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) <u>Photovoltaic</u>
 <u>Degradation Rates</u> <u>An Analytical Review</u>
- 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.

- o Source: U.S. Energy Information Administration
- Initial Electricity Savings (Year 1): Savings=Generation (kWh)×Electricity Rate (per kWh) Assume a baseline rate, R₁, 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.
 - o 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) <u>Present Value of Photovoltaics – User Guide</u>
- 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.
 - o Source: <u>U.S. DOT Federal Highway Administration</u>

2. Calculate Annual Net Savings

For each year:

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

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:

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

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**.

5. Tools for Calculation

Baseline electricity rate (R₁) 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.

o 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 calculate 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 apply 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 \rightarrow \$780 / yr; 246 kW \rightarrow \$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 \rightarrow \$780 / yr; 246 kW \rightarrow \$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)