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The Macro-Fiscal-Energy Scenario Tool

Financing and Efficiency, Not the Size of the Program, Decide What Climate Investment Does to Growth and Debt

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ABSTRACT

A finance ministry weighing a climate investment program needs to know at once what it costs the budget, how much carbon pricing could pay for, and what both do to growth and debt. Separate teams usually answer with separate models. The Macro-Fiscal-Energy Scenario Tool chains the answers in one workbook for 186 countries: a model of mitigation investment needs split by who pays, a screen for the most carbon pricing that stays within limits on political cost, simplified open versions of three IMF and World Bank macro-fiscal models, and a debt sustainability test. A stylized run shows that the financing mix and the efficiency of public investment move growth and debt more than the program's size, and that the binding political limit decides whether pricing raises revenue. A run for Kenya finds a budget need of 0.5 percent of GDP in 2030, mostly land use and non-CO_2 gases; feasible power-sector pricing covers about 5 percent of it, and the program adds 7 points of GDP to debt by 2050 for little growth. The tool compares packages; it does not replace a full debt sustainability analysis.

Keywords: climate finance, public investment, debt sustainability, carbon pricing, feebates, macro-fiscal modeling
JEL codes: E62, H54, H63, Q54, Q58

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[1]The lite models are simplified re-implementations written from the published descriptions of the parent models cited in the text; they are not endorsed by, and do not reproduce, the IMF or World Bank tools. The stylized run uses the tool's default illustrative calibrations. The Kenya run reports illustrative results from the tool, with income-group defaults where country data are missing; they are not forecasts or official estimates, and the public figures quoted beside them are from the sources cited. Errors are the author's own.

1 Executive summary

A finance ministry asked to commit to a climate investment program wants one answer: what does it do to our debt? The answer depends on four estimates that are usually made apart: the investment the program needs and how much of it falls on the budget; what carbon pricing could raise to pay for it; what the spending does to growth; and what all of that does to debt and the risk of debt distress. Different teams run these on different models and calibrations, and the numbers rarely add up.

The Macro-Fiscal-Energy Scenario Tool runs the four in one pass, for 186 countries, in one workbook. An investment model estimates what a net zero path needs to 2050 and splits it by who pays. A pricing screen finds the most abatement a power-sector carbon tax, a feebate or a mix can deliver without breaching three limits on political cost: the rise in household tariffs, the loss to poor households, and the loss to coal and oil generators. Simplified, open versions of three IMF and World Bank macro models turn the financed program into paths for GDP and debt, and a simplified Bank-Fund debt framework rates the risk of debt distress before and with the program. Every assumption is a visible cell.

A stylized run shows that how a program is financed and how well the money is spent matter more than its size. For public investment of 1 percent of GDP a year for ten years, earmarking carbon revenue of 0.5 percent of GDP cuts the debt peak from 57 to 53 percent of GDP at no cost to growth. Lowering the efficiency of public investment from 0.7 to 0.5 cuts the GDP gain by 30 to 40 percent at every horizon and leaves debt where it was. In the low-income model, financing 60 percent of the program with grants and concessional loans keeps debt 2.4 points of GDP lower at its peak and barely changes growth.

Which political limit binds decides whether pricing can raise revenue at all. In a stylized power sector the binding limit is the loss to high-emitting generators, not the household tariff. A tax, a feebate and a mix then deliver almost the same abatement, about a quarter of fossil power emissions, but only the tax raises money. Rebating revenue to households would not raise the feasible price; compensating the owners of high-emitting plants, or retiring them faster, would.

For Kenya, the tool finds a small budget need that carbon pricing cannot pay for and that adds debt without much growth. The direct budget need for a net zero program is 0.60 percent of GDP in 2030, 0.81 percent once weak delivery is allowed for; the increment over current trends is 0.49 percent, four-fifths of it land use and non-CO_2 spending rather than capital. Kenya's grid is over 90 percent renewable, so a feasible power-sector carbon tax of US$88 per tonne raises about 0.05 percent of GDP, about 5 percent of the need to 2050. Financed mostly by grants and concessional loans, the program adds 7.2 points of GDP to public debt by 2050 against debt held at its 2024 level, for a GDP gain of a quarter of a percent. The tool's debt test agrees with the published IMF-World Bank analysis that Kenya is at high risk of debt distress, with or without the program.

The tool is for comparing packages for one country, not for forecasting or ranking countries. Its macro models are much simpler than their parents and hold the real exchange rate fixed, the shock that actually drove Kenya's latest debt revisions; its debt test has no staff judgment. Used well, it shows a ministry which assumptions decide the answer (efficiency, the return on public capital, the financing mix, the political limits) and where better country data would pay most. The policy brief sets out what ministries and development-bank teams should do with it.

2 Introduction

A finance ministry asked to commit to a climate investment program cannot get one consistent answer to the question it cares about: what does this do to our debt? The energy team can estimate the investment a net zero path needs. The tax team can estimate what a carbon tax would raise. The macroeconomists can run a public investment scale-up through a growth model, and the debt team can run a debt sustainability analysis. Each answer depends on the others: the growth model needs the investment path and its financing, the debt analysis needs the growth path, carbon tax revenue depends on the emissions the investment avoids, and how much carbon pricing a government can impose depends on who loses and how visibly. The stakes are large. The IMF estimates that reaching net zero mainly through spending could raise public debt by 45 to 50 percent of GDP by 2050 in a representative large-emitting country, and that a mix with carbon pricing holds the rise to 10 to 15 percent of GDP in an indicative advanced-economy scenario (International Monetary Fund 2023).

This paper asks whether those four pieces can be put into one consistent scenario that a ministry economist can run and inspect for any country. The answer is the Macro-Fiscal-Energy Scenario Tool, a single Excel workbook driven from one dashboard. It links a national model of mitigation investment needs that splits each need by who pays; a screen for carbon pricing under limits on political cost; simplified ("lite") versions of three IMF and World Bank macro-fiscal models; and a simplified debt sustainability test. Every module reads the same country data, each module's outputs are the next one's inputs, and every assumption is a visible cell.

Run on a stylized program and on Kenya, the tool says that financing and efficiency decide the outcome more than the program's size. Three results follow, each with its conditions (Section 7): financing changes the debt path much more than the growth path; the efficiency of public investment scales the growth gain and leaves debt unchanged; and the political limit that binds decides whether carbon pricing can raise revenue. For Kenya (Section 8) the mitigation bill is mostly land use and non-CO_2 spending that builds no capital, carbon pricing on a clean grid pays for little of it, and the starting debt position, not the program, decides the risk rating.

The tool's contribution is integration at country level, not new economics. The IMF's Global Integrated Monetary and Fiscal Model (GIMF) (Kumhof et al. 2010) and the Debt-Investment-Growth and Natural Disasters model (DIGNAD) (Marto et al. 2018), built on the DIG model of Buffie et al. (2012), are the standard tools for public investment scale-ups in advanced and low-income economies; the joint Bank-Fund Debt Sustainability Framework for low-income countries (LIC-DSF) is the standard debt test (International Monetary Fund and World Bank 2018); the Climate Policy Assessment Tool (CPAT) estimates the effects of carbon pricing and related policies for more than 180 countries (CPAT Team 2023; Black et al. 2023). The closest integrated work is the World Bank's macro-structural model extended with climate policies and impacts for use by ministry staff (Burns et al. 2021) and the IMF's model-based estimates of the debt cost of net zero policy mixes (International Monetary Fund 2023). What none of these does is run a country's own mitigation investment program, split by payer, and its politically feasible carbon pricing through a macro model and a debt test in one pass, for every country, with the same public data and every assumption open to change. The lite models make that possible by giving up detail the parents have, and the paper says what is given up.

3 The tool

The tool is one workbook with one driving tab. The Dashboard holds the country selector, the main levers and the headline results for 2030 and 2050, with six charts: public debt, revenue and expenditure, GDP against a no-new-measures baseline, green investment, the carbon price in force, and debt sustainability. The main levers are a revenue increase (percentage points of GDP a year, up to a ceiling), a public investment increase, the climate investment program on or off, and a carbon pricing mode (none, a manual tax and feebate, or the best feasible tax, feebate or mix). Secondary levers sit on a Policy settings tab: start years and ramp-up, the share of new taxes falling on capital, other new spending, the strength of the fiscal rule, the three feasibility limits, the phase-in of carbon pricing, and how carbon revenue is used (rebated to the bottom 40 percent, spent on green public investment, or kept by the budget). Behind the Dashboard sit detail tabs for the fiscal outlook item by item to 2050, the macro and debt results, green investment, carbon pricing and the model engines.

The scenario is a baseline plus levers, and the baseline is a reference point, not a forecast. The baseline holds the country's 2024 fiscal position (debt, revenue and spending ratios) fixed, except that fossil fuel rents fall on a global net zero path; growth is reported above or below trend. A user who switches the climate program on adds the country's incremental budget need for mitigation, financed by grants, concessional loans and commercial borrowing in shares set on the assumptions tab. A user who chooses a carbon pricing mode adds the revenue it raises and can earmark it for the program. Every result is therefore a difference from a flat reference, which is what makes packages comparable and what makes the levels unsuitable as projections (Section 8).

Four source models feed it, each a separate, documented module. Table 1 lists them. They share one data layer: the Global Fiscal Indicators panel described in paper 7.2 (Stretton 2026a), which supplies each country's debt, revenue, public investment, efficiency score, creditor mix and energy data from public sources.

Table 1. The tool chains four modules on one data layer. Source: the tool's documentation.

Module	What it computes	Parent or basis	Coverage
Investment model	Investment for a net zero path and a current-trends path, 2024–2050, by sector; incremental cost; split into five payer types; budget need	CPAT data, codes and activity equation; IEA, IRENA and Ember data	186 countries
Pricing screen (Price-Feasibility)	Abatement from a power-sector carbon tax, feebate or mix; three political-cost limits; best feasible mix	Stand-alone; priors to be replaced by CPAT runs or country evidence	Countries with Ember power data
Macro-fiscal models	GDP, consumption, interest rates and public debt paths for a financed program	GIMF-lite, DIGNAD-lite, DIGNAR-lite, and DIGNAD-R (a recursive version in formulas)	186 countries
LIC-DSF-lite	Four external debt indicators and the total public debt benchmark; mechanical risk rating before and with the program	Bank-Fund LIC-DSF	66 low and lower-middle income countries

The workbook is built by script from the source models, so a fix in a model reaches the tool on the next build. A build script runs each module's extractor, which writes results in the indicator panel's long format (country, indicator, value, year, source); splices the module's indicator definitions into the panel's configuration; runs the dashboard builder; and adds the live sheets. The build stops if a module names an indicator its extractor does not produce. A full rebuild from raw data takes about six minutes.

4 The energy side

4.1 Investment needs and who pays

The investment model estimates, for each country and year to 2050, what a net zero path needs and who pays for it. It is a stock-and-flow model built to CPAT conventions: it uses CPAT's energy data and its activity equation (Stretton 2026e), projected with income elasticities and autonomous efficiency improvement at real 2024 prices, and builds investment bottom up for road transport, buildings, industry and power, with spending lines for non-CO_2 gases, land use and other energy emissions. Paper 6.3 treats investment needs and the efficiency of public spending in depth, with a different method that shares a global estimate of all climate investment among countries (Stretton 2026d); the two answer different questions and their country totals should not be compared. Here what matters is the investment model's output: an investment path in two scenarios and its split by payer.

Every investment line is split into five payer types, and the split decides the fiscal cost. The types run from pure public (P1, repaid by taxes: public buildings, access grids, land

use), through regulated utility (P2, repaid by tariffs), contracted revenue (P3, repaid under a long-term contract with a public or regulated buyer), and viability gap (P4, market revenue plus a public top-up), to pure private (P5). The starting split of power investment comes from the country's power market structure, coded from the power sector reform data of Urpelainen and Yang (2019), which end in 2013, and updated where they are out of date. Three pressure indices then move investment toward the budget: one for poor utility cost recovery, one for a high cost of capital, one for large explicit fossil fuel subsidies. The direct budget need in year t is

$$N_t = I_t^{P1} + \gamma\, I_t^{P4}, \tag{1}$$

with $\gamma = 0.3$ the public share of the viability gap, an assumption. The tool adds two wider measures: the need adjusted for public investment efficiency, $N_t/(1-\epsilon)$, where the efficiency gap ϵ comes from the country's PEFA scores on public investment management where they exist and from income-group averages otherwise; and the need including regulated-utility investment, which becomes a contingent liability wherever tariffs do not recover costs. The IMF puts the average efficiency gap at around 30 percent (International Monetary Fund 2015).

Only the incremental need enters the macro models, split into capital and spending. The program is the net zero need less the current-trends need. Its capital part builds public capital in the macro models; its spending part (land use, non-CO_2 abatement and other annual outlays) is financed the same way but builds nothing. In many low-income countries most of the budget need is spending, not capital, and this matters for growth: spending raises debt without raising future output.

4.2 Carbon pricing under feasibility limits

The pricing screen asks how much abatement pricing can deliver without breaching limits on political cost. It covers the power sector only, and compares a carbon tax, a feebate (a charge on generation above a benchmark emissions intensity and a rebate below it, equivalent in this sector to output-based allocation or a tradable performance standard) and a mix of the two. The distinction that drives the screen is between the marginal and the average price. Fuel switching responds to the marginal price, which a tax and a feebate raise equally. Electricity demand responds to the average tariff, which only the tax raises, because a feebate's charges and rebates cancel at the benchmark (Stretton 2026b). A feebate is a price-based instrument whose carbon-price equivalent is its rate at the margin, in the sense of the Total Effective Carbon Price (Stretton 2026c).

Abatement has a substitution part and a demand part. With a tax τ_t and a feebate rate τ_f in US dollars per tonne of CO_2,

$$A^{\text{sub}} = s_{\max}\left(1 - e^{-(\tau_t+\tau_f)/\tau_s}\right), \qquad \Delta p = \frac{\phi\, e_{\text{avg}}\, \tau_t}{p_{\text{res}}}, \qquad A^{\text{dem}} = |\,\varepsilon\,|\,\Delta p, \tag{2}$$

and total abatement as a share of baseline fossil power emissions is $E = 1 - (1 - A^{\text{sub}})(1 - A^{\text{dem}})$. Here $s_{\max}$ is the largest share of fossil output that cleaner supply can displace by about 2030, τ_s is the price at which switching is well under way (at τ_s it has reached 63 percent of its maximum; calibrated from coal and gas prices and heat rates), ϕ is the pass-through of carbon costs to tariffs (set by power market structure), e_{avg} is the average grid emissions intensity, p_{res} is the residential tariff and ε is the price elasticity of electricity demand. A feebate gets the same substitution as a tax at the same rate, with no tariff rise.

Three limits stand in for political feasibility. The first is the visible price: the first-year rise in the residential tariff, $F_1 = \Delta p/n$ for a phase-in over n years. The second is the

household loss: the net burden on the bottom 40 percent as a share of their consumption, $F_2 = b_{40}\,\Delta p\,(1 - \min(\rho/(\phi\, r\, q_{40}), 1))$, where b_{40} is their electricity budget share, ρ the share of revenue rebated to them, r the residential share of sales and q_{40} their share of residential use; $\phi r q_{40}$ is the share of revenue they pay, so a rebate of that share leaves them whole. The third is the concentrated loser: the net payment by coal and oil generators as a share of their revenue,

$$F_3 = \frac{\tau_t\, e_{\mathrm{hi}}(1-\phi) + \tau_f(e_{\mathrm{hi}} - e_{\mathrm{avg}})}{p_{\mathrm{w}}}, \tag{3}$$

where e_{hi} is their emissions intensity and p_{w} the wholesale price. The first term is the tax cost they do not recover; the second is the feebate's net transfer away from high emitters. The first term assumes each generator recovers the share ϕ of its own carbon cost, as under a cost-plus contract. If instead every generator receives the same price increase, the grid-average pass-through $\phi e_{\mathrm{avg}}\tau_t$, the unrecovered cost is $\tau_t(e_{\mathrm{hi}} - \phi e_{\mathrm{avg}})$, larger, and the limit binds sooner (Section 7). The screen searches tax and feebate rates from 0 to 200 US dollars per tonne for the mix with the most abatement that satisfies all three limits, and reports which limit binds. The default limits (10 percent for F_1, 0.5 percent for F_2, 15 percent for F_3) are placeholders, not recommendations. Choosing them is a political judgment; the tool's job is to show what each choice costs in abatement and revenue.

Revenue links pricing to the budget. Carbon tax revenue is the tax rate times fossil power emissions, as a share of GDP; a feebate raises nothing. The tool can earmark pricing revenue for the climate program, which lowers its debt financing. The financing gap the dashboard reports is the incremental budget need less feasible pricing revenue.

5 The macro-fiscal side

5.1 Why simplified models

The parent models are the right tools, but they cannot be run in one pass for every country. GIMF and DIGNAD need country calibrations that take weeks, run in specialist software and are maintained by small teams. A ministry economist cannot open them, change an assumption and watch the debt path move. The lite models keep the mechanisms that matter for a financed public investment program (households that do not fully discount future taxes, productive public capital, an efficiency wedge, a debt-elastic borrowing premium, a fiscal rule) and drop the rest. They are written in Python, solved under perfect foresight with a sparse Newton solver, and calibrated from public data with income-group defaults where data are missing. Table 2 sets out what each keeps and drops.

Table 2. The lite models keep the mechanisms of their parents that matter for a financed program and drop the rest. Source: the tool's method note and the parent papers cited.

Lite model	Parent	Kept	Dropped or simplified
GIMF-lite	GIMF (Kumhof et al. 2010; Anderson et al. 2013)	Overlapping-generations households with finite horizons (Blanchard 1985); liquidity-constrained households; private capital with adjustment costs; productive public capital; sticky prices and wages; inflation-targeting rule; uncovered interest parity with a debt-elastic premium; fiscal rule with a chosen instrument	One country facing a fixed world instead of several regions; one good; annual, not quarterly; no oil block, financial accelerator or zero lower bound
DIGNAD-lite	DIGNAD (Marto et al. 2018), built on DIG (Buffie et al. 2012)	Savers and hand-to-mouth households; Tobin's q; standard and adaptation public capital; investment efficiency; concessional and commercial external debt with a debt-elastic rate; fiscal rule on consumption tax and transfers; disasters	One traded good, so no real exchange rate; inelastic labor; no domestic debt; a disaster is a one-off surprise
DIGNAR-lite	DIGNAR (Melina et al. 2016)	Resource rents as an endowment shared between government and savers; a permanent fall in rents as a fiscal and income shock	Everything DIGNAD-lite drops; no resource fund; a firmer fiscal rule is imposed
DIGNAD-R	DIGNAD-lite	The same equations made recursive, in live spreadsheet formulas	One fiscal instrument; no energy savings or private investment push
LIC-DSF-lite	Bank-Fund LIC-DSF (International Monetary Fund and World Bank 2018)	Debt-carrying capacity from the Composite Indicator; four external debt indicators with thresholds and the total public debt benchmark; standard stress tests plus a disaster test; mechanical rating	Realism tools, staff judgment and the small-breach rule; loan cohorts instead of loan-by-loan data; no market financing module

5.2 GIMF-lite

GIMF-lite keeps the feature of GIMF that matters most for debt-financed investment: households do not fully discount future taxes. Each household survives each year with probability θ, so its planning horizon is $1/(1-\theta)$, 20 years at $\theta = 0.95$, and its labor income declines over its life at rate χ (Blanchard 1985; Kumhof et al. 2010). Human wealth is then discounted at a rate above the government's borrowing rate:

$$HW_t = (1-\psi)[(1-\tau_L)w_t l_t + tr_t] + \frac{\theta\chi}{1+r_t} HW_{t+1}, \tag{4}$$

and these households consume a fixed share of financial plus human wealth. A share ψ of households are liquidity constrained and spend current income. Because $\theta\chi < 1$, government debt is net wealth to households alive today: Ricardian equivalence fails, and in the long run higher public debt crowds out private capital and net foreign assets.

Public capital raises output, with an efficiency wedge. Production is $y_t = A\,(1+sav_t)\,KG_{t-1}^{\alpha_G}\,K_{t-1}^{\alpha}\,l_t^{1-\alpha}$, and public capital accumulates as $KG_t = (1-\delta_G)KG_{t-1} + s\,IG_t$, where only a share s of each dollar of public investment becomes capital. The output elasticity α_G is calibrated from an assumed return on public capital; since α_G equals the return times the ratio of public capital to output, a return of 15 percent with public capital of two-thirds of GDP gives an elasticity of 0.10, close to the meta-analytic average of 0.106 and the long-run estimate of 0.12 for core public capital (Bom and Ligthart 2014). The climate program enters as extra public investment, extra spending that builds no capital, extra private investment and net energy cost savings (sav_t, entered as a value-added gain). A fiscal rule sets the path of the debt ratio, letting a share of the program be debt financed and closing the rest, including interest, with transfers or the labor tax:

$$B_t - B_{t-1} = d\,(IG_t^x + G_t^x - R_t^x) - \lambda_B(B_{t-1} - \bar{B}), \tag{5}$$

where B is debt as a share of GDP, IG^x, G^x and R^x are the program's extra public investment, extra spending and earmarked revenue, d is the debt-financed share and λ_B is the speed of return to the debt target $\bar{B}$.

5.3 DIGNAD-lite, DIGNAR-lite and DIGNAD-R

DIGNAD-lite is the model for low-income and concessional borrowers. It keeps DIGNAD's split between savers, who borrow abroad at a debt-elastic premium, and hand-to-mouth households, who spend current income. It has two public capital stocks: standard capital and adaptation capital, which costs more and is destroyed less by disasters (Marto et al. 2018). The government borrows concessionally at a low fixed rate and commercially at $r_t^c = r^* + \eta\, e^{(d_t^c - \bar{d})}$, and a fiscal rule raises the consumption tax and cuts transfers as commercial debt rises. Programs are financed in stated shares of grants, concessional loans and commercial debt, the choice that matters most for low-income countries (Buffie et al. 2012).

DIGNAR-lite adds resource rents for fossil exporters. Rents are an endowment; the government takes a share and savers the rest (Melina et al. 2016). A permanent fall in rents on a global net zero path is a permanent fiscal and income shock, so the model solves for the steady state at the final rent level and imposes a firmer fiscal rule. In the integrated run, rents start at the country's latest fossil rents and fall 80 percent by 2050, with a government take of 50 percent; both are assumptions.

DIGNAD-R puts DIGNAD-lite into spreadsheet formulas so the user can see what moves. It makes the equations recursive, so they run in Excel without a solver and respond at once to the assumptions: disaster size, grant and concessional shares, the pricing earmark, the

fiscal rule. It treats every country as a DIGNAD-type economy, has one fiscal instrument and leaves out energy savings, so for upper-middle and high-income countries it sits below the integrated run. The tool shows both on purpose: read the integrated run for the number and DIGNAD-R for the mechanism.

5.4 LIC-DSF-lite

The debt test follows the structure of the Bank-Fund framework. Debt-carrying capacity comes from the Composite Indicator, a weighted sum of 10-year averages (five years of history, five of projection) of the country's CPIA score, real growth, import cover of reserves and its square, remittances and world growth. Capacity is weak below 2.69, medium from 2.69 to 3.05 and strong above 3.05. Four external indicators are compared with thresholds that depend on capacity: the present value of external public debt to GDP (30, 40 and 55 percent for weak, medium and strong) and to exports (140, 180, 240), and external debt service to exports (10, 15, 21) and to revenue (14, 18, 23). The present value of total public debt is compared with a benchmark of 35, 55 or 70 percent of GDP (International Monetary Fund and World Bank 2018, Tables 5–7). The 2018 guidance note remains in force, as modified by a 2024 supplement (International Monetary Fund and World Bank 2024).

Debt follows the standard dynamics, with a valuation term for foreign-currency debt. With d_t public debt as a share of GDP, i the nominal interest rate, g real growth, π the change in the GDP deflator, pb_t the primary balance and α the share of debt in foreign currency, which changes value with the depreciation rate ε_t,

$$d_t = \frac{(1+i_t)(1+\alpha\,\varepsilon_t)}{(1+g_t)(1+\pi_t)}\,d_{t-1} - pb_t + sfa_t, \tag{6}$$

where sfa_t collects other stock-flow adjustments. With $\alpha\varepsilon_t = 0$ this is the textbook recursion $d_t = (1+\lambda_t)d_{t-1} - pb_t$ with $1+\lambda_t = (1+i_t)/((1+g_t)(1+\pi_t))$ (Escolano 2010). New borrowing is on the terms of the country's creditor mix. The lite version applies the standard stress tests and a disaster test and rates risk mechanically: a breach in the baseline is high risk, a breach only under stress is moderate, no breach is low. It then shifts the baseline by the growth and primary-balance deviations the macro model produces, so the rating before and with the program can be compared. Because the lite macro models hold the real exchange rate fixed, the program's effect on the valuation term is zero by construction.

6 Integration and checks

One calibration file sets everything the macro models share, from the indicator panel. Public investment efficiency is one minus the efficiency gap, from PEFA scores where available and income-group averages otherwise. Tax revenue is split 40 percent consumption, 45 percent labor and 15 percent capital. Gross debt comes from the IMF World Economic Outlook, the concessional share from World Bank International Debt Statistics, and the commercial borrowing rate from the private creditor rate less 3 points, bounded between 3 and 8 percent. The return on public capital (20 percent for low-income down to 10 percent for high-income countries) and the share of constrained households (60 down to 25 percent) are income-group defaults. Government consumption closes the starting budget. Every setting carries its source in the file.

A rule chooses the model for each country. DIGNAR-lite runs for countries that are not high income and have fossil rents of at least 10 percent of GDP; DIGNAD-lite for low-income countries, disaster-prone countries and lower-middle-income countries whose external public debt is at least half multilateral; GIMF-lite for the rest. In the current build that gives

135 GIMF-lite countries, 35 DIGNAD-lite and 16 DIGNAR-lite. Two countries cannot stabilize debt under the fiscal rule even after it is tightened twice and are reported as not financeable, which is itself a result.

The integrated run chains the modules in a fixed order. For each country it reads the panel; runs the investment model for the budget need (split into capital and spending), private investment, energy savings and fossil power emissions; runs the pricing screen for the best feasible mix and its revenue; runs the chosen macro model with the program and the earmarked revenue; and, for low and lower-middle income countries, runs LIC-DSF-lite. The results feed the dashboard: the financing gap after pricing revenue, GDP against the baseline in 2030 and 2050, public debt in 2030 and 2050, the debt the program adds, and the debt risk rating before and with the program.

Every country is also run through the other model family, and the gap between the two has three known sources. If the integrated run used GIMF-lite, the cross-check uses DIGNAD-lite, and the reverse. Two channels exist only in GIMF-lite: the energy savings the program brings, entered as a gain in value added, and the private investment that comes with it. The third source is labor: GIMF-lite lets employment respond to higher productivity, while DIGNAD-lite fixes it; with labor nearly fixed in GIMF-lite, the tool's method note finds the two families give similar GDP gains for the same program. A large gap therefore says that the answer depends on whether energy savings, private investment and employment respond, which is a question about the economy, not a calibration error.

The models are checked against theory and against each other, not yet against their parents. In GIMF-lite's Ricardian limit (infinite horizons, no constrained households), debt-financed and tax-financed public investment give the same consumption path to 0.001 percent, as theory requires; at the default calibration they differ, as in GIMF. The households' budget constraint, which the solver does not impose, holds to 10^{-15}, a check on Walras's law. Terminal inflation equals the target, and results do not depend on the solution horizon. The Excel formulas and the Python engine agree to 10^{-14} for several countries and lever settings, and the investment model's spreadsheet and Python versions agree to 10^{-9}. These checks show the models are solved correctly. They do not show that GIMF-lite reproduces GIMF's published simulation properties (Anderson et al. 2013) or that DIGNAD-lite reproduces the DIG scale-up results (Buffie et al. 2012); that comparison, at the parents' own calibrations, is the next test.

7 A stylized run

The run uses the tool's default calibrations and a stylized program, not any country's data. The program is extra public investment of 1 percent of GDP a year for ten years. GIMF-lite starts from public debt of 50 percent of GDP, a 20-year planning horizon, a quarter of households liquidity constrained, a return on public capital of 15 percent and investment efficiency of 0.7. DIGNAD-lite starts from 30 percent of GDP in concessional debt and 20 percent in commercial debt, half of households hand-to-mouth, a return on public capital of 20 percent and efficiency of 0.6, with no disaster. The two calibrations differ, so their results are not directly comparable; each shows how its own levers work. The code is in `2.Source/stylized_run.py`; Table 3 gives the results.

Table 3. Financing changes the debt path; efficiency changes the growth path. Stylized program: extra public investment of 1 percent of GDP a year for ten years, at the tool's default illustrative calibrations. Source: author's run of the tool's models (`2.Source/stylized_run.py`, output saved in `stylized_run_output.txt`, 29 Oct 2026).

	Year 1	Year 5	Year 10	Year 20	Year 40
GIMF-lite: GDP, % deviation from baseline					
Debt financed	0.32	0.56	1.53	1.29	0.90
Tax financed (labor tax)	0.32	0.64	1.60	1.45	1.00
Debt financed, carbon revenue of 0.5% of GDP earmarked	0.34	0.56	1.52	1.30	0.93
Debt financed, efficiency 0.5	0.22	0.34	1.08	0.82	0.59
GIMF-lite: public debt, % of GDP					
Debt financed	50.8	54.2	57.2	54.1	51.3
Tax financed (labor tax)	49.8	49.7	49.2	49.3	49.5
Debt financed, carbon revenue earmarked	50.3	52.0	53.2	51.7	50.4
Debt financed, efficiency 0.5	50.9	54.3	57.4	54.4	51.4
DIGNAD-lite: GDP, % deviation from baseline					
30% grants, 30% concessional, 40% commercial	0.00	0.50	1.02	1.36	0.69
All commercial	0.00	0.51	1.04	1.36	0.66
DIGNAD-lite: public debt, % of GDP					
30% grants, 30% concessional, 40% commercial	50.7	52.9	55.3	56.0	52.5
All commercial	51.0	54.3	57.6	58.4	53.0

Result 1: financing changes the debt path much more than the growth path. *Conditions: either lite model at its default calibration; a one-off ten-year program; the fiscal rule of equation 5 or its DIGNAD counterpart.* In GIMF-lite, the debt-financed program raises GDP by 0.3 percent in the first year and 1.5 percent by year 10, and debt peaks at 57 percent of GDP in year 10 before the rule brings it back toward 50. Financing the same program by a labor tax keeps debt flat and leaves GDP slightly higher from year 5 on, because debt held by finite-horizon households crowds out private capital. Earmarking carbon revenue of 0.5 percent of GDP for the ten years cuts the debt peak by 4 points, to 53 percent, with no loss of growth; the model does not charge the tariff rise to anyone (Section 9). In DIGNAD-lite, financing 30 percent of the program by grants and 30 percent by concessional loans keeps debt 2.4 points of GDP lower at its peak than all-commercial financing (56.0 against 58.4 percent in year 20), and GDP is almost unchanged. The direction matches the IMF's finding that pricing revenue lowers the debt cost of net zero (International Monetary Fund 2023).

Result 2: the efficiency of public investment scales the growth gain and leaves debt unchanged. *Conditions: efficiency enters only the accumulation of public capital, as in GIMF and DIG.* Lowering efficiency from 0.7 to 0.5 cuts the GDP gain by 29 to 39 percent across the five horizons, while debt stays within 0.3 points of GDP of the base case: the same borrowing buys less capital. The first-year GDP gain of 0.32 percent per percent of GDP spent sits above the average short-run multiplier of about 0.2 that Furceri and Li (2017) estimate for developing economies, and their finding that multipliers are larger where investment efficiency is higher, like that of Abiad et al. (2016) for advanced economies, supports the ranking. In DIGNAD-lite, output rises more slowly than in GIMF-lite, because labor is fixed and there is no demand stimulus in the first year, and peaks around year 20 as the program tapers. For a low-income country the financing package is a debt question; the growth case rests on efficiency and the return on public capital.

Result 3: the political limit that binds decides whether carbon pricing can raise revenue. *Conditions: the static power-sector screen of equation 2 and equation 3.* Table 4 applies the screen to a stylized power sector: average grid intensity 0.60 tCO_2 per MWh, coal and oil generators at 0.95, pass-through 0.6, a residential tariff of US$150 per MWh, a wholesale price of US$90, and a three-year phase-in. At the default limits, the concentrated-loser limit F_3 binds for every instrument. The best tax (US$35 per tonne), the best feebate (US$38) and the best mix deliver almost the same abatement, about a quarter of baseline fossil power emissions, but only the tax raises revenue. With a tighter limit on the visible price, a first-year tariff rise of at most 2 percent, the tax alone falls to US$25 per tonne and 20 percent abatement; the feebate is unaffected, and the best mix (US$18 tax plus US$19 feebate) gets 25 percent abatement while keeping some revenue.

Table 4. When the generators' loss binds, a tax, a feebate and a mix deliver the same abatement, but only the tax raises revenue. Stylized power sector; $F_2 \leq 0.5$ percent in both cases and it does not bind. Source: author's calculation (`2.Source/pricing_screen.py`, which reproduces the tool's formulas).

Limits	Instrument	Tax (US$/t)	Feebate (US$/t)	Abatement (%)	F_1 (%)	F_3 (%)	Binding limit
Default: $F_1 \leq 10$, $F_3 \leq 15$	Tax only	35	0	25.3	2.8	14.8	F_3
	Feebate only	0	38	24.5	0.0	14.8	F_3
	Best mix	30	6	25.4	2.4	15.0	F_3
Tight visible price: $F_1 \leq 2$	Tax only	25	0	20.1	2.0	10.6	F_1
	Feebate only	0	38	24.5	0.0	14.8	F_3
	Best mix	18	19	25.1	1.4	15.0	F_3

The generators' limit is sensitive to how carbon costs are passed through, and the sensitivity strengthens Result 3. If every generator receives the same tariff increase rather than recovering the share ϕ of its own carbon cost (Section 4.2), the tax-only optimum falls to US$22 per tonne and 18 percent abatement, and the best mix becomes a pure feebate (US$38, 24.5 percent). In both cases no amount of rebating to households would raise the feasible price, but compensation to the owners of high-emitting plants, or a faster schedule for retiring them, would.

8 A country run: Kenya

Run for Kenya, the tool finds a small mitigation budget need that carbon pricing cannot pay for and that adds debt without adding much growth. The run is the tool's own output at its current build (Macro-Fiscal-Energy Scenario Tool 2026). Country data come from the indicator panel; four macro inputs (the return on public capital, the hand-to-mouth share, grants and baseline public investment) are income-group defaults, and exports and imports for the debt test are assumptions. Table 5 gives the chain from investment to debt risk, with the published figures beside the tool's where they exist. The tool's results are illustrative, not forecasts.

Table 5. Kenya's net zero program needs 0.5 percent of GDP a year from the budget, pricing pays for little of it, and Kenya is at high risk of debt distress with or without it. Program financed 30 percent by grants, 30 percent by concessional loans and the rest commercially, less pricing revenue. Tool results are illustrative, not official estimates. Sources: Macro-Fiscal-Energy Scenario Tool (2026) (author's extraction, `2.Source/kenya_run.py`); public figures as cited.

Step	Tool result (illustrative)	Public figure
Investment on a net zero path, 2030	2.31% of GDP (US$3.6 billion)	
Investment on current trends, 2030	0.66% of GDP	
Emissions in 2030, current trends and net zero path	121 and 89 $MtCO_2e$	NDC: 143 business as usual; target 32% below, about 97 (Republic of Kenya 2020)
Direct budget need, equation 1, 2030	0.60% of GDP; 0.81% after the efficiency gap	
Incremental budget need entering the macro model, 2030	0.49% of GDP: capital 0.10, spending 0.39	
Fossil power generation	(input)	8.5% of generation, 0.74 $MtCO_2$, 2024; no coal (Ember 2026)
Best feasible power-sector carbon tax	US$88 per tonne ($F_3$ binds)	
Pricing revenue	0.05% of GDP in 2030; about 5% of the need to 2050	
Financing gap, 2030	0.44% of GDP	
Macro model (rule)	DIGNAD-lite: lower-middle income, external public debt 56% multilateral	56% in 2024 (World Bank 2026a)
GDP against baseline, 2030 and 2050	+0.07% and +0.26%	
Public debt, 2050	74.6% of GDP with the program, against 67.3% held at its 2024 level (+7.2 points)	67.3% in 2024; IMF projects 71–74% in 2025–2030 (International Monetary Fund 2026)
Cross-check, GIMF-lite: GDP and debt, 2050	+4.6% and 70.5% of GDP	
Debt-carrying capacity (Composite Indicator)	Medium (2.73)	Medium (3.01) (International Monetary Fund 2024)
PV of public debt, peak	66.4% of GDP (2025–2034), against a benchmark of 55	68% of GDP (2023); above 55 through 2029 (International Monetary Fund 2024)
Risk of debt distress, before and with the program	High and High	High (external and overall) (International Monetary Fund 2024)

The need is modest and mostly not energy. Kenya's power is already over 90 percent renewable (Ember 2026), so of the 1.64 percent of GDP of incremental investment in 2030, 0.94 is for land use and non-CO_2 gases and only 0.26 for power and grids (Macro-Fiscal-Energy Scenario Tool 2026). The payer split puts 0.38 percent of GDP on the budget as pure public investment and 0.73 percent in viability-gap contracts, of which the budget carries 30 percent; the direct need is 0.60 percent of GDP. The tool's efficiency gap for Kenya, 26.5

percent, derived from PEFA scoring of public investment management and close to the IMF's average of around 30 percent (International Monetary Fund 2015), raises the need to 0.81 percent of GDP: weak delivery adds a third to the bill. The program goes further than Kenya's NDC: the tool's net zero path cuts 2030 emissions to 89 $MtCO_2e$, below the NDC target of about 97, from a current-trends path (121) that is itself below the NDC's business-as-usual of 143 (Republic of Kenya 2020).

Carbon pricing cannot pay for it, because a clean grid leaves little to tax. The pricing screen finds a feasible power-sector tax of US$88 per tonne, limited by the loss to fossil generators, but Kenya's fossil generation is small: oil-fired plants produced 1.13 TWh and 0.74 $MtCO_2$ in 2024 and 0.92 $MtCO_2$ in 2025 (Ember 2026). At US$88 per tonne that base yields US$65 to 80 million a year, about 0.05 percent of a 2030 GDP of US$155 billion, which matches the tool. The revenue covers about a tenth of the 2030 need and, as oil plants retire, about 5 percent of the need to 2050, leaving a financing gap of 0.44 percent of GDP in 2030. The contrast with the stylized power sector of Section 7 is the point: there the same limit binds but the revenue base is large. Kenya's own NDC counts on international support for 87 percent of the cost of its mitigation and adaptation actions, estimated at US$62 billion (Republic of Kenya 2020).

The program adds about 7 points of GDP to public debt by 2050 for a quarter of a percent of GDP. Kenya runs on DIGNAD-lite because it is lower-middle income and most of its external public debt is multilateral (56 percent in 2024 (World Bank 2026a)). Most of the incremental need is spending that builds no capital, so the growth effect is small: GDP is 0.26 percent above baseline in 2050, while debt reaches 74.6 percent of GDP against 67.3 percent in a baseline that holds debt at its 2024 level. That baseline is a reference, not a projection: the IMF projects Kenya's debt at 71 to 74 percent of GDP in 2025–2030 with no climate program (International Monetary Fund 2026). The 7.2 points are the program's addition to whatever path debt follows. The GIMF-lite cross-check gives a GDP gain of 4.6 percent and debt of 70.5 percent, mainly because it credits energy savings of 1.7 percent of GDP by 2050 and the private investment that comes with the program (Section 6). Whether those channels operate in Kenya is the largest uncertainty in the run.

Kenya is at high risk of debt distress before the program, and the program does not change that. The tool's debt test rates Kenya's capacity as medium and finds the present value of public debt at 66.4 percent of GDP at its highest over 2025–2034, above the benchmark of 55, both before the program and with it (66.5 percent) (Macro-Fiscal-Energy Scenario Tool 2026). The published IMF-World Bank analysis of December 2023 agrees on all three points: medium capacity, a present value of public debt above 55 percent of GDP through 2029 (68 percent at its 2023 peak), and a high risk of external and overall debt distress (International Monetary Fund 2024). The two differ on the Composite Indicator: 2.73 in the tool against 3.01 in the published analysis. The difference comes from the tool's lack of trade data. It assumes imports of 40 percent of GDP for reserve cover, while Kenya's imports were 22 to 24 percent of GDP in 2022–2025 (World Bank 2026b); with imports nearer 20 percent the tool's indicator rises to about 3.07, just past the strong cut-off of 3.05. The published indicator, computed with full data, is the one to use; the tool's is a check.

The strongest objection is that the tool misses the shock that actually moved Kenya's debt. The published analysis revised Kenya's debt metrics up mainly because of real exchange-rate depreciation in 2023–2024 and higher interest costs (International Monetary Fund 2024). DIGNAD-lite has no real exchange rate, so in equation 6 the program cannot change the valuation term, and a depreciation shock to the starting debt is outside the run. The answer is to read the tool's result for what it is: the program's addition to debt, at given

exchange rates, under a stated financing mix. A ministry that wants the risk around that path needs the full framework's depreciation stress, which the tool does not replace. For a ministry the run says three things: the mitigation bill is a land-use and non-CO_2 bill best financed by grants and concessional loans, not carbon pricing; closing the efficiency gap would save the budget about 0.2 percent of GDP a year (0.81 less 0.60); and financing terms and the starting debt position, not the program's size, decide the debt outcome.

9 Limits and use

9.1 What the tool is not

The lite models are not their parents. GIMF-lite has one country and one good, so it cannot show spillovers, the terms-of-trade effect of lower fuel imports, or the zero lower bound. DIGNAD-lite has no real exchange rate and no domestic debt. Neither has yet been benchmarked against its parent's published simulations (Section 6). The calibrations are illustrative: four inputs to the live model (public investment, the return on public capital, the hand-to-mouth share and grants) are income-group defaults, not country estimates. A result from the tool is a scenario to be argued with, not a forecast, and it does not substitute for a calibrated GIMF or DIGNAD run, an IMF or World Bank debt sustainability analysis, or a CPAT run.

The debt test is simplified. Exports and imports, the denominators of two of the four external indicators and, through reserve cover, an input to the Composite Indicator, are assumptions because the build has no country trade series yet; Kenya shows how much that matters. Debt-carrying capacity uses the Composite Indicator only where a CPIA score exists and defaults to medium elsewhere. The coefficients, cut-offs and thresholds follow the 2018 guidance note (International Monetary Fund and World Bank 2018) and should be kept in line with its 2024 supplement (International Monetary Fund and World Bank 2024). There are no realism tools, no judgment, no market financing module and, because the real exchange rate is fixed, no depreciation channel from the macro models.

The energy side has its own simplifications. The investment model has no price response, and power follows target dates rather than least cost. The payer typology rests on power market codes that end in 2013 for most countries, updated by judgment, and the public share of the viability gap is an assumption. The pricing screen covers power only, has no dynamics, ignores indirect effects on households, and its priors (heat rates, displaceable share, pass-through, budget shares) should be replaced by CPAT runs (CPAT Team 2023) or country data before any number is quoted. Energy savings enter only GIMF-lite; pricing revenue covers power only; and the tariff rise is not fed back into the macro models.

The two macro families disagree most on the channels that matter most. Energy savings and private investment drive most of GIMF-lite's long-run gain and are absent from DIGNAD-lite. Which channels to credit is an open decision, and the tool shows both answers rather than hiding the choice.

9.2 How to use it

Use the tool to compare packages for one country, not to forecast or rank countries. The baseline is a fixed reference, so the useful outputs are differences: debt with and without the program, with and without earmarked pricing revenue, under concessional or commercial financing, at higher or lower efficiency. A ministry economist sets the country, switches the program on, tries the financing and pricing levers, and reads the change in the debt path and the risk rating. The highlighted input cells show which assumptions are doing the work.

Check the starting point against the published analysis before reading the change. Where an IMF-World Bank debt sustainability analysis exists, its capacity rating, its Composite Indicator and its debt path are the reference; the tool's own debt test is a consistency check on its inputs, as Kenya shows.

Treat a large cross-check gap as a finding. Where the two model families disagree, the honest statement is that the answer depends on whether energy savings, private investment and employment respond, and the next step is evidence on those, not a choice of model.

Replace defaults with country data in order of influence. The stylized run suggests the order: investment efficiency and the return on public capital first, then the financing mix, then the trade data behind the debt test, then the feasibility limits and the pricing priors. Each replacement is one input cell, and the build records the source of every input.

10 Conclusion

Putting the investment need, feasible carbon pricing, growth and debt into one open workbook shows a ministry which assumptions decide its answer. In a stylized run and for Kenya, those are the financing mix, the efficiency of public investment, the political limit that binds on pricing and the starting debt position, not the size of the program. The main limitation is that the lite models have been checked for correctness but not against their parents, and that they cannot see exchange-rate shocks. The next steps are to benchmark GIMF-lite and DIGNAD-lite against the parents' published simulations, to add trade data to the debt test, and to replace the pricing screen's priors with CPAT runs for the countries that use it.

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