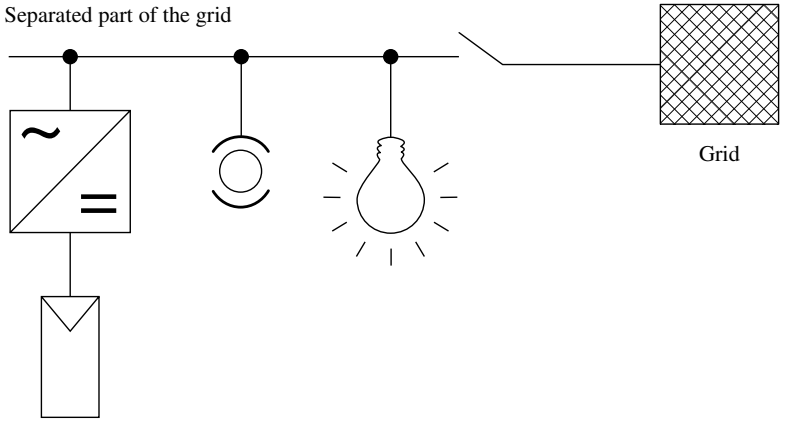


**Figure 19.50** After switch-off, the separated part of the grid may continue operation, if the injected power by the PV system equals the actual load

As a first measure, frequency and voltage monitoring will identify by far most situations in grids turned off since the smallest deviations in production or in consumption will lead to changes in frequency or voltage or in both of them. The experience with big wind farms has shown that limitation of voltage or frequency may lead to undesired results, however.

In case of heavy loads on the grid, both the voltage and the frequency may fall below the set point. In this situation, cut-off of power sources takes place when they would be needed urgently to support the grid. As a further method to identify islanding conditions, monitoring of the grid's impedance is being performed by injecting power peaks, which do not correspond with the fundamental frequency (50 or 60 Hz), by the inverter into the grid and by monitoring this influence on the grids voltage shape. This method is currently accepted by German safety code.

This code, which applies to grid-connected single-phase PV systems smaller than 5 kW, requests a separation from the grid, if the impedance of the grid exceeds 1.75 ohms or if a jump in the impedance $\geq$0.5 ohms occurs. Reconnection to the grid is allowed for grid impedance smaller than 1.25 ohms. There are two independent monitoring and switching systems that have been requested. One of the two systems must act on a mechanical switch, for example, a relay, while for the second system, the semiconductors of the inverter output bridge are accepted. Figure 19.51 explains this configuration.

In addition to the monitoring of the grid impedance, frequency deviations above $\pm$0.2 Hz or voltage differences bigger than $-15$ or $+10\%$ must lead to a separation of the grid as well. The safety protection device can either be integrated into the inverter or installed separately between the inverter and the grid. The latter may be used preferably in combination with small-scale inverters, for example, module-integrated ones. In these cases, the investment cost for integrating the unit in each of the small inverters with a power of not more than a few hundred watts may not be economic. In case of a separate installation, one supervision unit could be used to protect several small module-integrated inverters. As an alternative, also accepted as a safety device, voltage monitoring of all three phases of the grid, which lead to a separation, if one of the three phases becomes