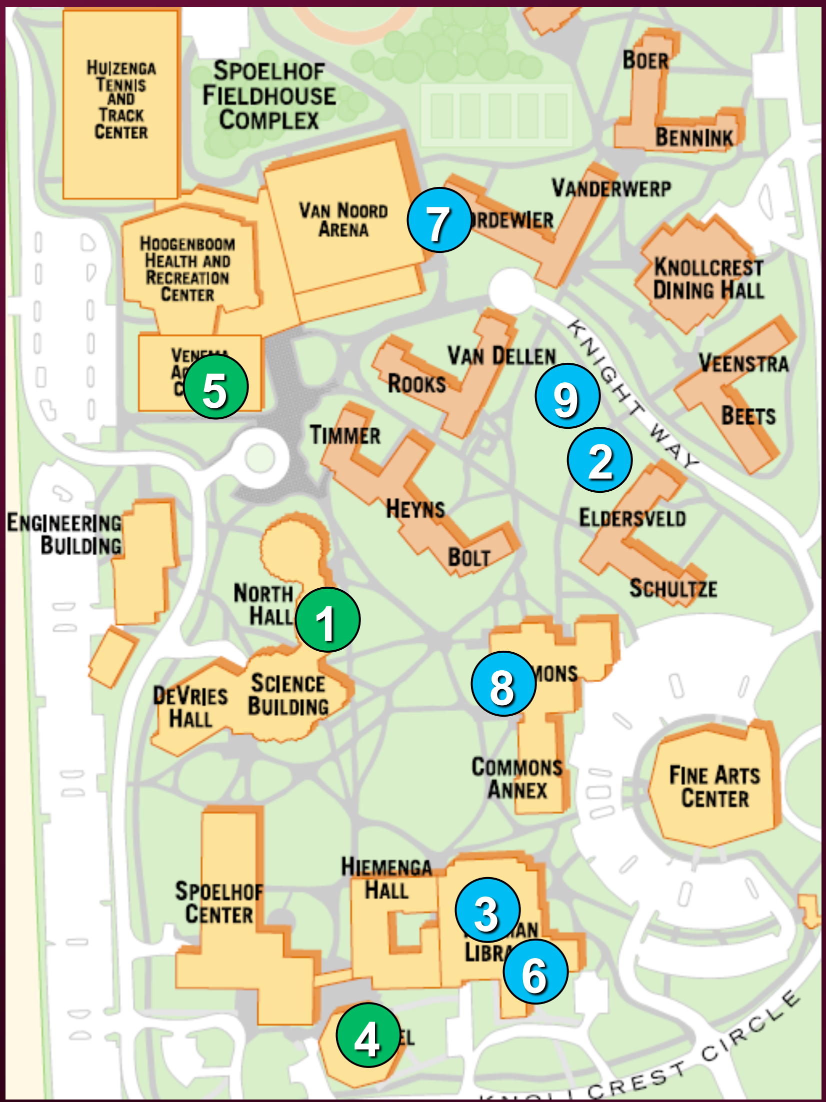
Fund Timeline (years)
Optimistic
Nominal
Pessimistic
Contingency
CALVIN


Fund Cash Flows
Fund Cash Flow (Out-Year $)
$2,000,000
$1,800,000
$1,600,000
$1,400,000
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$-
0
5
10
15
20
25
30
35
40
45
50
Fund Timeline (years)
Last Project
Hand-Off
Optimistic
Nominal
Pessimistic
Contingency
CALVIN

Proposed CEEF Projects



Tech Group 1

1. Light Replacement
2. Motion Sensors
3. Light Harvesting

Tech Group 2

4. Chapel Airlock
5. Solar Water Heating
6. Forced Computer Shutdown

Tech Group 3

7. Dorm Tunnel
8. CDH Windows
9. Dorm Hall Lights

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Conclusion

- Calvin Energy Efficiency Fund is feasible
- Opportunity for Calvin to save money
- Many other potential energy efficiency projects
- Further steps in creation care

What We Learned

- Coordination between Groups
- Communication with Resources
- Value of Deadlines
- Accountability
- Relationship between Engineering and Stewardship

Acknowledgements

- Henry DeVries (VP of Finance)
- Paul Pennock (Physical Plant)
- Don Winkle (Physical Plant)
- Chuck Holwerda (Electronics Shop)
- Prof. Matt Heun (Professor of Engineering)

And Many Others

Questions

MY HEART I OFFER TO YOU LORD • PROMPTLY AND SINCERELY •

CALVIN