Crops, Drops and Climate Change:
Using Energy Efficiency to Configure the Perfect Sustainability Storm

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Yields have increased; as have fertilizer and water use

Note: Countries with more than 30% of their agricultural area under irrigation in 2005 were analyzed separately as MICs; Solid and dashed lines are for 10- and 30-y machinery lifespans, respectively

Relative contribution of farm inputs

Source: Pedro Pellegrini, and Roberto J. Fernández, PNAS, 2018
Windows for Irrigation are small; we have tended to overcompensate and overirrigate.

### Rice: Irrigation stages
- Crown root initiation* (20-25 DAS)
- Late tillering (40-45 DAS)
- Late jointing* (65-70 DAS)
- Flowering stage* (90-95 DAS)
- Milk stage (105-110 DAS)
- Dough stage (120-125 DAS)

### Wheat: Irrigation stages
- Crown root stage* (20-25 DAS)
- Tillering (40-45 DAS)
- Node Formation* (60-65 DAS)
- Flowering (80-85 DAS)
- Milk formation (100-105 DAS)
- Grain filling (115-120 DAS)

* Critical stage

DAS – Days after sowing

Source: Mom R, 2007; Zwart and Bastiaansen, 2004; Chapagain and Hoekstra, 2004

**Water used**

**Water required**

**Rice**

- Water used: 1432
- Water required: 909

**Wheat**

- Water used: 1300
- Water required: 500

Source: FAO AquaStat

Irrigation water withdrawal (km³/yr)

- Africa: 171.2
- Americas: 397.2
- Asia: 2025.9
- Europe: 69.1
- Oceania: 9.1
- World: 2672.6

Irrigation water requirement (km³/yr)

- Africa: 82.6
- Americas: 195.2
- Asia: 1173.5
- Europe: 43.6
- Oceania: 5.3
- World: 1500.4
Multiple impacts of global warming and climate disruption on agriculture

- Global warming
  - Climate change
    - Diverse pathways
      - Storms
      - Weeds
      - Loss of labour
    - Desertification and land degradation
    - Human health
      - Air pollution
      - Malnutrition
      - Disease
      - Poverty / Debt
  - Impaired photosynthesis
    - Tropospheric ozone depletion
    - Stratospheric ozone depletion
    - Biodiversity loss and ecosystem function
    - Conflict resource scarcity
    - Altered precipitation
    - Freshwater decline for irrigation
    - Melt down mountain top glaciers

- Agricultural productivity
  - Drought
  - Heat waves
  - Pests

UV radiation
Achieving the Paris Goal Needs Simultaneous Action on at least Three Fronts in the Agriculture Sector

4 transition strategies need to be pursued simultaneously to achieve a well below 2°C scenario

**Transition strategy**

1. Decarbonization of power combined with extended electrification
   - Business as usual 2040: 47
   - WB2C 2040: 20

2. Decarbonization of activities which cannot be cost-effectively electrified
   - Business as usual 2040: 13
   - WB2C 2040: 4
   - Reduction: 48%

3. Acceleration in the pace of energy productivity improvement to 3% per annum
   - Business as usual 2040: 8
   - WB2C 2040: 2
   - Reduction: 30%

4. Optimization of fossil fuels use within overall carbon budget constraints
   - Business as usual 2040: 2
   - WB2C 2040: 2
   - Reduction: 7%

**Illustrative path to WB2C scenario**

Annual emissions, 2040, Gt CO₂e

**SOURCE:** Ad hoc analysis developed by Copenhagen Economics for the Energy Transitions Commission
Strategy for Agriculture Sector Decarbonization

• Enhance water-use and energy-use and fertilizer-use efficiency in agricultural operations;

• Convert agricultural operations to utilize electricity instead of fossil fuels; and

• Decarbonize the electricity supply by converting to renewable sources, instead of fossil fuels, as energy sources for electricity generation, and for heating applications
Green Farming: Water Pumping & Water Use

Energy inefficient pump for flood irrigation

Efficient SPV pump with micro-irrigation and purchase of electricity by grid

For 1 hectare of wheat, over the growing season:

Cost of irrigation: ~ US$132
Revenue from Electricity sale: ~US$ 15
Cost of SPV system (5HP) = ~ $ 5,000

For 1 hectare of paddy, over the growing season:

Cost of irrigation: US$ 340
Cost of irrigation: ~ US$163.4
Revenue from Electricity Sales: ~US$12
Creation of Demand, and Reduction in their Cost are the Current Challenge

Demand creation to exploit economies of scale

Loans for Zero-Carbon options

The challenges are the same as those faced by HYV crops during the Green Revolution!

Approach is to create demand, and enable price reductions with increasing scales of production
India’s Experience

- Fastest growing LED market in the world
- Domestic LED market on the rise (100 million LED bulbs delivered; 770 million by 2019)
- Economies of scale at work
- High quality is priority

**Renewable Energy**

Capacity installed
- ~29000 MW (solar)
- ~35000 MW (wind)

Tariff
- Decline in cost from 0.25$/kWh to < 0.04$/kWh

**Agricultural Knowledge and Information Systems**

**Markets and Financial Institutions**

**Public Policy**

**Infrastructure**

**Green Revolution**

- Capacity installed: ~29000 MW (solar), ~35000 MW (wind)
- Tariff: Decline in cost from 0.25$/kWh to < 0.04$/kWh
Thank you