Discounted Cash Flow Payback Period Calculations

Why Use the Discounted Cash Flow Method to Evaluate Solar ROI?

When evaluating long-term capital investments like solar energy systems, it's important to use a financial method that reflects both the **timing** and **value** of future savings. The **Discounted Cash Flow (DCF) method** is a widely accepted approach for this purpose — especially in public sector infrastructure planning and energy project evaluation.

Unlike a simple payback calculation, which only shows how many years it takes to recoup upfront costs, the DCF method offers a **comprehensive picture of the project's true financial performance over time**. It accounts for:

- **Future cost savings** from reduced electricity purchases
- **Escalating utility rates**, which increase the value of solar-generated electricity
- **Ongoing operations and maintenance expenses**, including inverter replacement and system upkeep
- **System performance degradation**, typically 0.5% per year
- The **time value of money**, using a discount rate (5% in our model) to reflect inflation and investment risk

This approach allows us to make **apples-to-apples comparisons** between upfront costs and long-term benefits, providing a more **realistic and responsible** projection of return on investment. It also supports better decision-making around capital planning, grant justification, and resource allocation — helping us maximize value for the city and its residents.

The following is an example in how the DCF payback period (w/o incentives) was calculated for Long Center. The same calculations were used for Countryside Library, City Hall, North Greenwood Rec and Ross Norton Rec.

1. Key Assumptions and Data

- **System Cost (Year 0):** $540,494
- **Annual Solar Generation (Year 1):** 437,838 kWh
- **Degradation Rate:** 0.5% annually
    - Industry-accepted degradation rate of **0.5% per year**, which accounts for reduced energy generation over time.
    - Source: National Renewable Energy Laboratory (NREL) (DOE) [Photovoltaic Degradation Rates — An Analytical Review]
- **Electricity Cost Growth:** 5% annually
    - To reflect the historical and projected trend of rising utility rates. Historical data from Florida and national utility trends show that electricity prices have increased by

roughly 2%–6% per year over the past couple of decades. Given volatile natural gas markets, increasing grid infrastructure costs, and inflationary pressures, a 5% annual increase is considered a reasonable and conservative planning figure in the energy sector. It aligns with industry modeling practices and Department of Energy (DOE) forecasts for long-term utility rate escalation.

  - Source: U.S. Energy Information Administration

- **Initial Electricity Savings (Year 1):** Savings=Generation (kWh)×Electricity Rate (per kWh)
  Assume a baseline rate, R_1, for electricity.

- **Annual Maintenance Costs:** \$0.005/W
  Annual Maintenance=System Size (W)×0.005=268,000×0.005=1,340 per year.

  - Industry-standard estimate of **\$0.005 per watt per year**. For a 100 kW system, that equates to roughly \$500 annually, increasing over time due to inflation-adjusted utility rates. This covers routine upkeep and minor repairs.

  - Source: NREL 2024 Electricity ATB Technologies and Data Overview

- **Inverter Replacement Cost (Year 15):** Assume ~10% of system cost: \$51,249.

  - Inverters typically need replacement once during the 30-year life of the system (around year 15). We've included the cost of replacement in the model, spread out via the DCF approach.

  - Source: National Institute of Standards and Technology (NIST) (U.S. Department of Commerce) Present Value of Photovoltaics – User Guide

- **Discount Rate:** 5% annually.

  - This reflects both inflation and the time value of money, effectively reducing the value of future savings and costs. It ensures that we're not overstating long-term benefits and are conservatively modeling future cash flows.

  - Source: U.S. DOT Federal Highway Administration

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2. Calculate Annual Net Savings

For each year:

1. **Solar Production (kWh):** $\text{Generation}_t = 437{,}838 \times (1-0.005)^{t-1}$
2. **Electricity Rate:** $R_t = R_1 \times (1+0.05)^{t-1}$
3. **Electricity Savings:** $\text{Savings}_t = \text{Generation}_t \times R_t$
4. **Net Annual Savings:** $\text{Net Savings}_t = \text{Savings}_t - \text{Maintenance Costs}_t$

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3. Discount Future Cash Flows

Apply the discount rate to the net annual savings for each year to determine the present value (PV):

PV_t=Net $Savings_t/(1+0.05)^t$

For the inverter replacement in Year 15, subtract its cost as a negative cash flow:

$PV_{15}=-51{,}249/(1+0.05)^{15}$

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4. Determine the Payback Year

Cumulatively sum the discounted cash flows (starting with the initial cost as negative) until the cumulative total becomes positive. The year this occurs is the **payback year**.

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5. Tools for Calculation

Baseline electricity rate (R_1) in $/kWh is assumed rate (e.g., $0.10/kWh)

The **payback period** for the solar array installation is approximately **14 years** without incentives.

By updating the system cost to **$108,098**, and redoing the same calculations, the **payback period** is approximately **3 years**. This is the DCF with the 50% grant and 30% elective pay incentives.

City Hall

Since City Hall is a new building without historical energy data, we can estimate its electricity consumption and savings using standard energy benchmarks.

Office buildings typically consume **15-20 kWh per square foot** annually. **City Hall is 40,303 sq. ft.**

- **Low estimate:** 40,303 × 15 kWh = **604,545 kWh**
- **High estimate:** 40,303 × 20 kWh = **806,060 kWh**
- **Midpoint estimate: 705,303 kWh**

Next, we can estimate the electricity rate for commercial customers. The average electricity rate for commercial customers in Florida with Duke Energy is approximately $0.10 to $0.12 per kWh. To be conservative, we can use **$0.11 per kWh**.

Next, we can c**alculate the annual savings**. If the system generates 194,300 kWh annually (per Emerald), we can estimate the annual savings as:

- Annual Savings = 194,300 kWh×0.11 USD/kWh = **21,373 USD/year**

Finally, we can a**pply the discounted cash flow method as above with the cost of the solar system as $333,056, a 5% discount rate, and an annual savings of $21,373.**

The DCF payback period for the solar system without the incentives is **30 years** and approximately **6 years** with the 50% grant and 30% Elective Pay.

Countryside Rec Center

Assumptions:
Electricity escalation: 3.5% / year (per Bandes)
Discount rate: 5% / year
PV degradation: 0.5% / year (production declines by 0.5% annually)
Annual O&M: $0.005 / W (e.g., 156 kW → $780 / yr; 246 kW → $1,230 / yr)
Inverter replacement: $0.15 / W once in **Year 15** (added as a negative cash flow that year)
Analysis horizon: 30 years

NOTE: For Countryside Rec and North Greenwood Rec, Bandes used a 3.5% electricity escalation

System: **156 kW DC**
Annual generation: **243,789 kWh**
Year-1 savings: **$23,094**
Total 30-yr savings: **$1,182,003**
Costs: **Full = $415,519.40**, **50% DOE = $207,759.70**, **80% incentives final = $83,103.88**

Year	Gross savings	O&M + Inv	Net savings	Discounted CF	Cumulative DCF
1	$23,094.00	$780.00	$22,314.00	$21,251.43	$21,251.43
2	$23,782.78	$780.00	$23,002.78	$20,864.20	$42,115.63
3	$24,492.10	$780.00	$23,712.10	$20,483.40	$62,599.03
4	$25,222.58	$780.00	$24,442.58	$20,108.97	$82,708.00
5	$25,974.84	$780.00	$25,194.84	$19,740.82	$102,448.82
15	$34,848.75	$24,180.00	$10,668.75	$5,131.85	$269,679.25
30	$54,155.01	$780.00	$53,375.01	$12,349.77	$481,836.07

Full cost = $415,519.40 → DCF payback: Year 25 (21 with 5% escalation)
With 50% DOE ($207,759.70) → DCF payback: Year 11 (10 with 5% escalation)
With 80% incentives ($83,103.88) → DCF payback: Year 5 (4 with 5% escalation)

North Greenwood Rec Center

Assumptions
Electricity escalation: 3.5% / year (per Bandes)

Discount rate: 5% / year
PV degradation: 0.5% / year (production declines by 0.5% annually)
Annual O&M: $0.005 / W (e.g., 156 kW → $780 / yr; 246 kW → $1,230 / yr)
Inverter replacement: $0.15 / W once in **Year 15** (added as a negative cash flow that year)
Analysis horizon: 30 years

NOTE: For Countryside Rec and North Greenwood Rec, Bandes used a 3.5% electricity escalation

System: **246 kW DC**
Annual generation: **395,431 kWh**
Year-1 savings: **$33,960**
Total 30-yr savings (provided): **$1,738,158**
Costs: **Full = $677,994.80**, **50% DOE = $338,997.40**, **80% incentives final = $135,598.96**

Year	Gross savings	O&M + Inv	Net savings	Discounted CF	Cumulative DCF
1	$33,960.00	$1,230.00	$32,730.00	$31,171.43	$31,171.43
2	$34,972.86	$1,230.00	$33,742.86	$30,605.77	$61,777.19
3	$36,015.92	$1,230.00	$34,785.92	$30,049.39	$91,826.58
4	$37,090.10	$1,230.00	$35,860.10	$29,502.19	$121,328.77
5	$38,196.31	$1,230.00	$36,966.31	$28,964.07	$150,292.84
15	$51,245.50	$38,130.00	$13,115.50	$6,308.78	$394,507.27
30	$79,635.58	$1,230.00	$78,405.58	$18,141.28	$706,071.97

Full cost = $677,994.80 → DCF payback: Year 29 (24 with 5% escalation)
With 50% DOE ($338,997.40) → DCF payback: Year 13 (12 with 5% escalation)
With 80% incentives ($135,598.96) → DCF payback: Year 5 (5 with 5% escalation)